Aphasia and the Challenge of Writing

by

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2009

To the persons who so willingly provided me
with all their valuable information about,
and experiences of,
aphasia.

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The Sahlgrenska Academy at University of Gothenburg, Sweden, 2009

Printed by: Intellecta DocuSys, Västra Frölunda, 2009

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Abstract

Background Writing difficulties are usually one of the integral symptoms of persons with aphasia. Earlier research based on studies of the spelling of single words has yielded interesting results. This work includes analyses of texts and text production.

Aim The general aim of the thesis, which includes four studies, was to describe the characteristics of the writing process in aphasia.

Materials and methods The participants in the first three studies were a group of six men and two women with aphasia (the A-group) in the age range of 28 to 63 years (mean age 42.5 years) and a reference group (the R-group) consisting of five women and five men in the age range of 21 to 30 years (mean age 23.5 years). One of these studies also included 60 untrained raters. The participants in the fourth study were three individuals with aphasia, two men and one woman (aged 53, 56 and 59, respectively). The participants wrote two narratives and told one of them orally. Not only the final texts but also the revision phases were analysed. The analysis related to variables reflecting vocabulary, syntax and narrative structure. The narratives were also subjected to holistic assessment by the untrained raters. The intervention study had a single-subject ABA design replicated across the three participants. All writing tasks were carried out on a computer and key-stroke logging was used for the collection and analysis of the data.

Results The A-group wrote stories with a lower production rate and more word-level errors than the R-group, and also had more difficulty revising their texts. Narrative structure was not as good in the A-group's texts, but the most essential parts of the narrative were included; their written versions were in fact rated as more coherent and easier to understand than their spoken versions. Story length and the proportion of word-level errors to some extent predicted ratings, but not necessarily in the sense that fewer errors and longer stories predicted a higher rating. The intervention study showed that training with computerised writing aids improved writing in different ways.

Discussion The narratives produced by the participants with aphasia were characterised by linearity as a result of their use of short T-units with few subordinate clauses and simple syntax. The study of the revision phase revealed the same pattern: every word and sometimes every character was checked before the participants continued writing. Writing a narrative was a time-consuming task for the participants with aphasia, but the stories they eventually produced were explicit enough to meet the demands of the written medium. Regular training was effective and compensated for some of the difficulties.

Clinical implications Written language should be included in aphasia assessment and in planning for rehabilitation since it opens up a wider range of possibilities to communicate.

Keywords: Aphasia, writing ability, writing process, text writing, narrative, spoken language, discourse, revision, key-stroke logging, single-subject design, training, computerised writing aid

ISBN 978 – 91 – 628 – 7657 – 9 Gothenburg, 2009

Contents

List of publications

This thesis is based on the following papers, which will be referred to in the text by their Roman numerals:

I. Behrns, I., Ahlsén, E., & Wengelin, Å. Aphasia and Text Writing. Under revision.

II. Behrns, I., Hartelius, L., Wengelin, Å., & Olsson, M. B. A Comparison of Written and Spoken Narratives in Aphasia. Submitted.

III. Behrns, I., Ahlsén, E., & Wengelin, Å. (2008). Aphasia and the Process of Revision in Writing a Text. *Clinical Linguistics & Phonetics*, 22(2), 95–110.

IV. Behrns, I., Hartelius, L., & Wengelin, Å. (in press). Aphasia and Computerised Writing Aid Supported Treatment. *Aphasiology*.

Reprints were made with kind permission from *Clinical Linguistics & Phonetics* and *Aphasiology*.

Introduction

The ability to translate an idea or a concept into written language has become increasingly important in modern Western lives. New technologies have opened up a wide variety of opportunities for interaction through the written medium. The requirements imposed on an individual as regards what, how frequently and for whom he or she needs to write change constantly throughout life (Barton & Padmore, 1991). Written communication is also about the representation of self, and the act of writing has been described as an act of identity (Ivanic, 1998). Losing the ability to write, wholly or in part, may therefore change a person's life dramatically.

This thesis deals with aphasia and the process of writing. This means that the focus is not only on the final product – the completed text – but also on the actual work behind the composing of a story. The thesis includes a detailed description of the writing process in individuals with aphasia as well as suggestions for intervention methods.

Background

Aphasiology and writing research

Aphasia, a language disorder following acquired brain damage, most frequently occurs after a stroke in the dominant language hemisphere of the brain. Between 21 and 38 per cent of all stroke survivors exhibit aphasia (Laska, Hellbom, Murray, Kahan & von Arbin, 2001). The incidence in Sweden, according to the Swedish Aphasia Association (*Afasiförbundet*), is 12,000 cases every year, about 35 per cent of whom are of working age (Ahlsén, 2008).

The German physician Ludwig Lichtheim described in 1885 that writing ability was often affected by aphasia, and aphasiologists have been aware since then that writing may be one of the integral symptoms of aphasia. However, since written output has generally been seen only as a secondary aspect of spoken output, there has been no specific emphasis on developing theories for the writing process, and writing treatment has merely been viewed as part of a more global approach to aphasia therapy (Carlmagno & Ivarone, 1995). Interest specifically in written language emerged through research in *cognitive neuropsychology* (Marshall & Newcombe, 1966, 1973; Hatfield & Weddel, 1976). That is also the theoretical framework within which most research on acquired writing difficulties has been carried out. However, this field of research also includes an *ethnographic perspective* (Parr, 1992, 1995) and a *socio-cultural perspective* (Mortensen, 2004, 2005), which will be briefly described at the end of this section.
The goal of cognitive neuropsychological research is to develop models of normal cognitive tasks. The assumption made is that these functions, such as memory and language use, can be conceptualised as a sequence of sub-processes (for an overview, see e.g. Beeson & Hillis, 2001. This way of analysing language functions represents a highly analytical approach in that it describes and understands behaviour by identifying its

simplest components. In a pathological context, the identification of the impaired component makes it possible to plan for language rehabilitation where the goal is to improve an impaired process or to reinforce the unaffected ones according to the model. This line of research has been the subject of some criticism, mainly because while the models do help clinicians identify *what* functions to focus on during treatment, there is little knowledge about *how* treatment is best carried out (Wilson, 1997; Hillis & Heidler, 2005).

In the framework of cognitive neuropsychology, various information-processing models for writing, with focus on spelling, have been presented. The most influential one is the 'dual-route model' (Coltheart, 1980; Hatfield, 1983). Under this model, writing (and reading) takes place through two major routes, which are entirely separate from each other: the lexical route and the phoneme–grapheme-conversion route. The lexical route means direct retrieval of a word's spelling from information stored in the orthographic-output lexicon. The phoneme–grapheme-conversion route means segmental translation from phoneme to grapheme. Writing and reading disabilities are both described within the same model, a parallel way of diagnosing exists and they are often reported as existing together (Martin, 1998). Based on the dual-route model, symptoms may be categorised into different sub-groups:

- *Surface dysgraphia*: the writer does not have access to the lexical-orthographical representation of a word but relies on the phoneme–grapheme correspondence (Beauvois & Dérousné, 1981; Hatfield & Patterson, 1983);

- *Phonological dysgraphia*: the writer does not have access to the phoneme–grapheme conversion and can therefore spell words only by accessing stored whole-word orthographic representations (Shallice, 1981);

- *Deep dysgraphia*: the writer does not have access to the phoneme–grapheme conversion, and the lexical route may also be impaired. Because semantic processing is disturbed, semantic substitutions and/or neologisms are produced; this semantic involvement is in fact the critical symptom differentiating this disorder from phonological dysgraphia (Bub & Kertesz, 1982; Alexander et al., 1992).

Tests have been developed for analysing spelling difficulties into these sub-groups (Kay, Lesser & Coltheart, 1992), but they have not yet been adapted for Swedish.

The *ethnographic perspective* is represented by Parr (1992, 1995) in qualitative studies based on interviews. She suggested a perspective on reading and writing skills based on the assumption that the informant (patient) is the expert on his or her own personal situation and needs. Reading and writing abilities change not only because of linguistic difficulties associated with aphasia but also because the roles assigned to a person by society are often very different following brain damage. Her analysis (1995, p. 234) stresses that 'literacy does not involve a neutral set of technical and linguistic processes, but is imbued with social and cultural values'. She argues that assessment and planning of interventions should be based on knowledge of the patient's individual background. In

other words, factors such as social class, education, marital status and personal level of development have to be taken into account. Rehabilitation should therefore be individually planned subsequent to a careful analysis of the patient's reading and writing needs in the different situations and roles that he or she encounters in everyday life.

Parr stressed that reading and writing habits should be studied from a perspective where context and purpose are emphasised, suggesting three targets for therapy:

- *Activities.* The extent and importance of reading and writing vary according to the different roles played by the person with aphasia; therapy has to be planned on the basis of situations relevant to the individual;

- *Strategies.* Being in control, rather than being independent, should be the goal of intervention as regards reading and writing ability. Independence may imply the ability to complete a task without any assistance, but it is more important and relevant to be in control of the action – with or without assistance. Social and technical backups (significant others, technical aids, etc.) may be used as strategies to become in control of the writing activity;

- *Adjustment.* With assessment based on the individual's background factors, it is important also to include psychodynamic dimensions in therapy.

Mortensen (2005) uses a *socio-cultural perspective*, based on the Systemic Functional Linguistics framework (SFL theory) (Halliday, 1978, 1994). According to SFL theory, language structure is closely related to language use; the different purpose of written versus spoken language is emphasised. In her analysis of personal letters written by participants with aphasia she showed how information and interaction change and how these two factors interrelate. Her results indicated that writers with aphasia, because of the reduction in the amount of information provided, are perceived as less engaging in their interaction with the readers of their letters.

Localisation of brain damage associated with acquired writing difficulties

The French neurologist Joseph Jules Dejerine reported results in 1891 indicating that the cortical regions around the dominant angular gyrus are important for writing ability. Theories concerning information processes do not view different aspects of language as different skills with a certain focal localisation: 'There is no single brain centre for reading, writing, or comprehension. There are only networks of highly specific mechanisms dedicated to the individual operations that comprise a complex task.' (Caramazza, 1997, p. 133). However, the neuroanatomical correlates of writing may be grouped according to the different processes identified (for an overview, see e.g. Rapcsak & Beeson, 2002). Extrasylvian lesions involving the left temporo-parietal-occipital junction, in particular damage to the left angular gyrus, cause difficulties such as those found in *surface dysgraphia*. The lesion sites reported as causing *phonological dysgraphia* are more varying, but perisylvian lesions dominate. The perisylvian region has

been suggested as the location of a phonological network, involved also in activities other than writing (e.g. Alexander, Friedman, Loverso & Fischer, 1992), which is also supported by results from fMRI analysis of a non-brain-damaged group (Beeson & Rapcsak, 2003). As regards semantic processing involved in writing, which is affected in *deep dysgraphia,* regions within the left extrasylvian frontal and temporo-parietal cortex are active.
A somewhat different explanation for the semantic difficulties in deep dyslexia is the possibility of right-hemisphere reading in patients with extensive left-hemisphere damage (Coltheart, 1980, 2000).

Rehabilitation of writing ability

Several individual factors such as age, gender, education, etiology, physical and mental health and severity interact in the prognosis of aphasia (Patterson & Chapey, 2008). Individuals with aphasia make up a very heterogeneous group, which makes it difficult to generalise results from intervention studies. Intensive treatment focusing on specific language behaviour and treatment incorporating environmental factors in the intervention have both resulted in improvements (Ahlsén, 2008). Results concerning writing ability have shown that written language did not improve spontaneously as much as spoken language (Lomas & Kertesz, 1978). However, results have also been reported where it was possible to improve written language through rehabilitation even though spoken language did not improve (Beeson, 1999; Robson, Marshall, Chiat & Pring, 2001). Further, several positive results from interventions to improve the phoneme–grapheme correspondence (e.g. Hillis & Caramazza, 1994) or the lexical process (e.g. Behrman, 1987; De Partz, Seron & Van der Linden, 1992; Beeson, 1999) have been reported.

Aphasia and the use of computers in rehabilitation

The effects of computerised training in aphasia rehabilitation are in general encouraging. Use of a computer in the rehabilitation process had a motivational effect by making rather simple (low-tech) training tasks more advanced (high-tech) (Mortley, Enderby & Petheram, 2001). The amount of practice also seemed to increase (Mortley, Enderby & Petheram, 2001). Writing support by means of a word processor has also been used therapeutically, such as in a case reported by Pinhas-Vittorio (2007) where a person with aphasia wrote poems as a way of language restoration, or in writing groups that enabled persons to adapt to life after a stroke (Hartke, King & Denby, 2007). Computers have also been used specifically to treat writing problems in aphasia; three types of aids have been reported in the literature:

- *Synthesised speech* enabled participants to listen to what they had written, which led to a decrease in spelling errors and also made the individuals more independent and better able to carry out writing tasks independently (King & Hux, 1995);

- *Voice recognition* helped a participant to become a better writer; results showed an improved ability even when the writing aid was not used (Bruce, Edmundson & Coleman, 2003);

- *Word prediction*, where participants were presented with possible words after typing one or two letters, resulted in more words being produced both with and without the aid (Mortley, Enderby & Petheram, 2001).

It seems, then, that computerised writing aids not only have a very good compensatory effect but also work as a method for improving writing skills. Still, even if there is growing interest in computerised aids for persons with aphasia, more research is needed into what aids to use for whom, and how. It is also a fact that individuals with disabilities, who are among the groups that could benefit the most from access to computers, actually have limited access to such devices. As Swedes in general have increased their use of computers and the Internet, persons with disabilities have fallen behind in terms of computer access, especially older people and in particular older women (Brundell, 2006). It is also important to mention how aphasia affects a person's ability to learn how to use computers. Supervised hands-on learning is an effective method for people with aphasia, who find on-line situations (e.g. when a dialogue box emerges on the screen, asking for an updated version of a program) rather difficult to handle (Egan, Worrall & Oxenham, 2004). Individuals with aphasia also prefer icons to information presented as text (Egan, Worral & Oxenham, 2004).

What is the relationship between written and spoken language?

Catts and Kamhi (2005) summarised how spoken and written language differ, suggesting a division into the following seven aspects: (1) physical differences, i.e. sounds or marks on paper; (2) situational differences, i.e. if the speaker/writer and listener/reader are separated or not in time and space; (3) functional differences, i.e. labelling; (4) form differences, i.e. sounds versus letters; (5) vocabulary differences, i.e. spoken language is usually reported as being less diversified; (6) grammatical differences, i.e. speaking has high frequencies of coordination, repetition and rephrasing; (7) processing differences, i.e. metalinguistic processes. It may be added that, in many respects, these differences can be interpreted as due not mainly to the different modalities of speech and writing but rather to the difference between dialogue and monologue (Biber, 1988).
The analysis of spoken and written language produced by individuals with aphasia can be expected to show differences between the two modalities. Early research in aphasiology seemed to view writing as written speech, implying that the symptoms would be the same in written and spoken output (e.g. Geshwind, 1962; Luria, 1976; Kohn, 1989; Goodglass, 1992). However, different patterns for how difficulties are manifested in written versus spoken language have since been observed (Hier & Mohr, 1977; Graham, Patterson & Hodges, 2004).

Discourse analysis of language produced by persons with aphasia

Most studies on acquired writing difficulties are based on single-word processing (i.e. spelling), resulting in a focus on form rather than content and in research which is product-oriented rather than process-oriented (Mortensen, 2004). However, discourse analysis of spoken language has become an important tool in the context of aphasia (e.g.

Goffman, 1981; Ahlsén, 1985; Caplan, 1987; Prutting & Kirchner, 1987; Miceli, Silveri, Romani & Caramazza, 1989; Saffran, Sloan-Berndt & Schwartz, 1989; Ferguson, 1994, 1996, 1998; Klippi, 1990; Laakso, 1997, Lock & Armstrong, 1997) and is influencing research on written language. Three studies on written discourse were presented in the late 1970s and early 1980s (Ulatowska, Hildebrand & Haynes, 1978; Ulatowska, Baker & Freedman-Stern, 1979; Freedman-Stern, Ulatowska, Baker & Delacoste, 1984) and two more were published more recently (Mortensen, 2004, 2005). While the number of studies is thus limited, their results indicate similarities with spoken language in that general narrative structure is good despite manifested difficulties on other linguistic levels. Different findings, however, have been made for written stories produced by persons with traumatic brain injury (without aphasia), where overall structure appeared to be more affected by the brain injury (Wilson & Proctor, 2002)

A model of the writing process

Hayes and Flower's model of the writing process from 1980 contains three main components: the task environment, the writer's long-term memory and the cognitive processes involved in writing. The model focuses not only on spelling but also on planning what to write, generating the text and revising the text. The later version of the model from 1996 (Hayes) has been somewhat rearranged and includes two major components: the task environment and the individual. The environment encompasses two aspects: the social and the physical environment, and the individual encompasses three aspects: cognition, affect and memory. This later model is described as an *individual-environmental model* (Hayes, 1996, p. 5). The data used by Hayes and Flowers came from 'protocol analysis', where participants were asked to 'think aloud' during a writing task and all of their comments were analysed. The authors outline how the parts of the model are organised into several sub-units, how these are related and how they cooperate in the process of writing. Hayes (1996) proposed that individual differences in writing performance will be related to the ability to manage the often simultaneous constraints of planning, generating and revising.

Hayes and Flower's model has influenced research on the writing process (for a review, see Alamargot & Chanquoy, 2001). The model emphasises the interrelationship of the sub-units in the process, and it considers the writing process in the framework of memory functions (Hayes & Flower, 1980; Hayes, 1996; Kellog, 1996). For a skilled writer, writing activity is partly automatic; this enables the writer to focus on content and communication rather than on spelling or other low-level aspects. It is claimed that reduced access to cognitive resources leads to more fragmented processing, and that the 'deautomatisation' of an automatic sub-process will exert a negative influence on all dimensions needed for the writing activity (Chenoweth & Hayes, 2001; Van Gelderen & Oostdam, 2002; Schoonen, van Gelderen, de Glopper, Hultstijn, Simis, Snellings & Stevenson, 2003; Wengelin, 2007).

Further, interest in the revision phase has grown, especially owing to the introduction of key-stroke logging, which means that information about all actions performed by a writer on the keyboard or using the mouse is saved in data files, making it possible to analyse

how the writer worked on the text: how words and sentences were changed, what parts were deleted and how long the pauses were. Such information has been very valuable to pedagogical research and to the study of writing impairments (Holmström, Johansson, Strömquist & Wengelin, 2002; Lindgren 2005). Even if the log files cannot reveal why a writer revised his or her text in a certain way or why he or she paused, the data make it possible to analyse the composing of the text, i.e. the text-production process.

Research on single-word production has long been well established in the field of acquired writing difficulties, for diagnostic purposes as well as for rehabilitation. The description in this thesis is an attempt to focus – based on earlier studies and established writing theories – not only on single-word production but also on text writing. Final texts, as they look when the writers have decided they are finished, are analysed. But in addition to analysing the end product of the writing activity, the composing of the text is also studied by means of data revealing what words have been changed and how sentences have been rearranged.

Aims

The general aim of this thesis was to describe the characteristics of the writing process in aphasia.

The specific aims were:

I to systematically describe text writing in a group of participants with aphasia;

II to explore how a personal narrative produced by a person with aphasia differs between written and spoken communication;

III to analyse the revision phase of the writing process in a group of participants with aphasia;

IV to investigate whether writing difficulties in aphasia may be reduced by regular training using a computerised writing aid.

Materials and methods

The thesis includes four studies. Studies I, II and III stem from the same research project. These are descriptive group studies and combine analyses of quantitative measured variables with a holistic assessment. Study II is partly based on questionnaires. The participants, eight individuals with aphasia and ten without aphasia, are identical for Studies I–III. Study II also includes 60 raters.

Study IV has a single-subject design with three participants and the results are analysed visually in graphs but also statistically.

Results from Studies I–III are supplemented with individual results from the group of participants with aphasia as well as findings from short interviews with all of these participants where they talked about their writing ability. These results and findings were not presented in the articles.

Participants

Studies I, II and III

Six men and two women with aphasia (the A-group), in the age range of 28 to 63 years (mean age 42.5 years), took part in the study. The inclusion criteria were: Swedish as native language; focal CVA in the left hemisphere; a minimum of six months post onset; a mild to moderate comprehension disorder (BDAE, Goodglass & Kaplan, 1973); ability to write on a keyboard and familiarity with keyboard writing; right-handedness (pre-morbid); and no visual defects. Details describing the participants in the A-group are summarised in Table 1.

The reference group (R-group) consisted of five female and five male university students with no history of reading and writing difficulties, in the age range of 21 to 30 years (mean age 23.5 years) and with Swedish as their first language. Their main experience of typing was from writing essays at the university and from writing e-mails. The ideal would have been to compare the A-group with a control group, matched for age, gender and education. Level of education has been reported as influencing concept and topic coherence, but no clear influence of gender or age was demonstrated (Mackenzie, Brady, Norrie & Poedjianto, 2007). Still, contradictory results concerning age have been reported (Mortensen, 2005; Wright, Capilouto, Wagovich, Dranfill & Davis, 2005). However, the education level of the two groups was rather similar since four of the eight participants in the A-group had a university degree and a fifth was studying at university when he had his stroke. In addition, two of the A-group participants were trained secretaries with many years in the profession. Consequently, seven of the eight participants with aphasia had many years of writing practice and were all experienced writers, and so the groups are in fact comparable as regards the analyses performed in this thesis. Still, comparisons of results for the A-group with results for the R-group have to be interpreted with due regard to the fact that there are differences between the groups, especially in age and gender.

Study II also included a group of 60 persons who rated the narratives produced by the participants in the A-group and R-group. These raters were 52 women and 8 men in the age range of 19–82 years (mean age 29.4 years). As regards their level of education, they were grouped into four categories: less than completed upper-secondary school (3%), upper-secondary school (24%), university (65%) and no information on level of education (8%). Two questionnaires were excluded because of faulty marks on rating scales.

Study IV

Three individuals with aphasia, two men and one woman (aged 53, 56 and 59, respectively), took part in the study. The inclusion criteria were similar to those in Studies I–III, except familiarity with keyboard writing, and also included a requirement that no other training with a speech and language pathologist was taking place during the study. See Table 2 for a description of the participants.

Table 2. Participants, Study IV. The table shows an overview of the participants: age, gender, educational background (lower-secondary school, upper-secondary school or university), profession, time past onset (years), localisation of brain damage, aphasia type and hand(s) used for typing

	Age (years)	Gender	Education	Profession	Time past onset (years)	Locali-sation of damage	Aphasia type	Hand(s) used for typing
Anders	53	Male	Upper-secondary school	Office worker	5	L. fronto-temporo-parietal lobe	Broca's	R+L, L for mouse
Bo	59	Male	Lower-secondary school	Office worker	17	L. frontal lobe, L. superior part partial lobe, L. perisylvian region	Broca's	L
Carol	56	Female	University	Teacher	4	Large intracerebral haemorrhage in the left hemisphere with a break-through to the ventricles, causing a 1 cm midline displacement	Mixed non-fluent	L

Table 1. The A-group, Studies I, II and III. The table shows an overview of the participants in the A-group: age, gender, educational background (lower-secondary school, upper-secondary school or university), profession, time past onset (months), localisation of brain damage, aphasia type and hand(s) used for typing

Partici-pant	Age	Gen der	Education	Profession	Time post onset (months)	Localisation of brain damage	Aphasia type	Severity	Hand(s) used for typing
AA	50	M	University	Engineer	10	L. capsula interna	Mixed fluent	Mild	L+R
AB	59	M	University	Engineer	12	L. parieto-temporal lobe	Anomic/semantic	Mild	L+R
AC	58	M	University	Engineer	36	L. arteria cerebri media	Transcortical motor	Mild-moderate	L
AD	63	M	University	Teacher	6	L. thalamus	Wernicke's	Moderate	L+R
AE	53	F	Lower-secondary school	Secretary	100	L. fronto-parietal lobe, cortical and subcortical areas	Transcortical sensory /anomic	Mild-moderate	L
AF	49	F	Upper-secondary school	Secretary	72	L. arteria cerebri media, subcortical areas	Wernicke's→afferent motor	Mild	L+R
AG	33	M	Upper-secondary school	Mechanic	15	L. central basal ganglia	Wernicke's	Mild-moderate	L
AH	28	M	University	Student	39	Contusions haematoma + L. arteria cerebri media infarct	Broca's	Mild-moderate	L

Procedure

Studies I, II and III

The participants in the A-group and the R-group produced two narratives. The first one, entitled 'I have never been so afraid', was a free narration. The second, 'Frog Story', was a picture-elicitation task. The 'Frog Story' is based on a children's book, *Frog, where are you?* (Mercer & Meyer, 1969), which has been used for various research purposes, e.g. cross-linguistic studies (Berman & Slobin, 1994), studies of young peoples' narratives (Coggins et al., 1998) and narratives produced by dyslexic writers (Wengelin, 2002). The texts were written on a Macintosh computer, using the software *ScriptLog* (Strömquist & Karlsson, 2002) for key-stroke logging. For the 'Frog Story' task, the 24 pictures from *Frog, where are you?* were presented one by one in chronological order on the screen. The text produced by the participants was shown below the picture; they switched to the next picture by pressing the Enter key. For more details, see Behrns, Ahlsén & Wengelin (submitted) and Behrns, Ahlsén & Wengelin (2008).

'I have never been so afraid' was produced first in a written version and then also in a spoken version. The participants were videotaped during the narrative task and the narratives were subsequently transcribed using the Modified Standard Orthography 5 (MSO5) (Nivre, 1999). Orthographic transcriptions were made, where homonyms were coded for different meanings. For more details, see Behrns, Hartelius, Wengelin & Olsson (submitted).

'I have never been so afraid' was used as the main source of information; it was used for describing characteristics of text writing (Study I), for comparison of spoken and written narratives (Study II) and for the analysis of the revision phase (Study III). The 'Frog Story' was used together with 'I have never been so afraid' for the majority of the analyses in Study I. The 'Frog Story' was used alone for one analysis of narrative structure (Coggins et al., 1998) in Study I. In addition to the measurement of various variables in the texts, a holistic assessment was made of the written and spoken versions (only audio recordings were presented to the raters) of 'I have never been so afraid' (Study II). A group of individuals without earlier experience of aphasia read and listened to the written and spoken versions of the stories (from both groups), rating them on scales based on bipolar adjectives inspired by the 'semantic differential scale' used by Osgood (1962), e.g. 'I think this is a *bad/good* story', using a 100 mm Visual Analogue Scale (VAS). The choice of adjectives was based on a study of participants' impressions after reading 'I have never been so afraid' narratives (Olness, Ulatowska, Carpenter, Williams-Hubbard & Dykes, 2005; Davidsson & Holmström, 2007). For a detailed description of the ratings, see Behrns, Hartelius, Wengelin & Olsson (submitted).

Study IV

Design. A single-subject design is suitable for the study of treatment effects where large, well-defined homogenous groups do not exist (Backman, Harris, Chisholm & Monette,

1997; Todman & Dugard, 2001, 2007; Beeson & Robey, 2006; Thompson, 2006). The present study used a single-subject ABA design replicated across three participants. The baseline (A) was established by measuring the dependent variables on four occasions prior to the start of therapy. During the intervention phase (B), the dependent variables were measured on ten occasions. A follow-up (A) was made ten months after the end of the intervention phase and included measurement of all dependent variables.

Training. The writing aids used were originally designed for dyslexic writers. Their programming included sophisticated statistics of common misspellings in Swedish and phonotactic rules, making it possible for them to 'guess' what the user was trying to write. The two different aids used were a word-prediction program, *Saida*® (Oribi AB), and a spell-checker, *Stava Rätt*® (Oribi AB). The duration of treatment was nine weeks, with two weekly sessions. The first four sessions were individual and the remaining ones took place in a writing group. The treatment consisted of instructions and practice in the use of the writing aids chosen. The writing task set was to describe pictures from books chosen by the participants. The participants used Microsoft® Word 2003 together with the writing aids. Software for key-stroke logging, *ScriptLog* (Strömquist & Karlsson, 2002), was used to collect and analyse data.

Evaluation. The participants were asked to write a diary note *with* the writing aids once a week and one *without* the aids every four weeks. The dependent variables, which were chosen after the analysis of the results from Study III, were the following: total number of words in the final text; proportion of correctly written words; words per minute; and proportion of edits resulting in a correctly written word (successful edits).

Short interview

All participants with aphasia took part in an interview about their writing habits and writing ability, their compensatory strategies and any writing aids they used. Participants AA–AH (Studies I–III) were asked if they had any expectations of computerised writing aids. Anders, Bo and Carol (Study IV) were also asked about their writing habits before and after the training they received. Notes were taken during the interviews. The interviews were also video-recorded; the recordings were used if there was any uncertainty about the participants' answers.

Summary

Several analyses were performed in Studies I, II, III and IV. See Table 3 for an overview of the different analyses, including information about in what studies they were used and where the results are presented.

Table 3. Analyses and results, explanations and information as to in what study they were used and where the results are presented

Variable		Explanation	Study No
Productivity	Word total	Word total in the final text, as it looked when the writer had finished it	I, II, III, IV
Production rate	Words per minute	Word total divided by total time spent on the writing task	III, IV
Errors	Spelling errors and morphological errors	An instance of a word that is not written according to spelling rules and/or contains a morphological error	I, II
	Word-level errors	An instance of a word that is incorrectly written or incorrect in context even though it is correctly spelled	III, IV
	Features affecting word-level errors or edits	Position in word Open-class or closed-class word Word length Frequency Position in sentence	I, III I, III III III III
	Semantic substitutions, neologisms and substitutions of function words		I, II
Lexical measures	Lexical density	The proportion of open-class words	I, II
	Lexical diversity	Based on a 'theoretical vocabulary' allowing texts of varying length to be analysed (Grönquist, 2000)	I, II
Syntactic measures	Words per T-unit	A T-unit is defined as a main (i.e. independent) clause plus any clauses subordinate to it (Hunt, 1970, cited in Wolfe-Quintero, Inagaki & Kim, 1998)	I, II
	Clauses per T-unit		I, II
	Description of individual syntactic ability and types of subordinate clauses		I
Narrative measures	Text structure and coherence	Analysis according to Coggins et al. (1998)	I
	Holistic assessment by ratings	Persons with no earlier experience of aphasia filled out a questionnaire after reading/listening to the stories	II
Revision phase	Proportion of deleted keystrokes	The proportion of total keystrokes that were deleted during the writing process	III
	Proportion of edited words	The proportion of words (relative to word total in the finished text) that were edited	III
	Successful edit	An editing operation resulting in a correctly written word	III, IV
	Failed edit	An editing operation resulting in an incorrectly written word	III, IV
	Strategy for edits	Only one strategy is presented: trial and error where the writer tries out several options	III
Subjective reflections on writing	Findings from interviews with the participants about their writing ability		Results presented here

Statistics

Study I

The texts were analysed for the different variables and the results were compared between the two groups. The Mann-Whitney U-test was used and the level for rejection of the null hypothesis was set at $p < 0.05$. Descriptive statistics only were used for semantic substitutions, neologisms and substitutions of function words. The individual syntactic characteristics of the stories written by the A-group were analysed qualitatively. To test reliability, 33 per cent of the corpus was analysed for word-level errors by a second person. Point-by-point agreement was 90.4 per cent for word-level errors (whether a word was correctly written or not) and 92.8 per cent for position in word (whether the error was in the word stem or in the affix). Point-by-point agreement was 88 per cent for all ratings concerning text structure and 93 per cent for all ratings concerning coherence.

Study II

To analyse overall main and interaction effects of group (aphasia and reference) and modality (written and spoken), a two-way ANOVA test was used. An overall main effect of group means that the difference found in the results can be explained by the fact that the stories were told by the A-group or the R-group. An overall main effect of modality means that the difference in the results can be explained by the story being spoken or written. An interaction effect means that the results for spoken and written language point in different directions for the two groups. When there is no interaction effect, results for spoken and written language do not point in different directions for the two groups. Multiple linear regression analysis was used to see how well the measured variables could explain the variance of the outcome of the qualitative ratings. Results where the adjusted R-square was 0.30 or less were not further analysed.The level for rejection of the null hypothesis was set at $p < 0.05$. An independent t-test was used for control across raters (the stories produced by one of the participants in the A-group were rated by all raters and under all conditions (i.e. written or spoken story first).

Study III

The Mann-Whitney U-test was used to compare the results of the two groups. Stepwise discriminant analysis was used for the analysis of factors influencing edit results (i.e. whether an edit resulted in a correctly written word or not). The level for rejection of the null hypothesis was set at $p < 0.05$.

Study IV

Results from the continual recordings of the four dependent variables were analysed by visual inspection of the graphs and supplemented by statistics derived from the calculation of effect sizes (Kromrey & Foster-Johnson, 1996; Beeson & Robey, 2006; Bergström, 2007) and time-series analyses using C-statistics (Tryon, 1982; Jones, 2003, 2006). In the analysis of results for effect size, small, medium and large effect sizes

correspond to a *d*-index of 2.6, 3.9 and 5.8, respectively (Beeson & Egnor, 2006; Beeson & Robey, 2006). The time series were checked for autocorrelation, but no autocorrelation was found in the data. The level for rejection of the null hypothesis was set at $p < 0.05$. To test reliability, an experienced speech and language pathologist performed an analysis of correctly written words; point-by-point agreement was 94 per cent.

Analysis of the short interviews

The notes from the short interviews were checked with the video-recordings if necessary. First, the participants' answers to each question were listed individually, using the participants own expressions. Second, the most essential parts of the answers were marked and presented in a table (Table 10). The questions about writing habits (when and how writing was used) were asked before and after the training (study IV) and the answers were compared to identify changes reflecting functional writing for these three participants. One of the participants (Carol) chose to ask her husband to join her during the interview and his answers were analysed together with the answers given by Carol. Finally, answers with similar content were grouped together and presented in a summary of results.

Ethical considerations

The studies were approved by the Regional Ethics Committee in Gothenburg and were thus performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Results

Study I

The participants in the A-group produced significantly shorter narratives with significantly more spelling errors and morphological errors. The texts written by the A-group had less complex syntactic structure than the texts written by the R-group. Open-class words were significantly more affected by errors than closed-class words in the A-group, but not in the R-group. There was a significant difference in the proportion of errors affecting the word stem compared with the affix for both groups However, lexical density seemed less affected by aphasia. Further, text structure and coherence were affected in the A-group's texts. See Table 4. For more details, see Behrns, Ahlsén & Wengelin (submitted). For individual results, see Table 9.

Table 4. Results from the analysis of the texts 'I have never been so afraid' and 'Frog Story', A-group and R-group. Mean values and standard deviations for the parameters analysed

		A-group		R-group	
		M	SD	M	SD
Productivity	Word total	434.4*	272.4	1,103	599.6
Spelling errors and morphological errors		3.2 *	2.6	0.6	0.5
Vocabulary measures	Lexical density	47.1%	5.4%	47.9%	4.9%
	Lexical diversity, 'I have never been so afraid' (Vocab, 50)	106.0	43.3	222.2	53.2
	Lexical diversity, 'Frog Story' (Vocab, 150)	156.5**	83.8	316.9	118.0
Syntactic measures	Words per T-unit	7.5*	2.4	11.2	1.9
	Clauses per T-unit	1.2**	0.3	1.6	0.3
Narrative measures	Text structure	3.5**	2.0	5.9	0.3
	Coherence	13.5*	6.2	20.7	2.2

Both texts were analysed together, except as regards lexical diversity. Only the 'Frog Story' was analysed for narrative complexity. * $p < 0.05$, two-tailed test; ** $p < 0.01$, two-tailed test.

Study II

Measured variables

In general, the written versions (of both groups) were shorter and had higher lexical density and more words and clauses per T-unit than the spoken versions (i.e. a significant overall main effect of modality). Further, the A-group wrote texts with significantly fewer words per T-unit than the R-group. The results for clauses per T-unit in written and spoken versions pointed in different directions for the two groups (i.e. a significant interaction effect), and the difference between the two modalities was larger for the A-group than for the R-group. See Table 5. For more details, see Behrns, Hartelius, Wengelin & Olsson (submitted). For individual results, see Table 9.

Table 5. Measured and rated variables, A-group and R-group. The table shows results for the measured and rated variables. The asterisks indicate significant effects of modality and group as well as interaction effects

	Variable	Significant overall main effect of modality	Significant overall main effect of group	Significant interaction effect
Measured variables	Word total	*		
	Lexical density	**		
	Lexical diversity			
	Words per T-unit	**	**	
	Clauses per T-unit	**	*	**
Rated variables	Difficult/easy to understand		**	**
	Not interesting/interesting		**	
	Bad/good		**	
	Inadequate/adequate choices of words	**	**	
	Incoherent/coherent	*	**	*
	The narrator seems to dislike/like telling the story		**	**

* $p < 0.05$, two-tailed test; ** $p < 0.01$, two-tailed test.

Rated variables

The R-group's narratives (spoken and written versions) were rated significantly higher for all variables than those of the A-group (i.e. a significant overall main effect of group). Vocabulary was generally rated as less adequate in the written versions than in the spoken ones (for both groups) but the written ones were rated as more coherent (i.e. a significant overall main effect of modality). The A-group's written versions were rated as easier to understand and also as told by a narrator who enjoyed telling stories less, compared with their spoken versions. By contrast, the ratings for the R-group concerning these two variables showed the opposite pattern (i.e. a significant interaction effect). Both groups' written versions were rated as more coherent than their spoken versions, but the A-group's written stories were rated as more coherent than their spoken versions with a larger difference between the two versions, than for the R-group (i.e. a significant interaction effect). See Table 5. For more details, see Behrns, Hartelius, Wengelin & Olsson (submitted). For individual results, see Table 9.

Individual results, A-group, 'difficult/easy to understand' and 'incoherent/coherent'

Figures 1 and 2 show individual differences (not presented in the article). The ratings for the two variables 'difficult/easy to understand' and 'incoherent/coherent' were higher for the written versions of AC, AF, AG and AH. The spoken versions were rated higher for both variables for AA, AB and AE. The results for AD show that the rating for 'difficult/easy to understand' for his spoken version was higher than that for his written version whereas the ratings for 'incoherent/coherent' showed the opposite pattern. (These results were not presented in the article.)

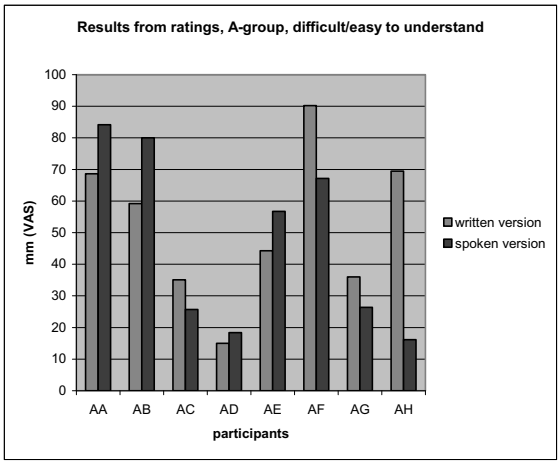

Figure 1. Ratings for 'difficult/easy to understand' for each participant in the A-group

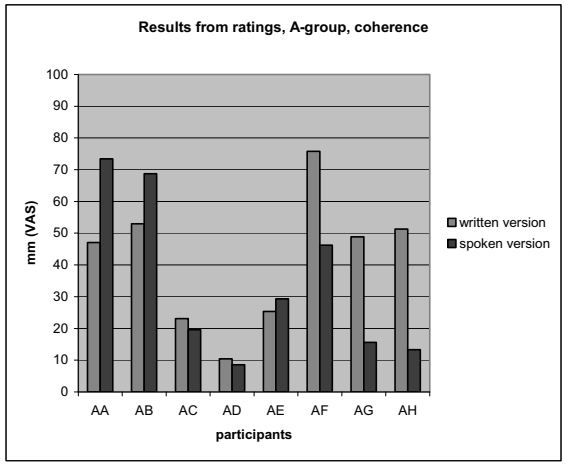

Figure 2. Ratings for 'incoherent/coherent' for each participant in the A-group

Regression analysis

The model for written stories (word total, lexical density, clauses per T-unit, word-level errors) could explain at least 30 per cent of the variance of the ratings for 'difficult/easy to understand', 'inadequate/adequate choices of words', 'incoherent/coherent' and 'the narrator seems to dislike/like telling the story' for the A-group. The model for spoken stories (word total, lexical density, clauses per T-unit) could explain at least 30 per cent of the variance of the ratings for 'difficult/easy to understand', 'inadequate/adequate choices of words' and 'incoherent/coherent' for the A-group. 'Incoherent/coherent' for the spoken stories was the rating best predicted by the measured variables, with more complex syntax and a high lexical density predicting higher ratings (i.e. more coherent stories). The model for spoken language explained the variance to a larger degree than the model for written language. For the R-group, neither model could explain at least 30 per cent of the variance of any rating. See Table 6. For more details, see Behrns, Hartelius, Wengelin & Olsson (submitted).

Table 6. Results from regression analysis. The table shows the variables that made significant unique contributions to the models, indicating whether the correlation was positive or negative

	Model, written versions					Model, spoken versions			
	R2	Word total	Lexical density	Clauses per T-unit	Word-level errors	R2	Word total	Lexical density	Clauses per T-unit
Difficult/ easy to understand	0.393	- **		**	- *	0.435	**	**	**
Inadequate/ adequate choices of words	0.372	- **	- **	**	**	0.336	*	*	**
Incoherent/ coherent	0.307	- **		**	- **	0.499		**	**
The narrator seems to dislike/like telling the story	0.412	**	**	**	**				

* $p < 0.05$; ** $p < 0.01$; - negative correlation (i.e. lower results for a measured variable predicted higher ratings)

Study III

The results showed that the A-group had a significantly lower production rate than the R-group and that the participants in the A-group had significantly less active typing time. Further, there was no significant difference in the proportion of key strokes left in the final text, meaning that both groups of participants deleted similar proportions when writing the stories. However, the A-group made edits only at the word level but the R-group also made edits where larger units, such as sentences and paragraphs, were changed, moved or deleted. The A-group used significantly more 'trial and error', testing several alternative spellings before deciding on the final version, and more of their edits did not result in a correctly written word (without significant differences between the groups, however). Further, the results showed that any word in any position might be edited, but chances were better for an edit to be successful when the error was in the word

stem rather than in the affix (Behrns, Ahlsén & Wengelin, 2008). See Table 7 for comparisons between the two groups. For individual results, see Table 9.

Table 7. Production rate, active typing time, revisions and types of revisions made by the A-group and the R-group

	A-group M (SD)	R-group M (SD)
Words per minute	4.5 (1.3)**	18.1 (9.0)
Active typing time (%)	33 (13.4)*	55 (17.9)
Proportion of keystrokes left in the final text (%)	82 (13.4)	93 (17.9)
Proportion of words edited (%)	12.5 (7.5)*	6.3 (2.9)
Proportion of unsuccessfully edited words (%)	1.9 (2.5)	0.2 (3)
Proportion of edits made using a 'trial and error' strategy (%)	13.8 (17.5)*	7.3 (15.4)

An unsuccessfully edited word is a case where a word was changed and the outcome was a new incorrectly written word.

Study IV

A summary of the results shows that after the training, improvement was found in the word total for Carol and to a lesser extent for Bo, in the proportion of correctly written words for Carol, and in successful edits (resulting in correctly written words) for Anders and Carol (and perhaps for Bo). There was also a qualitative change in the written data for all three participants. See Table 8 for a summary of the results. For more details, see Behrns, Hartelius & Wengelin (in press).

Table 8. Summary of results for the three participants: answers to the question, 'Did the training lead to an improvement in the variable of …?'

	Word total	Correctly written words	Words per minute	Successful edits	Qualitative change
Anders	No	No	No	Yes	Yes
Bo	Yes? (A)	No	No	Yes? (B)	Yes
Carol	Yes	Yes	No	Yes	Yes

'Yes' means that an increase was visually identifiable as well as supported by a positive *d*-index and a significant change of trend. (A): *d*-index = 3.23 but no significant change of trend; (B): *d*-index = 2.10 but no significant change of trend.

Individual results, Studies I–III

Table 9 shows that all of the individual results for each participant tend to be on the same level, revealing patterns of writing performance which are *generally high* (AB), *moderate-to-high* (AF and AH), *moderate-to-low* (AA and AG) or *generally low* (AC, AD,AE).

AB had a *generally high writing performance*. Comparison of his results shows that spelling errors and morphological errors were his main concerns, even though he was usually able to correct them. He wrote the longest stories in the A-group, with long T-units containing several subordinate clauses, few omitted words and no semantic substitutions. His text in the picture-elicitation task had a good overall structure, and his free narrations were rated as coherent and easy to understand (even though he did not obtain the highest rating in the group). Even so, his spoken versions were rated higher than his written ones concerning coherence and how easy they were to understand.

AF and AH had a *moderate-to-high writing performance*. They produced texts of different length (AH's texts were longer than AF's, whose stories were the shortest in the group), but their overall results were similar although not as good as those of AB. They both used several subordinate clauses in their texts and made no, or only few, semantic substitutions and omissions of words. They made some errors during writing, and AH also had difficulty correcting them. Their text structure and coherence in the picture-elicitation task appeared to be slightly influenced by their aphasia, but their free narrations were rated as coherent and easy to understand (AF's story received the highest ratings in the group). Their written versions were rated as even more coherent and easier to understand than their spoken versions of the story.

AA and AG had a *moderate-to-low writing performance* and wrote short stories with very few word-level errors, semantic substitutions or omissions of words. However, they used short T-units with few subordinate clauses and had low lexical diversity. AG's picture-elicitation task had a better text structure and better coherence than AA's. Their stories were rated as coherent, but AA's story was rated as easier to understand than AG's. AA's spoken version of the story was rated as less coherent and more difficult to understand than his written version, whereas the ratings for AG showed the opposite pattern.

AC, AD and AE had a *generally low writing performance*, with a high proportion of word-level errors and a high proportion of edits that did not result in correctly written words. They all made several semantic substitutions, and words were often omitted. Except for AC, they produced short T-units with few subordinate clauses and had difficulty writing coherent stories; their stories were also rated as difficult to understand. However, AC and AD wrote fairly long stories, AD and AE had a high lexical density, and AD had a high lexical diversity. AD was the participant who had the most extensive writing difficulties, but a look at his results indicates that spelling was comparably lightly affected. The ratings show that AC's written version was rated as easier to understand and more coherent than his spoken one while AE's spoken version was rated higher than her written one. AD's written version was rated as more coherent but more difficult to understand than her spoken one.

Table 9. Overview, individual results, A-group, Studies I, II and III. The table shows results from most of the analyses together with the mean values and standard deviations for the group

	M (SD)	AA	AB	AC	AD	AE	AF	AG	AH
Words per minute ('I have never…')	4.5 (1.3)	6.24	**4.2**	**2.45**	5.35	**4.4**	7	**2.35**	5.58
Word total	434 (272.36)	**284**	1053	470	469	**321**	**201**	**225**	452
Word-level errors	3.2 (2.6)	0.2	2.9	**6.2**	**4.0**	**7.2**	3.0	0.4	2.3
Proportion of failed edits ('I have never…')	1.9 (2.5)	0	0.6	**6.4**	**2**	**5**	0	0	1.2
Semantic substitutions		1	0	3	13	4	2	0	0
Omissions of words		0	P (1), S(1)	P (2), S (3), F (7)	S (6), P(13), F (2), ? (13)	P (1), S (2), F (2)	F (1)	P (1)	? (1), word order (1)
Lexical density	47.1 (5.4)	49.6	**43.8**	**42.3**	48.6	48.5	**43.4**	**42.7**	48.0
Lexical diversity	156.5 (83.8)	**92**	348	**137**	193	**116**	**100**	**115**	**151**
Words per T-unit	7.5 (2.3)	**7.3**	10.1	7.7	**4.1**	**6.8**	**6.1**	**4.7**	**5.0**
Clauses per T-unit	1.23 (0.31)	**1.02**	1.58	**1.14**	**1.01**	**1.08**	1.27	**1.04**	1.80
Text structure ('Frog Story')	3.5 (2.0)	**2**	6	**3**	**0**	**2**	4	5	4
Coherence ('Frog Story')	13.5 (6.2)	**12**	24	**11**	**4**	**8**	17	14	18
Incoherent/coherent, ratings ('I have never…')	41 (33)	47	53	**35**	**10**	**25**	76	49	51
Difficult/easy to understand, ratings ('I have never…')	53 (34)	69	60	**23**	**15**	**44**	90	**36**	69

Bold numbers = below the mean for the group (except for word-level errors and proportion of failed edits, where it means above the mean for the group); P = predicate, S = subject, F = function word, ? = missing word that cannot be classified.

Short interviews

The participants' answers are presented individually in Table 10.

Summary of interviews

The participants described how:

- writing and reading were previously used for work and meant joy and pleasure;
- writing is now difficult and used mostly for training;
- memory limitations and fatigue influence reading negatively;
- their writing difficulties include problems planning what to write;
- their writing difficulties include problems identifying errors and spelling correctly, but also problems in relation to syntax;
- a computer may compensate for some of the writing difficulties, especially for motor disabilities and during revision, but instructions and regular training are needed;
- a computer may compensate for some of the reading difficulties, for example by the possibility to make larger font size;
- improved writing ability from training on a word processor has a positive effect on functional writing.

Table 10. Findings from short interviews about writing ability, all participants with aphasia

	Reading and writing habits before illness	Reading and writing habits at present	Reading and writing aids used	Expectations of computerised aids for reading and writing
AA	Used to read and write daily in his job. Used to have confidence in his own writing ability.	Writes daily in a diary, uses a word processor. Uses written communication with authorities. Difficult to identify misspellings, especially omissions and double/single consonant. Writes more than he reads. Reads half a page at most, difficult to understand and to remember.	Has a computer. Word processor is good for making edits.	Spelling aid. Speech synthesiser supports his reading in that he can listen to the text.
AB	Used to read and write daily in his job. Used to write information for the public. Used to read much – fiction as well as for his job.	Tries to write daily, hard to find motivation. Problems finding the right word, difficult to make corrections. Reading is 'a source of despair', takes too long, difficult to draw conclusions. Reads only occasionally, newspapers, no books.	Has a computer (did so even before illness). Prefers electronic magazines: can change size of fonts, etc.	Speech synthesizer as writing aid but also to read electronic information on the computer.
AC	Used to read and write daily in his job.	Was initially not able to write but could read. Writes every day. Difficulty to write owing to motor deficits. Spelling difficult, identifies spelling errors but is not able to correct them. Uses a strategy of trial and error. Good reading ability.	Uses PC and word prediction.	Finds that his existing computer-based aids work very well.
AD	Used to read and write in his job and in his spare time.	Writes 'memory notes'. Problems finding the right word but can write simple, short words. Reads headlines in newspapers. Re-reads old books.	No.	Does not know.
AE	Used to read and write daily in her job. Used writing for private purposes, like letter writing. Not very interested in reading books.	Writes in her diary every day. Poor reading and writing ability initially. Prefers books with large fonts.	Tried a computer, would prefer that to writing by hand (with a pen): easier to make edits. Prefers large fonts for reading.	Compensation for motor disability and spelling problems.
AF	Used to read and write daily in her job. Reading was her main interest, used to read two books a week.	Was initially not able to write at all. Poor reading ability. Now writes and reads only for training; takes too long. Still writes better than she speaks. Used to compose a sentence 'in her mind' before writing it, visualised the words. Word endings difficult.	Tried a computer, did not compensate for her problems, just as difficult as writing with a pen.	Grammatical support. Spell-checking.
AG	Used to read the daily newspaper, no books. Did not write much.	Was initially not able to read or write. Poor writing ability, writes letters reversed. Poor reading ability. Words and letters get mixed up, difficult to remember what he just read, problems grasping the meaning of a text.	Has tried a computer. Needs to search for the letters on the keyboard. Does not have any compensatory strategies for reading or writing.	Difficulty formulating an answer about aids.
AH	Used to read and write daily as a university student.	Mixes up many letters when writing with a pen. Prefers using the computer as compensation for motor disability. Word processor facilitates edits. Reading ability almost as before the illness, but he becomes tired more quickly.	Uses a Macintosh computer. Initially a prediction program but does not need it any more. Does not use existing spelling support.	Suggestions for how to start a sentence.

	Reading and writing habits before illness	Reading and writing habits at present	Reading and writing aids used	Writing ability after the intervention
Anders	Used to read and write daily in his job. Spent much time reading in his spare time.	Reports that he avoids writing. Reads the newspaper daily. Uses a fax with prepared messages for Augmentative and Alternative Communication (AAC).	Used a word-prediction program during the intervention described in this study.	Enjoys writing more; had, for example, started to write words on the blackboard when assisting communication training at the local aphasia association. At the follow-up he described how he had continued to use the writing aid on his own. He practised writing by copying poems by his favourite author.
Bo	Used to read and write only rarely.	Reading ability at the start of the study was 'OK' and he read daily in his job, where he also used a computer regularly. Writing ability was still very limited.	Had ways to compensate for the impairment. Had some functional writing strategies, e.g. he answered e-mails by pasting words from the incoming message into his replies.	Started to generate words on his own when answering e-mails by using the word-prediction program. Had not continued to use word prediction at follow-up – too time-consuming – and was able to compensate by using the word processor's functions to edit the text.
Carol	Used to read and write daily in her job before the illness; reading used to be a main interest in her spare time.	At the start of the study she wrote and read only rarely and had no functional writing ability.		Her husband reported how she was more independent in solving crossword puzzles and had also started to write shopping lists

Summary of results, comparisons between the A-group and the R-group

In Studies I–III, a number of analyses were performed where the A-group was compared with the R-group. Both groups have a limited number of participants, who differ in age and background (see also the section entitled 'Limitations'), and therefore all results have to be interpreted with caution. Table 11 summarises the results for the two groups. There were differences between the groups, but also similarities in global language structure and in the relationship between written and spoken language:

- The A-group had a very low production rate in writing compared with the R-group and also made proportionally more word-level errors;
- The participants in the A-group wrote the 'Frog Story' in a way that was less coherent and had less good text structure than the R-group, but they did include the most essential parts of the story;
- 'I have never been so afraid' did not differ in story length between the two groups, but there was a difference if the 'Frog Story' was included;
- Lexical density and lexical diversity did not differ significantly between the two groups; both of them had higher lexical density in written language;
- The A-group had less complex syntax than the R-group, but both groups had more complex syntax in written than in spoken language;
- The R-group's stories were generally rated higher than the A-group's stories. However, both groups' written versions were rated as more coherent than their spoken versions, and both groups' spoken versions were rated as having more adequate choices of words than their written versions. Ratings for the two modalities pointed in different directions for the two groups as regards how easy the stories were to understand and whether the narrator seemed to like story-telling;
- The results from the regression analysis show that the measured variables could predict (to some extent) seven of the rated variables in spoken and written language for the A-group, but none of the rated variables for the R-group;
- The two groups deleted the same proportion of keystrokes during the writing process. However, the A-group's edits were made on word level only, more often followed a trial-and-error approach and more often resulted in an incorrectly written word in the final text.

Table 11. Summary of results, comparison between the A-group and the R-group

The A-group differed from the R-group in …	**But the A-group had similar results to the R-group in …**
Lower *production rate* (W)	
More *word-level errors* (W)	Errors usually affected the *word stem* (W)
Lower results for *coherence* and *text structure* (analytical approach, 'Frog Story') (W)	The *most essential parts of the story* were included in the narratives (W)
Story length, picture-elicitation task (W)	*Story length*, free narration (W, S)
	Longer stories in spoken language than in written language (W, S)
	Lexical density (W, S)
	Higher lexical density in written language than in spoken language (W, S)
	Lexical diversity (W, S)
Less complex syntax (W, S)	*More complex syntax in written language* than in spoken language (W, S)
Lower ratings in general in the holistic assessment (W, S)	
	Written versions more coherent than spoken ones (W, S)
	Spoken vocabulary more adequate than written vocabulary (W, S)
Written versions easier to understand than spoken ones for the A-group, opposite pattern for the R-group	
Speaking narrators rated as enjoying story-telling more than writing narrators in the A-group, opposite pattern for the R-group	
The measured variables predicted the variance of seven of the rated variables for the A-group's stories, none for the R-group's stories	
	Delete the same proportion of keystrokes during writing (W)
Edits concerned word level *only* (W)	
Try out *several options* when making an edit (W)	
Sometimes the edit *results in a not correctly written word* in the final text (W)	

(W) = the analysis was made only for written language; (W, S) = the analysis was made for both written and spoken language

Discussion

Error analysis, word-level errors in writing

Since all participants in the A-group had reported spelling difficulties in their interviews, it was surprising how few spelling errors and morphological errors there actually were in the final texts. Even so, their texts had proportionally more incorrectly written words than those of the R-group. Both groups' errors usually affected the word stem rather than the affix. Function words were less affected than content words in the A-group's texts – implying that different processes are used for writing entire texts than for writing words in isolation, in accordance with Silverberg, Vigliocco, Insalaco & Garrett, (1998). There were not many semantic substitutions or neologisms in the texts written by the A-group. AA and AC produced one semantic substitution each, AF produced two and AD produced the rest of the A-group's semantic substitutions and neologisms. The analysis of semantic involvement in text writing, especially in a free narration, is different from a naming task where the target word is known. Results in a naming task have been found to be different from semantic performance in a (spoken) narrative (e.g. Ahlsén, 1985). In a free narration, an instance of a word may very well be a semantic substitution but not recognised as such by the researcher, and in a free narration it is also possible for the narrator to avoid certain words, thereby not revealing difficulties with e.g. semantics.

Vocabulary and syntax in written language and compared with spoken language

The results showed that the participants had difficulties with vocabulary and syntax, but several overall structures seemed not to be affected by their aphasia to the same degree. There was no significant difference between the two groups in written-story length nor in the proportion of different parts of speech or in lexical diversity as regards 'I have never been so afraid'. However, significant differences in story length and lexical diversity were found when 'I have never been so afraid' was analysed together with the 'Frog Story'. This finding may be related to the earlier discussion about the degree of semantic involvement in different tasks, but it may also indicate that a narrative task within a more fixed framework, such as the story-elicitation task, was more demanding than the free narration in these respects. Ulatowska et al. (2001) compared story length in a free narration, using the same task ('I have never been so afraid'), and found no difference between participants with aphasia and a reference group. That study was based on spoken language, but it indicates that a free narration generates similar story length for participants with and without aphasia.

As regards the comparison between the written and spoken versions, both groups produced overall shorter written than spoken versions but there was no difference in lexical diversity between the two modalities. Both groups' written versions had a higher proportion of content words, which is in line with the findings from a comparison of the frequency of parts of speech in written and spoken Swedish by Allwood (1998).

The participants in the A-group wrote texts with significantly less complex syntax than those in the R-group. Their written narratives were usually constructed of short T-units with no or only few subordinate clauses. AC, AD and AE had instances of incomplete clauses in their texts where words had been omitted.

As regards the comparison between the written and spoken versions, both groups had a more complex syntax in their written versions than in their spoken ones. Such a difference in syntactical complexity is also reported by Catts and Kamhi (2005) on general differences across the two modalities as well as by Ulatowska et al. (1978, 1984) from a study of participants with aphasia.

Coherence and text structure in written language: analytical assessment

The method to assess coherence and text structure was taken from Coggins et al. (1998) and was originally intended for analysing the spoken language of adolescents with Fetal Alcohol Syndrome (FAS). It turned out to be a useful tool also in the assessment of written language produced by participants with aphasia. The analysis of (spoken) discourse structure is often a time-consuming task and is difficult to carry out in a clinical setting (Armstrong, Brady, Mackenzie & Norrie, 2007), but this protocol is in fact suitable for use by clinicians. The A-group's (written) 'Frog Stories' had significantly poorer text structure and coherence than the R-group's ones. Even so, the parts of the story that are the most essential for the reader – the start of the story, where the characters are introduced and the plot is set out, and the end of it, with the punchline – were always included. The reason why the A-group received lower scores for coherence was not that they provided incorrect information about what was happening in the pictures, but rather that their descriptions were vague and incomplete. This was sometimes due to semantic substitutions, but more often to a failure to provide enough information, e.g. by only describing who was in the picture but not what was actually happening (*det är pojken, getingarna och en uggla på bilden* ['the boy, the wasps and an owl are in the picture'] – AA about Picture 12, where the boy is falling out of a tree, chased by an owl, and the dog is being chased by wasps) or by only commenting on the pictures (*plask vad vått det är!* ['splash, how wet it is!'] – AE about Picture 19, where the boy and the dog fall into a pond). The analysis in the present study confirmed previous results for spoken narrative discourse (e.g. Ahlsén, 1985; Miceli et al., 1989; Saffran et al., 1989; Ferguson, 1994, 1996, 1998; Klippi, 1990; Laakso, 1997; Lock & Armstrong, 1997) as well as for written narrative discourse (Ulatowska et al., 1978; Ulatowska et al., 1984; Mortensen, 2005): narrative structure was reported to be good in spite of aphasia.

Holistic assessment, ratings by a group of individuals without earlier experience of aphasia, comparison between written and spoken language

A holistic assessment was made of the free narratives as a supplement to the analytical approach, to describe certain qualitative dimensions of language (Olness et al., 2005). The

results were also of special interest since the ratings were made by individuals who did not have any previous experience of aphasia. The results from the holistic assessment showed that the R-group's stories were generally rated higher than the stories told by the A-group. When comparing the results, however, it is important to note that there were large variations in the ratings for the R-group and that the mean values were about 50–85 mm (on the 100 mm VAS). The mean values for the A-group were 40–55 mm for the written stories and 30–55 for the spoken ones (Behrns, Hartelius, Wengelin & Olsson, submitted). This must be interpreted to mean that the A-group's stories were fairly easy to understand, interesting, good and coherent, with adequate vocabulary and told by someone who enjoyed story-telling. The different modalities had an effect on the ratings for coherence, where the written stories were rated as more coherent for both groups, which was in accordance with Ulatowska (1978), and the difference between written and spoken coherence was proportionally larger for the A-group's stories. The different modalities also had an effect on vocabulary, which was rated as more adequate in the spoken than the written versions for both groups. Still, modality seemed to have less impact on the ratings, implying that the general impressions of the stories were not mainly related to if they were told in spoken or written language. For the measured variables, however, the vocabulary and syntax of written language differ in certain respects from those of spoken language (Allwood, 1998; Catts & Kamhi, 2005). The A-group's written stories were rated as easier to understand than the spoken ones, while the results for the R-group showed the opposite pattern. The A-group's spoken versions were rated as being told by someone who enjoyed story-telling more than their written versions, while the ratings for the R-group showed the opposite pattern. In interpreting the results, individual differences among the story-tellers and the raters are of importance, but the question was also if the measured variables could predict any of the ratings.

Predicting the ratings

The measured variables could predict the ratings only to a small degree. In fact, these variables could explain some of the variance of some of the ratings for the stories told by the A-group but could not at all predict the ratings of the stories told by the R-group. 'Incoherent/coherent' for the spoken stories was the rating best predicted by the measured variables, with longer stories, more complex syntax and a high lexical density predicting higher ratings. The measured variables also predicted (to some extent) the ratings for 'difficult/easy to understand' (written and spoken versions), 'inadequate/adequate choices of words' (written and spoken versions), 'incoherent/coherent' (written and spoken versions) and 'the narrator seems to dislike/like telling the story' (written version only). Olness et al. (2005) reported that longer stories received higher ratings on a scale of good–bad than shorter stories. In this thesis, however, such results were not found: the ratings for 'bad/good' were not predicted by the measured variables. The explanation may relate to the use of different measures for length as well as to the data: Olness and co-workers based their analysis on spoken stories told by non-brain-damaged individuals. A further difference is that the ratings in that study were made on the basis of transcriptions of the narratives while raters in the present study had access to audio recordings. Further, the present study showed that more words, more complex syntax, higher lexical density and more word-level errors predicted higher ratings for 'the narrator seems to dislike/like telling the story'. Part of the explanation why more word-level errors would predict a

higher rating may be found in findings from focus-group discussions of written stories produced by participants with aphasia (Davidsson & Holmström, 2007), where a text with frequent word-level errors could be interpreted as written by someone who liked to tell stories but did not worry too much about making errors.

Regression analysis showed that the model for the written stories (word total, lexical density, clauses per T-unit and word level errors) could explain about 30–40 per cent of the variance of the ratings for 'difficult/easy to understand' and 'incoherent/coherent'. It also showed that shorter stories with lower lexical density, fewer word-level errors and more clauses per T-units predicted higher ratings. The model for the spoken stories could explain more of the variance for these variables (about 40–50 per cent), with longer stories, higher lexical density and more clauses per T-unit predicting higher ratings. These two variables were analysed for individual differences. Results showed that the written versions were easier to understand for AC, AF, AG and AH while the spoken versions were rated higher for AA, AB, AD and AE. The written versions were rated as more coherent for AC, AD, AF, AG and AH while the spoken versions were rated higher for AA, AB and AE. The measured variables could explain the variance of the ratings to some extent, but the differences in ratings for the written and spoken versions require further analysis. Even so, a few interesting observations can be made: The ratings for the participant who had a generally good writing performance (AB) were higher for his spoken than his written versions. The ratings for one of the participants with a generally low writing performance (AC) were higher for his written than his spoken versions on both variables. AD's written version was rated as easier to understand. For the participants in the present study, high ratings for spoken versions thus did not necessarily mean that ratings would be as high for the written versions, and low ratings for the written versions did not prevent better ratings for the spoken versions.

It is important to note, when evaluating the results for the participants in the A-group, that no participant in the R-group produced an ideal, completely correct story or narrative that was given top ratings across the board. There are some aspects of text writing that are probably not related to the language disorder at all, but rather to individual differences among writers. It is also important to keep in mind when interpreting the ratings that there are individual differences among readers, who may have different opinions about what constitutes a good text (Smidt, 1989). Better interpretation of the results of the comparisons would require closer analysis of the spoken versions, using more appropriate variables and tools. However, the focus in the study (as in the thesis as a whole) was on written language, and the variables used for comparison were chosen from that perspective.

The revision phase

The holistic assessment gave important information about readers' impressions of the written stories. The use of key-stroke logging makes it possible to draw conclusions about what constitutes problems for writers and what strategies they use. The A-group and R-group did not differ in how large a proportion of the key strokes they decided to delete during the writing process. These findings were similar to those reported in data from developmental dyslexia (Wengelin, 2002). However, the vast majority of edits made by

the participants with aphasia concerned the word level and were made at the time of entry (i.e. immediately after writing the problematic letter), and they made no edits concerning larger units such as sentences. The analysis of the revision phase indicates how writers move their focus during the writing process (Lindgren, 2005); the writers in the A-group seemed to have their main focus on the word level. Still, as has been mentioned earlier, the participants' final texts did not contain many errors, so the strategy of evaluating every word or even every letter was successful in that respect. The question is how other ongoing processes were affected by this focus on the word level and whether the less complex structure of their texts was to some extent related to processing constraints associated with their concentration on the word level. Previous findings have also shown that revision patterns are related to the development of writing skills in that a larger number of edits at clause boundaries (and not only at the time for entry) was associated with more advanced writing (Chanquoy, 2001).

The average production rate was three times lower for the A-group than for the R-group. One participant produced an average of slightly more than two words per minute; it is obvious that the writing task was hard work that required considerable persistence and patience. Motor deficits are probably one explanation for the low production rate. However, the analyses of edits revealed how the participants evaluated each word and sometimes each letter, thereafter having to decide if the letter or word was in accordance with their intended plan or not. Reading, evaluation and decision-making probably required a great deal of time and effort, and are also likely to have interrupted other ongoing processes. Making an edit took a long time. Making an edit by trying out several options took longer, and if the edit resulted in an incorrectly written word, the time was prolonged even more.

The earlier study of errors on the word level showed that the errors did not affect the affix to the same extent as the word stem, but the A-group had greater difficulty editing affixes, and errors made in affixes resulted more often in incorrectly written words in the final text. This may be interpreted as indicative of difficulties with processes where the context has to be taken into consideration. Automatic processing is a prerequisite for fluent, dynamic writing where the skilled writer can focus on communicative aspects (Chenoweth & Hayes, 2001; Schoonen et al., 2003). For the participants with aphasia in this study, the writing process was frequently interrupted by edits on the word level, which probably reduced the possibility of fluent writing.

Individual differences

The individual results from Studies I–III showed that the participants could be grouped into participants with a generally low writing performance, participants with a moderate writing performance and participants with a generally high writing performance.
AC, AD and AE had a generally low writing performance, with difficulties in relation to most of the analysed variables. Even so, AC's written versions were rated as easier to understand and more coherent than his spoken ones, and AD's written versions were rated as more coherent than his spoken ones. This shows that even if written language is heavily affected by aphasia, it can still be useful for interaction, sometimes even more so

than spoken language. AD made several word-level errors in his text, but this was not the main issue in the analysis of his writing ability.
AB had a high general writing performance with good results for the analysed variables, even though he committed a proportionally large number of word-level errors. It seems, then, that error analysis on the word level often but not always interacts with other dimensions of written language. Four of the participants had a generally moderate writing performance. Of these, AA and AG made almost no word-level errors in their texts while AF and AH produced more complex syntax and stories with better text structure and higher (analysed and rated) coherence. The written versions produced by AF, AG and AH were rated as easier to understand and more coherent than their spoken versions.
There was no obvious relationship between localisation of brain damage or aphasia type and writing performance. Severity seemed to be relevant as regards the participants at the two endpoints of the scale: AB, who had a high writing performance, had mild aphasia whereas AD, who had the greatest difficulties, had moderate aphasia. When interpreting the differences in ratings between spoken and written language, no obvious relationship was found between fluent and non-fluent aphasia types. AC and AH had aphasia types that usually include non-fluent speech and received higher ratings for their written versions. AA had a mixed fluent type and received higher ratings for the spoken modality. The other participants had aphasia types associated with fluent speech, but no obvious links could be found in the ratings. AB and AE produced highly rated versions in the spoken modality, AD did so for both modalities, and AF and AG received high ratings for their written versions.

Comparisons between the A-group and the R-group

The results showed that the R-group performed better and received a higher rating for the majority of variables used in the studies. There were, however, also results that can be interpreted to mean that the A-group's narratives had a good global structure as regards vocabulary, syntax and narrative structure, and that the relationship between written and spoken language was similar in both groups (i.e. the A-group showed signs of having retained mastery of the differences between writing and speech). The most salient differences between the groups may concern the production rate, the proportion of word-level errors and the results for the revision phase.

Regular training with a computerised writing aid

The training had a positive effect on the writing ability of all three participants in Study IV, but the change was statistically significant for only two of them: Anders and Carol. After the training, Anders was able to make proportionally more revisions that resulted in correctly written words in his final texts. Carol wrote more words, had a larger proportion of correctly written words and made more edits resulting in correctly written words.

These results were found for the dependent variables when the participants were using the writing aids. However, similar results were also found for these variables when the aids were not used (although not to the same extent and statistically significant only for Carol's proportion of successful edits), indicating results similar to those of Bruce et al.

(2003) and Mortley et al. (2001). Regular writing training improves writing, and regular writing training with an aid improves it even more, but access to a writing aid without regular training is probably not as effective. At the time of pre-training testing, all participants had difficulties with tasks where sub-lexical processes are needed, but the writing aids compensated for this impairment by helping them make use of their better-preserved lexical processes. The localisation of Bo's brain damage was in the left perisylvian region, which has been described as the location for a phonological network (e.g. Alexander et al., 1992). No such obvious relationship was found between the localisation of Anders' and Carol's brain damage and their writing difficulties, however.

Learning how to use an aid may require a large effort, which may explain the decline in the data series for some of the variables. The training period may also have been too short, which is supported by improved results at follow-up (e.g. concerning word total for Anders). Another explanation, of course, is that further adjustment of the aid could have been needed. What is more, even though word prediction has been reported as very useful for persons with aphasia (Mortley et al., 2001), it is possible that another type of aid would have been a better choice.

The participants' writing also showed signs of improved sentence structure, even though this was not the subject of specific training during the intervention (for examples, see Behrns, Hartelius & Wengelin, 2008). This may be interpreted as indicative of improved syntactic ability *per se*, maybe because learning to use a writing aid through regular training also meant syntactic training. But it may also partly be interpreted as a result of increased availability of cognitive resources as the participants did not have to focus on their spelling to the same degree. Another positive finding was that, even though the intervention did not include any functional training, the interviews revealed that the participants' improved writing ability and improved motivation to use written language had resulted in small but important increases in their use of the written modality in their everyday lives.

Subjective reflections on writing ability (all participants with aphasia)

The findings made during the short interviews about the participants' writing ability and their writing habits before their illness and at present pointed to several important issues.
The majority of the participants used to write and read daily before their illness, and writing and reading were important to them both in their daily professional activities and in their private lives. Losing the ability to read and write was described as a great loss. When describing their present writing ability, the participants could identify in detail what elements of the writing process were difficult for them, e.g. judging whether a word was correctly spelled or not. Several of the participants had used a word processor for writing, and some – but not all – believed this was a good way to compensate for their writing difficulties. The three participants who took part in the intervention (Study IV) all characterised their training as very encouraging and motivating, saying that computerised writing training helped but that detailed instructions and regular training were necessary.

Summary and concluding remarks

What are the reasons for focusing more on the writing process in language rehabilitation? First, written interaction is becoming increasingly important owing to new technologies, and there is an urgent need to reduce the effects of the 'digital divide' for persons with disabilities. Individuals with aphasia are a group that can derive considerable benefit from the use of written language since this enables communication that may not be possible to the same degree through spoken language. Access to new technology, suitable aids, individual adjustment of these and good methods for learning how to use them would most likely improve the communicative ability of people with aphasia. Second, the processing conditions for writing, where a person can sit down in a quiet room and write (and rewrite) without time pressure, facilitate communication for an individual with aphasia. Third, results showed that written stories received higher ratings than the spoken versions for some dimensions, also in individuals whose ability to produce written language was strongly affected by their aphasia.

The thesis also showed that it is possible to improve writing ability, even if the writing difficulties were rather extensive to begin with and even if several years had passed since the onset of the illness. All three participants found their training motivational and very encouraging. There were, however, also unchanged or declining trends for some of the participants' results concerning the product (word total) even though trends were positive for the process of revision (successful edits). Ensuring that patients are in control of their writing activity, for example using the strategy of computerised writing aids, is clearly a very important treatment objective.

Analysis of the revision phase moves the focus to issues of importance to the writer during the writing process. The participants in this thesis concentrated their efforts on the word level and evaluated every word or even every single character before deciding to move on in their text production. This strategy was effective when it comes to reducing the number of word-level errors in the final text, but it may have affected other linguistic levels, reducing fluency and leaving the writer with less ability to focus on the communicative aspects of the writing process. Results from the intervention indicated that use of a computerised writing aid that supported production and revision on the word level led to improved sentence structure, which partly confirmed the earlier hypothesis that the complexity of syntax would be reduced as a result of processing constraints. Clinicians sometimes meet persons with aphasia who have predominantly subjective language difficulties which cannot be analysed by means of the established tests used in aphasiology. Analysing the revision phase of the writing process may be one way to gain access to information about such difficulties.

The analytical assessment as well as the ratings confirmed that persons with aphasia have good text structure and coherence (Ulatowska et al., 1978; Ulatowska et al., 1979; Freedman-Stern et al., 1984; Mortensen, 2005) and that overall structure may be even better in written than in spoken language (Ulatowska et al., 1978). Short T-units with simple syntax and edits made on the word level at the time of entry gave the impression that the participants moved through the text-production task in a rather linear way. The

participants had good overall writing structures, probably as a result of long writing experience, even if they did not make any changes to the general plan for the story once they had started writing

The participants described in detail what difficulties they experienced during writing in a way that was in accordance with what had been found through the different analyses. The interviews also revealed important background factors about earlier and present writing habits – important in setting goals for treatment but also in interpreting results from the different analyses, as emphasised in Parr's (1992, 1995) findings. The participants further reported how communication in written language before the illness had involved joy and creativity and how writing at present involved a big challenge.

Limitations

The number of participants in Studies I–III is limited and interpretations of results have to be made with caution. The A-group was heterogeneous, with different types of aphasia and different degrees of severity. All participants met the inclusion criteria, but the results might have been easier to interpret if all of them had had aphasia of similar severity. At the same time, however, the differences in results for writing performance are among the interesting findings made.

The ideal would have been to compare the participants in the A-group with a group matched for age, gender and education. The main reason for the difference is that the A-group was studied in a research project that also included two other groups of people with writing difficulties, whose participants were younger and more comparable with the reference group in that respect (Strömquist & Ahlsén, 1998). There are, however, reasons to consider the A-group and R-group comparable despite the difference in age. Age may affect production rate: a younger person may write faster than an older person. On the other hand, an older person is most likely to have longer writing experience, which would probably increase the production rate. The difference in production rate between the two groups is very large in the present data, and age probably cannot be the only explanation. Further, all writing tasks were performed on a computer, which is why the ability to use a keyboard and experience of keyboard writing were two of the inclusion criteria (to avoid cases where e.g. a motor deficit or visual deficits would be a disadvantage when performing the task). Seven of the eight participants in the A-group had used writing in their professional lives and many of them had also done so in their spare time and had many years of extensive writing experience. Four had university degrees and were thus used to academic writing (of course with individual differences). One of the participants was studying at university (i.e. was at the exact same educational level as the participants in the reference group, who were all university students) when he fell ill. Level of education is related to concept and topic coherence in narratives, but no clear influence of age has been demonstrated (Mackenzie et al., 2007). It is therefore argued that the groups are possible to compare as regards the variables that were studied in this thesis. However, the thesis should not be viewed as a typical group study but rather as a study whose aim is to explore and give a detailed as well as a more general picture of writing ability in aphasia.

The title for the task used for the free narrative (‘I have never been so afraid’) prompted four of the participants in the A-group to describe their experience of their disability and the situation in the acute phase. This may have resulted in stories with a higher level of affect; the ideal would have been to compare the A-group’s stories with stories told by persons with (other) traumatic life experiences. However, Ulatowska (2001) argues in favour of this type of task, claiming that it may be more motivational for individuals with aphasia.
The writing tasks used in Study I also need to be discussed, since they represent two different types (free narration and picture elicitation). This may have affected the results

The writing tasks used in Study I also need to be discussed, since they represent two different types (free narration and picture elicitation). This may have affected the results (e.g. as regards lexical diversity). However, the two stories were analysed together since this made the corpus larger, which was advantageous for the study.

Results from the intervention study indicated improvements in sentence structure, even though this had not been the subject of specific training. Closer analysis might have yielded more information. However, this was not done since the issue concerned did not belong to the main research questions of the study.

Future research

This thesis suggests several areas for future research, which are listed below.

- The evaluation of different types of writing aids for persons with aphasia should include speech synthesisers (together with the current aids);

- Another important issue from the intervention study is the question of generalisation to reading and to spoken language. If a generalisation effect was found, then perhaps writing training could be used also to improve spoken language. The permanence of written language could facilitate several aspects of language training;

- It is also important to see how writing training carried out in a clinical setting may affect the everyday life of individuals with aphasia;

- The study of patterns from the revision phase could be expanded to include, for example, processes for writing plans to a larger extent;

- The results from the comparison between written and spoken language require further research, for example into how different situations affect the two modalities;

- Several questions concerning the ratings remain unanswered and require further investigation. For example: how results from the different ratings in the questionnaire give different rating profiles, what predicts the ratings and to what extent the measured variables, e.g. word-level errors and story length, correspond to rated variables.

Acknowledgements

In the writing – and rewriting – of this thesis, many people have been important and have contributed in different ways. I would like to thank:

Lena Hartelius, my main supervisor and co-writer, for guiding me through all details with all your experience in the research field, and for always believing in me.

Åsa Wengelin, my supervisor and co-writer, for generously sharing all your knowledge and personal contacts in the writing-research community.

Elisabeth Ahlsén, my co-writer and supervisor for the licentiate thesis, for introducing me to neurolinguistics and for giving me skilful support throughout my work.

Malin B Olsson, my co-writer, for giving me invaluable scientific advice on how to make questionnaires and how to analyse them.

Anette Lohmander for always supporting me and my work.

Everyone at the Division of Speech and Language Pathology, University of Gothenburg, for laughs, talks and coffee-breaks but also for valuable comments on the manuscript and help with the lay-out.

All members at Afasiföreningen, Göteborg, for generously and enthusiastically sharing your life experiences and for letting me use your rooms and computers.

Katrin Davidsson and Michaela Holmström, former SLP students at the University of Gothenburg, for contributing to this work by analysing the discussions of focus groups.

Erik Hellström for spending many hours on the questionnaires.

Henrik Karlsson for generously sharing your experiences of computerised writing aids with me.

Ann Ander and Gunilla Virdebrandt-Nordgren for all your help during data collection and analysing.

Lotta and Christian Sjögreen at Mun-H-Center, for all generous help analysing the video recordings.

Anneli Bergström for willingly spending hours discussing treatment strategies in aphasia.

Elisabeth Carlsson, Julia Hartelius, Barbro Henriksson, Örjan Henriksson and Linda Malmgren for helping me find readers and listeners.

Lotta Saldert, for always knowing when the time was best for a good cup of tea.

Ulrika Ferm for interesting conversations and good friendship.

Magnus, Cecilia and Viktor Behrns for all your love, patience and support.

This research was financially supported by grants from the Swedish Council for Working Life and Social Research, the Swedish Stroke Association and the Promobilia Foundation.

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Summary in Swedish

(Svensk sammanfattning)

Tidigare forskning som rör afasi och skrivförmåga har fokuserat på förmågan att stava enstaka ord. Utgångspunkten för detta arbete var att fokusera på sammanhängande text och att då analysera den färdiga texten, men också den del av skrivprocessen som innebär omarbetning av texten.

Det övergripande syftet med avhandlingen var att noggrant beskriva vad som karakteriserar skrivförmågan hos personer med afasi. Avhandlingen består av fyra delarbeten, med följande delsyften:

- att beskriva vad som karakteriserar sammanhängande text som producerats av personer med afasi
- att jämföra skriftligt berättade historier med muntligt berättade historier
- att beskriva vad som karakteriserar den del av skrivprocessen som utgörs av redigeringsarbete
- att undersöka på vilket sätt datorbaserade skrivstödsprogram kan användas för att träna skrivförmågan vid afasi

Metod

Deltagare

Deltagarna i studie I, II och III utgjordes av två kvinnor och sex män med afasi, i åldrarna 28–63 år (medelålder: 42,5 år). Inklusionskriterierna var: svenska som första språk, högerhänthet (före insjuknandet), afasi efter cerebrovaskulär insult i vänster hemisfär, ej mer än måttligt nedsatt auditiv förståelse, tangentbordsvana och bibehållen förmåga att använda ett tangentbord. I studien ingick en referensgrupp som utgjordes av fem kvinnor och fem män i åldrarna 21–30 år (medelålder 23,5 år). I studie II ingick även en grupp med 60 personer utan tidigare erfarenhet av afasi. Deltagarna i studie IV utgjordes av en kvinna och två män, 53, 56 och 59 år. Inklusionskriterierna motsvarades av dem i studie I–III (frånsett tangentbordsvana) samt att ingen annan logopedbehandling pågick samtidigt som studien genomfördes.

Genomförande

Deltagarna i *studie I, II och III* fick i uppgift att skriva en fri berättelse och en historia som baserades på bilder. Den fria berättelsen berättades även muntligt. Samtliga deltagare deltog vidare i en kort intervju där de berättade om sina erfarenheter av skrivande, före och efter insjuknandet. Samtliga skrivuppgifter gjordes på dator. För insamling och analys av data användes ett program som spelar in och sparar alla tangentnedtryckningar och allt

som görs med musen (dvs. även allt som redigeras bort). På så sätt är det möjligt att få insyn i vad skribenten lagt ned mycket arbete på under redigeringsarbetet och vilka ändringar som gjorts.
Den färdiga texten, så som den såg ut när deltagarna hade avslutat sitt arbete med den, analyserades i *studie I* och jämfördes mellan de personer som hade afasi (A-gruppen) och referensgruppen (R-gruppen). De variabler som analyserades var stavfel, vokabulär, syntax och berättelsernas övergripande struktur. I *studie II* gjordes samma analyser av de muntligt berättade historierna och resultaten jämfördes såväl inom som mellan A-gruppen och R-gruppen. Vidare gjordes en helhetsbedömning av samtliga deltagares skriftliga och muntliga versioner av berättelserna. Gruppen av personer utan tidigare erfarenhet av afasi ombads att, efter att ha lyssnat på respektive läst historierna, i en enkät skatta sina intryck av berättelserna. Resultaten från skattningarna jämfördes sedan såväl inom som mellan grupperna. Förutom analys av den färdiga textens struktur och hur den upplevdes av läsaren, gjordes i *studie III* en analys av deltagarnas redigeringsarbete. Här beräknades produktionshastighet (ord per minut), hur stor del av den ursprungliga texten som redigerats bort, hur stor del av orden som redigerats och vilka av redigeringarna som resulterat i korrekt skrivna ord respektive vilka ord som fortfarande var inkorrekt skrivna trots redigering.

Studie IV var en behandlingsstudie med single subject-design och A-B-A-utformning, med baslinje (A) en gång per vecka under fyra veckor, behandling (B) två gånger per vecka under nio veckor och uppföljning (A) efter 10 månader.
De datorstödda skrivstödsprogram som användes var ordprediktion och rättstavningskontroll. Båda programmen är ursprungligen utformade för personer med dyslexi och har anpassats efter vanliga felstavningar i svenskan och efter svensk fonotax. En kontinuerlig mätning gjordes av de beroende variablerna antal ord, andel rättstavade ord, ord per minut och andel redigeringar som resulterade i korrekt skrivna ord. För analys av resultaten användes grafiska metoder som kompletterades med statistiska beräkningar.

Resultat

Studie I, II, III

Deltagarna i A-gruppen hade genomgående en mycket låg produktionshastighet (ord per minut). Samtliga deltagare i A-gruppen hade i intervjuerna berättat om stora svårigheter att stava, men texterna innehöll trots detta förvånande få stavfel. Några av deltagarna hade inslag av semantiska substitutioner och utelämnade ord i sina texter, men övergripande mått på vokabulär och ordförråd visade stora likheter med referensgruppens resultat. A-gruppen skrev kortare satser med enklare syntaktisk struktur än vad R-gruppen gjorde. Däremot visade resultaten tecken på att båda grupperna hade en mer avancerad vokabulär och en mer komplex syntax i sina skriftliga historier än i sina muntliga. A-gruppen hade vissa svårigheter med textens övergripande struktur men nämnde trots allt de mest väsentliga delarna i historien. R-gruppens historier skattades genomgående högre än A-gruppens. Båda gruppernas skriftliga versioner skattades som mer sammanhängande än de muntligt berättade och båda gruppernas muntliga historier skattades högre vad gäller

ordval. Variablerna antal ord, vokabulär, syntax och stavfel kunde förutsäga resultaten i skattningarna för enbart några få av de skattade variablerna och då inte alltid med ett förväntat positivt samband. Resultaten från redigeringsfasen visade att båda grupperna valde att ta bort lika stor andel av tangentnedslagen, men att A-gruppen gjorde sina redigeringar på enskilda bokstäver eller ord och inte flyttade runt i texten och gjorde stora förändringar som R-gruppen gjorde. A-gruppen gjorde också flera försök under redigeringen av ord och lyckades inte alltid, utan slutresultatet blev ibland ett nytt, fortfarande felstavat, ord.

Studie IV

Resultaten visade att skrivförmågan påverkades positivt för samtliga tre deltagare. Den första deltagaren gjorde fler lyckade redigeringar medan den andra skrev fler ord, skrev större andel av orden korrekt och gjorde större andel lyckade redigeringar. Den tredje deltagarens förbättringar var inte statistiskt signifikanta.

Intervju

Under intervjun beskrev samtliga deltagare vilken stor förlust det var att inte kunna skriva på samma sätt som tidigare och att de efter insjuknandet sällan skrev i annat syfte än att träna. De kunde själva beskriva sina skrivsvårigheter, där ett gemensamt drag var svårigheter att rätta sina stavfel även om de upptäcktes. Vidare framkom att datorn kan vara ett bra hjälpmedel, men att kontinuerlig träning och uppföljning behövs.

Diskussion

De berättelser som skrevs av deltagarna med afasi karakteriserades av en linjäritet, av korta satser med enkel syntax och få bisatser. Även redigeringsarbetet var linjärt: deltagarna kontrollerade noga varje ord och bokstav, ibland flera gånger, men förflyttade sig sällan runt i texten (som R-gruppen gjorde). Denna noggranna strategi resulterade dock i historier med förhållandevis få fel och med en relativt god övergripande struktur. Tidigare forskning som baserats på muntliga historier har visat på väl bibehållen textstruktur, trots svårigheter på andra lingvistiska nivåer. Avhandlingens resultat visade att detsamma gäller för skrivna berättelser och att skrivna versioner till och med upplevdes som mer sammanhängande och lättare att förstå än samma historiers muntliga versioner.

Resultaten visade också att deltagarna i detta arbete trots nedsatt skrivförmåga ändå skrev på ett sådant sätt att en läsare som befinner sig på annan plats och i en annan tid kan förstå, dvs. med tillräckligt tydlig vokabulär och syntax.
Interventionsstudien visade framför allt på två viktiga fynd, där det första var att det med datorbaserat skrivstöd är möjligt att förbättra skrivförmågan vid afasi. Det andra fyndet var att det vid utvärderingar av behandling är viktigt att analysera redigeringsarbetet eftersom det framför allt var här som framstegen blev synliggjorda och tydliga.

Ett ytterligare viktigt fynd från avhandlingen kom från deltagarnas egna erfarenheter, där det tydligt framgick hur viktigt det skrivna språket är för individen och hur tillgången till det skrivna ordet påverkar möjligheten till interaktion med omgivningen.