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The effect of high-frequent homework on the semantic system of persons suffering from chronic aphasia

Master thesis Taal- en Spraakpathologie

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IV Abbreviations

AAT	Aachen aphasia test [Ger.: Aachener Aphasie Test]
BIWOS	Bielefelder screening of word-finding [Ger.: Bielefelder Wortfindungsscreening]
CETI	Communicative Effectiveness Index
ICF	International Classification of Functioning, Disability and Health
NAT	Neurolinguistic aphasia therapy [Ger.: Neurolinguistische Aphasietherapie]
PALPA	Psycholinguistic assessments of language processing in aphasia

Abstract

Purpose: Aphasia is an acquired language disorder requiring high-frequent therapy to meliorate. Therapy at high frequency cannot be afforded for each patient due to logistical and financial problems. Alternatives have to be found to replenish direct speech and language therapy. The aim of this investigation was to examine the effect of paper-pencil homework executed at high frequency by individuals suffering from chronic aphasia on the semantic system.

Method: Repeated measures were performed using the language outcome of five individuals (three men, two women; aged between 57 and 74 years) suffering from aphasia for at least six months. The participants worked high-frequently (minimally 300 minutes per week over three weeks) on paper-pencil homework selected from the NAT (Neurolinguistische Aphasietherapie, Eng.: Neurolinguistic aphasia therapy; Neubert, Rüffer & Zeh-Hau, 2005b). Their language abilities were tested using the AAT (Aachener Aphasie Test, Eng.: Aachen aphasia test; Huber, Poeck, Weniger & Willmes, 1983), BIWOS (Bielefelder Wortfindungsscreening, Eng.: Bielefelder screening of word-finding; Benassi, Gödde & Richter, 2012) and LEMO 2.0 (Stadie, Cholewa & De Bleser, 2013). Furthermore, the influence on the communication in daily life was assessed using the CETI (Communicative Effectiveness Index; Lomas et al., 1989).

Results: The intervention did not lead to significant effects. However, positive trends were observed concerning the overall language ability, oral naming and auditory speech comprehension. Slight positive trends were recognised in written naming and visual speech comprehension (i.e. comprehension of text). Furthermore, the communication ability in the participants' daily lives slightly improved over the intervention period.

Conclusion: The findings of this investigation indicate that high-frequent homework performed by patients suffering from chronic aphasia leads to positive changes in the semantic system and in daily communication. Further research is needed proving homework to be an evidence-based alternative replenishing speech and language therapy.

Keywords: homework, semantic system, high frequency, word-finding deficit, chronic aphasia

1. Introduction

Aphasia often affects word retrieval (Martin, 2013), disabling to communicate as before. Words are confounded, used in the wrong way or context and often naming objects is not possible anymore (Wijnen, Van Ewijk & Eling, 2012). Much research has been done in order to find therapies having a positive influence on the semantic system. Today, speech and language therapists utilise different methods to improve word retrieval and naming.

Regarding the frequency of therapy, the majority of the patients suffering from aphasia receive two 45-minutes sessions a week (Asmussen, Bremer, Heldt & Krüger, 2013). Yet, speech and language therapy is effective especially when provided at high frequency (Bhogal, Teasell & Speechley, 2003). The low frequency is due to different reasons: the speech and language therapist, the prescribing doctors, the patient and the organisation of the outpatient department (Asmussen et al., 2013). However, as high-frequent speech and language therapy is desirable for patients suffering from aphasia (Grötzbach, 2005), alternatives have to be found replenishing the outpatient therapy provided by therapists. Several methods could be used providing high-frequent therapy for patients: using computers, group therapy and the dedication of a co-therapist are only three possibilities. Another old and well-known method to assist face-to-face teaching is homework. Teachers provide their pupils with them every day. Homework could assist speech and language therapy as well, because the tasks can be performed unaided, independently from place and time and furthermore, they are timesaving. However, little is known about the effectiveness of homework used in this context. This lack of research has to be filled. Hence, this study investigates the effect of complementing speech and language therapy with high-frequent homework on the semantic system.

2. Theoretical background

This chapter includes background information, which is important in order to understand the content of this investigation.

- Common causes of aphasia are enumerated.
- Incidence and prevalence of aphasia is described.
- Aphasia including its types and syndromes is explained and illustrated with the help of a psycholinguistic model.
- Research results of an adequate frequency of aphasia are provided.
- Methods to replenish direct speech and language therapy are discussed.

This information leads to the research question and the corresponding hypotheses underlying this investigation. These are provided in the last section.

2.1. Aphasia

The most common cause of long-term disabilities in adults is stroke (Albert & Kesselring, 2012). The incidence of stroke in Europe varies from 101.2 to 239.3 per 100,000 in men and 63 to 158.7 per 100,000 in women (European Registers of Stroke, 2009). In developed countries, the incidence declines but the prevalence remains high due to aging of the population (Stroke Center, 2015). A common consequence of stroke is aphasia (Barthel, Meinzer, Djundja & Rockstroh, 2008; Pedersen, Jorgensen, Nakayama, Raaschou & Olsen, 1995). Almost 40% of stroke patients suffer from aphasia (Huber, Poeck & Springer, 2013; Pedersen et al., 1995). Nevertheless, stroke does not necessarily lead to aphasia (Rupp, 2010). Aphasia is an acquired language impairment following brain damage in areas important for language (Wehmeyer & Grötzbach, 2010). The causes of brain damage leading to aphasia are shown in Figure 1. Stroke is the most common cause of aphasia. Traumatic brain injury, brain tumour and other diseases cause only 20% of aphasias. In total there are 120 to 160 people per 100,000 habitants suffering from aphasia and per year there are 80 acute and 40 chronic first instances of aphasia (per 100,000 habitants; Huber et al., 2013).

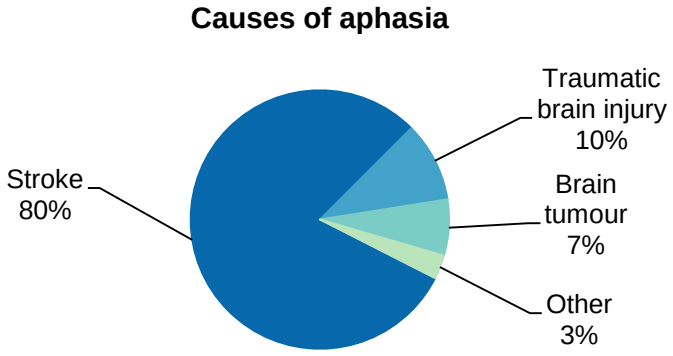


Figure 1. Causes of aphasia (see Schneider, Wehmeyer & Grötzbach, 2014).

Generalising, aphasia is divided into three stages (Hillis & Heidler, 2002):

- The first four weeks after the incident form the ***acute stage*** (Huber, Poeck & Weniger, 2002) in which rapid recovery is likely to occur (Hillis & Heidler, 2002).
- The subsequent ***subacute stage*** is divided into *early subacute stage* (lasting until seven months post onset) and *late subacute stage* (lasting until twelve months post onset; Huber et al., 2002; Huber et al., 2013). In this stage, neural reorganisation occurs (Hillis & Heidler, 2002). Spontaneous recovery often leads to an improvement of language skills in the first year after the aphasia-inducing event (Barthel et al., 2008; Robey, 1998). The more training the patient attends, the higher the possible improvement (Robey, 1998).
- The ***chronic stage*** of aphasia has its onset twelve months after the incident (Huber et al., 2013; Weniger, 2014). In this stage, the symptoms of patients are unlikely to change without intervention of a speech and language therapist (Rupp, 2010).

Hillis and Heidler (2002) hypothesise that these stages do not have clear limits. That may be the reason for some researchers to regard patients suffering from aphasia already six months post onset as chronic (e.g.: Aftonomos, Appelbaum & Steele, 1999; Basso & Macis, 2011; Blomert, Kean, Koster & Schokker, 1994; Baumgaertner et al. 2013). To avoid confusion, people suffering from aphasia more than six months are considered to suffer from chronic aphasia in this investigation.

Aphasia affects one or more modalities (i.e. speaking, reading, writing and comprehending) in each stage and therefore can have a huge impact on the patient's life (Barthel et al., 2008). Being restricted in the use of at least one communication mode (input/output) limits the participation in activities of daily life. The bigger part (80%) of patients suffering from aphasia can be allocated to one of the four standard syndromes (Huber et al., 2002). The remaining 20% suffer from special types of aphasia or are not classifiable. Allocating a patient to syndromes/types is achieved by assessing his symptoms (Potagas, Kasselimis & Evdokimidis, 2013). Table 1 provides information about the standard syndromes and special types thereof, and holds information about the main symptoms of patients suffering from different types of aphasia. A minus represents a disruption of the corresponding function and a plus represents a relatively spared function. It is easy to conclude that patients suffering from global aphasia have the most deficits in language functions, while patients suffering from anomic aphasia or transcortical motor aphasia have problems with only two language functions. According to this table, writing is impaired in all standard syndromes and special types of aphasia, while naming is spared in transcortical motor aphasia and repeating in amnestic aphasia. The language functions mostly impaired due to aphasia are speech comprehension and repeating. The fluency of speech is affected in half of the syndromes/types. In case the patient uses his speech fluently, paraphasias are likely to occur except in amnestic aphasia.

However, recent literature questions the division into syndromes (Wehmeyer & Grötzbach, 2010) and proposes focussing on the description of symptoms instead (Potagas et al., 2013). This investigation uses both, the symptoms and the syndromes/types to describe a patient.

Table 1. The syndromes/types of aphasia and the corresponding symptoms.

		Speaking	Speech compr	Repeat	Name	Read	Write
Standard syndromes	**Global aphasia**	Non-fluent	**-**	**-**	**-**	**-**	**-**
	Broca's aphasia	Non-fluent	+	-	-	-	-
	Wernicke's aphasia	Fluent, paraphasia	-	-	-	-	-
	Amnestic aphasia	Fluent	+	+	-	+	-
Special types	**Conduction aphasia**	Fluent, paraphasia	+	-	-	-	-
	Transcortical sensory aphasia	Fluent, paraphasia	-	+	-	-	-
	Transcortical motor aphasia	Non-fluent	+	+	+	-	-
	Mixed transcortical aphasia	Non-fluent	-	+	-	-	-

Note. Speaking = Spontaneous speech; Speech compr = Speech comprehension; Repeat = Repeating; Name = Naming; Read = Reading and comprehending; Write = Writing; + = spared function; - = impaired function. Information taken from: Huber, Poeck & Weniger (2002); Potagas, Kasselimis & Evdokimidis (2013)

Focussing on the symptoms/syndromes of aphasia, only the functional part of a patient is regarded. Taking the patient's participation and activities into account forms the basis of the International Classification of Functioning, Disability and Health (ICF; WHO, 2001). The ICF is used to describe a person in more ways: body functions, body structures, activities and participation, and environmental factors (WHO, 2001). A therapist using this classification does not only describe the disability of a patient, but considers his unique environmental status as well (Grötzbach & Iven, 2009). The patient is not seen as a disabled person but as a holistic individual. The ICF focusses on impact (WHO, 2015) and is patient-centred (Baumgaertner et al., 2013). The status of the patient is described using the subsets of the different categories by allocating a positive or negative influence. Summarising and in essence, it is important to take into account all four categories when analysing a patient.

Regarding the functional category, researchers invented models to facilitate the understanding of the complex processes taking place in human minds. Among these, there are models concerning the process of word recognition and word retrieval. The PALPA-model (Psycholinguistic assessments of language processing in aphasia) is one example. It is used to illustrate naming-impairments and its effects. As naming is commonly impaired in persons suffering from aphasia (see Table 1 above), a more detailed description of the model is provided below.

The ***PALPA-model*** is based on the process of healthy people to comprehend speech, pictures and texts and to express speech and texts. Impairments, regardless of the origin (e.g. eyes/ears) are not included in the model. The semantic system forms the centre of the model, as

this is where the information about the meaning/content of a word is stored. Details about the object as well as related words can only be retrieved from there. Thus, when the correct word with the corresponding stress, spelling and meaning is found, the semantic system was consulted. To put it another way: naming an object correctly requires the person to know the content of the word, too. The PALPA-model disposes of three input channels (see Figure 2):

- The first one is the spoken word: someone says a word that is subsequently perceived by another person. When the auditory phonological analysis took place (the listener identified speech as speech), the phonological input lexicon analyses the word and splits it into phonemes. Thereafter, the meaning of the word can be retrieved from the semantic system.
- The second input channel is the written word. When the abstract letter identification (written words are identified as a sum of letters) is completed, the word is split up into letters and subsequently the meaning of the word can be retrieved from the semantic system.
- The third input channel is the visual one. Seeing an object or picture leads to the retrieval of the correct word and related content information in healthy persons. When the input-routes work well, people are able to answer questions related to the spoken/written word or seen object correctly.

Consequently, corresponding to the way a word was provided (i.e. orally, in written form or visually using a picture), different routes are passed to retrieve the semantical meaning of it. Having retrieved the correct word and its meaning from the semantic system, there are three ways to produce the word: saying it, writing it or gesture it. However, sign language is not included in this model. For the production of the spoken word, phonemes have to be retrieved from the phonological output lexicon. For the production of the written word, graphemes, which are retrieved from the orthographical output lexicon, have to be combined. The buffers of each route keep the retrieved phonemes and graphemes available until the word has been expressed.

However, these routes are only passed in case everything works well and as there are many steps, a lot can go wrong. Aggravating, in order to repeat/copy a word, the semantic system does not necessarily have to be passed: it can be bypassed. In this case, words might be repeated and copied accurately without understanding the meaning of it. The person is not able to answer questions about the content of the word correctly. Thus, in case the semantic system does not work well, producing semantically related words and sorting words of different semantical fields are not possible. In essence, the semantic system is crucial for understanding and producing content-related words. For a more detailed description of the model, see Kay, Lesser and Coltheart (1996).

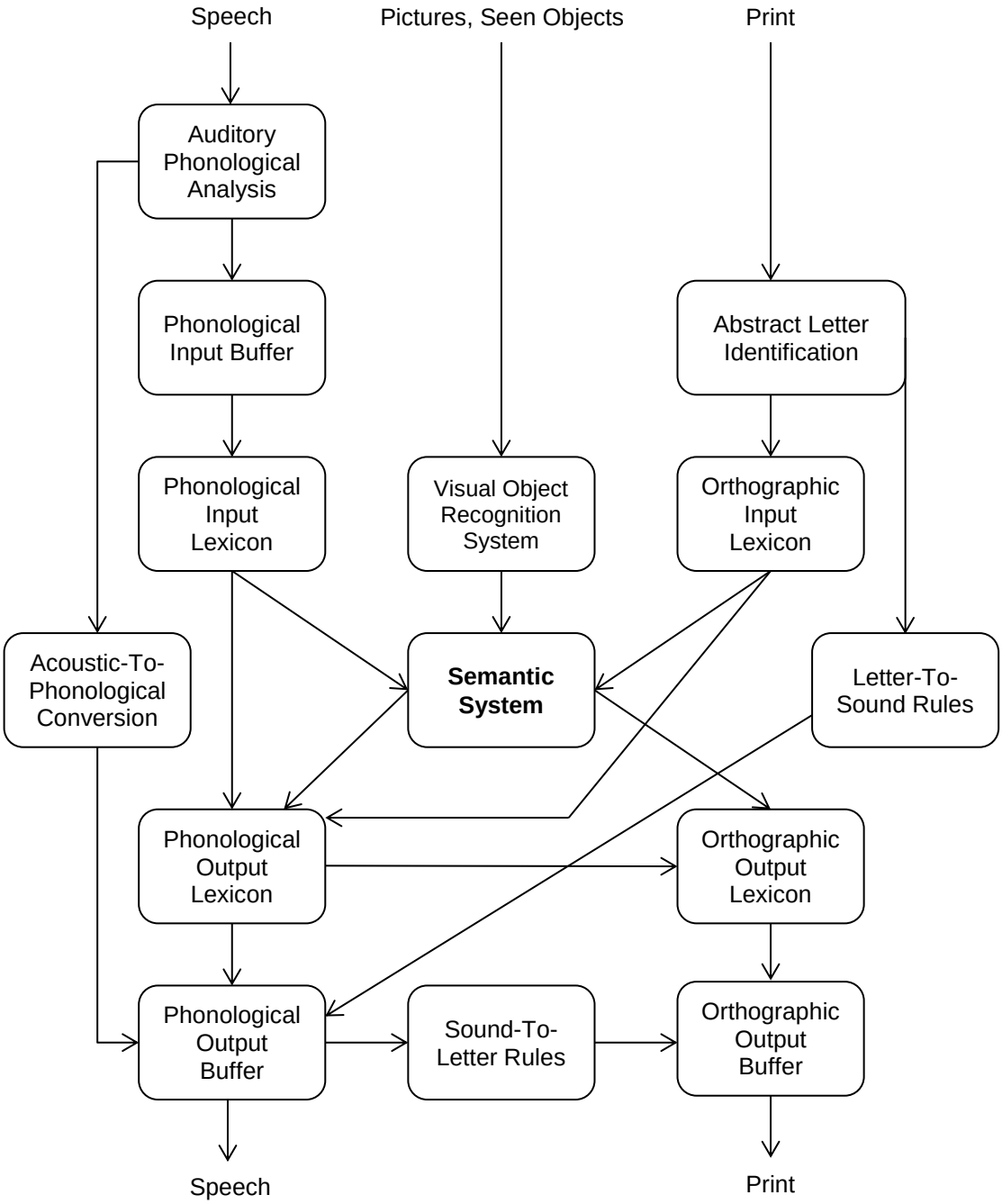


Figure 2. PALPA-model (see Kay, Lesser & Coltheart, 1996, 172).

2.2. Therapy of aphasia

When the process of word/object recognition and expression is understood, the question remains which treatment to choose for a person having problems in one or more of these routes. In aphasia therapy, many different methods exist to improve the language ability of a patient. In addition, not only the method plays an important role; the frequency of the treatment is decisive for the therapy progress as well. Which treatment-frequency leads to the highest language improvements? The majority of speech and language therapists define therapy as "intensive" when patients receive three hours therapy per week (Asmussen et al., 2013). In literature, generally a treatment with five or more hours per week is regarded as "intensive" (Brindley, Copeland, Demain & Martyn, 1989; Denes, Perazzolo, Piani & Piccione, 1996; Robey, 1998). However, researchers do not agree on an exact amount; yet, they agree on the fact that "intensive" therapy leads to substantial language improvements (Bhogal et al., 2003; Kelly, Brady & Enderby, 2010; Robey, 1998; Salter, Teasell, Foley & Allen, 2013). Table 2 was derived from Salter and colleagues (2013), showing the results of different randomised control trials with different intensities.

Table 2. Intensity of therapy provided in randomised control trials.

Study	PEDro Score	N	Intensity of Therapy	Result
Lincoln et al. 1982	4	24	12 * 30 minutes over 4 weeks	-
Lincoln et al. 1984	6	327	2 * 1 hour per week for 23 weeks	-
Wertz et al. 1986	6	121	8-10 hours per week for 12 weeks	+
Hartman 1987	6	60	2 sessions per week for 6 months	-
David et al. 1982	5	155	30 hours over 15 to 20 weeks	-
Shewan et al. 1984	5	100	3 * 1 hour per week for 1 year	+
Marshall et al. 1989	5	121	8-10 hours per week for 12 weeks	+
Prins et al. 1989	5	32	2 sessions per week for 5 months	-
Meikle et al. 1979	4	31	3-5 * 45 minutes per week	-
Brindley et al. 1989	4	10	5 hours over 5 days a week for 12 weeks	+
Denes et al. 1996	6	17	60 sessions vs. 130 sessions over 6 months	+
Bakheit et al. 2007	8	97	4 hours/week vs. 2 hours/week (over 12 weeks)	-

Note. Table was derived from Salter, Teasell, Foley & Allen (2013, 16). PEDro Score = PEDro is the free Physiotherapy Evidence Database containing randomised trials, systematic reviews and clinical practice guidelines. The literature has been assessed for quality and a score was matched to each publication. The scoring system is 0-11 (11 being the highest). N = Number of participants in the investigation.

A safe conclusion from Salter and colleagues' findings (2013) is that the intense trials led to significant changes in language outcome: therapy provided five to ten hours per week for twelve weeks or three hours per week for one year had a significant effect. These results are compatible with the requirements of the "Quality Criteria and Standards for the Treatment of Patients with Acquired Neurogenic Disorders of Language (Aphasia) and Speech (Dysarthria)" (Bauer et al., 2001). Here, therapy given in intervals of at least one hour per day for six to eight weeks is prescribed in the chronic stage. A meta-analysis of Bhogal and colleagues (2003) revealed therapy of 8.8 hours for 11.2 weeks to be effective. Other authors found three hours per day for ten days leading to a significant change in

language outcomes (Barthel et al. 2008; Meinzer, Djundja, Barthel, Elbert & Rockstroh, 2005; Schomacher et al., 2006). The investigation of Meinzer and colleagues (2005) revealed length and severity of aphasia and the age of the patient to be unimportant factors for the success of intense language therapy. Summarising, these investigations showed intensive speech and language therapy for patients suffering from chronic aphasia leads to significant language improvements. However, Cherney (2012) mentioned the following in her commentary:

> *"Currently there is no standard definition of intensity, although levels have been artificially created from meta-analyses and retrospective reviews of the prevailing literature. The simplistic notion that "more is better" is not necessarily supported by the evidence. Optimal intensities may vary depending on the type of intervention, and the specific stimuli given and responses required of the participant. Additionally, participant characteristics and environmental variables impact treatment intensity and outcomes, further complicating the determination of optimal treatment intensity."* (p.430)

In conclusion, a general answer regarding the amount of therapy leading to the highest language improvements cannot be found. Each type of treatment and each patient require a tailored amount of training hours leading to significant effects. However, recent research suggests that a high-frequent therapy is more effective than a low-frequent therapy (Bhogal et al., 2003; Kelly et al., 2010). In non-clinical settings, therapy of aphasia is often provided up to two times per week (Asmussen et al., 2013; Rupp, 2010). Nonetheless, most speech and language therapists want to provide an intense therapy, but mention the patient and his doctor to be obstacles (Asmussen et al., 2013). According to this, Nobis-Bosch, Springer, Radermacher and Huber (2011) mention high-frequent speech and language therapy to be unrealistic for general clinical practice. Thus, alternatives have to be found to replenish the amount of direct speech and language therapy with other types of therapy. Some of these are displayed in Figure 3 and further discussed below.

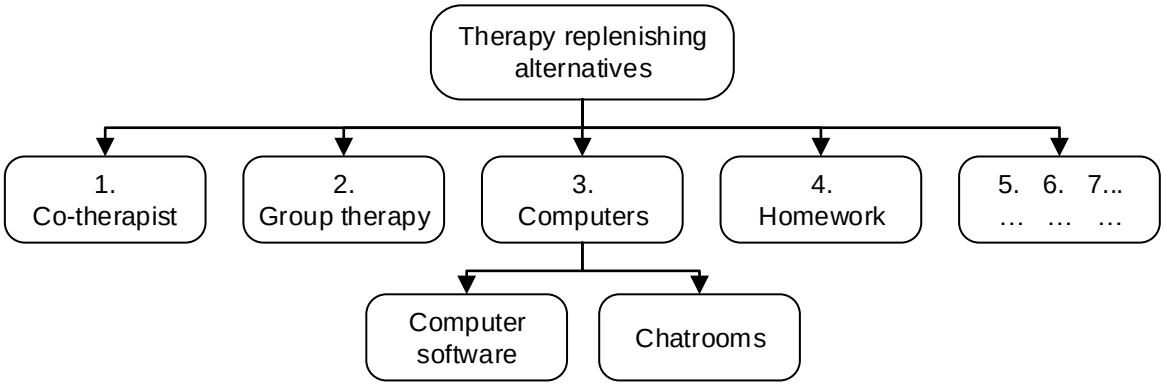


Figure 3. Alternatives to replenish speech and language therapy.

The ***first alternative*** is training patients' relatives making them able to act as a co-therapist. However, not all of the relatives have time to work with the patient. Furthermore, not everybody enjoys working with a relative on language problems in a therapeutic way. In clinical practice, just a minority of speech and language therapists includes family members in therapy, teaching them communication strategies (Johansson, Carlsson & Sonnander, 2011). Johansson and colleagues (2011) mention different reasons: the organisation, the education of the speech and language therapist and the existence of and compliance to guidelines. Thus, an alternative being less time-consuming should be found.

Group therapy is the ***second alternative***. This type of treatment may lead to a higher learning-motivation (Huber et al., 2013). However, for group therapy patients with analogical disorders are needed. Grouping analogical patients might be challenging, especially in rural areas.

The use of computers is the ***third alternative***. Corresponding applications/software can be installed on almost any computer and can be timesaving. In the last years, a lot of research has been done on this kind of therapy, resulting in the existence of many different programs nowadays. Some of them have shown to be effective, some have not and others have not yet been examined (see Palmer, Enerby & Paterson, 2013; Sünderhauf, Rupp & Tesak, 2008). A computer-based therapy can lead to the same improvements as conventional therapy (Rupp, Sünderhauf & Tesak, 2007). Thus, this seems to be a good alternative. However, most speech and language therapists taking part in the investigation of Detterer, Euscher and Wick (2012) were not familiar with software for computers. Integrating the use of software into the daily life of a therapist would take some time. A second possibility concerning computers is the use of chatrooms. Grefe (2004) describes the use of chatrooms as a very helpful kind of therapy. SOCRATES is a chatroom, which was invented for people suffering from aphasia (Spaniol, Klamma, Springer & Jarke, 2004a). With the use of this software, they are offered the opportunity to communicate with other people suffering from aphasia and with therapists and researchers. In this multi-user chat, patients communicate on the same level without having to be afraid of rapid conversations they cannot follow. Furthermore, they can meet other people while they can stay at home and that achieved one aim of this software: preventing personal isolation (Spaniol, Klamma, Springer & Jarke, 2004b). Nonetheless, not everybody disposes of a computer, even though the number is increasing year by year (Statistisches Bundesamt, 2014). The use software and chatrooms is a good alternative for people disposing of a computer and therapists being experienced with language programs.

The ***fourth alternative*** is a more classical way of repeating what has been learned in the session before: homework. This would comprise specific tasks the patient is requested to perform at home. These paper-pencil tasks have advantages:

- Therapists can easily provide paper-pencil tasks. Copies can be handed out to the patient. In case solution sheets are available, they can be handed out as well.
- As the patient is asked to work at home, he determines time and duration to work on the tasks by his own.
- The patient can work wherever he likes and neither the patient nor the therapist has to leave the home/office to train.

Yet, paper-pencil tasks have a range of disadvantages as well:

- The motivation for completing such tasks may decrease over time (see Schupp, Lederhofer, Seewald & Haase, 2006).
- The speech and language therapist cannot control the work the patient is doing and consequently, the patient could copy the correct answers without working further with the material in case solution-sheets are provided. Another possibility to get the correct answers quickly is by asking a healthy relative. Thus, the periods the patient is working on the sheet cannot be controlled. Therefore, the patient could claim to have worked half an hour per day although he worked only ten minutes in total.

Nevertheless, most people suffering from aphasia are adults (Van Hout, 1997) and therefore, should be aware of the importance to care about their own health status, rendering supervision unnecessary. Participants wanting to improve the language outcome will probably work on the sheets in the extent and way requested. Motivational problems concerning the execution of the tasks may occur regardless of the material used. Consequently, the disadvantages mentioned above may be neglected.

Unfortunately, there is no clear evidence for the effectiveness (see Table 3 for definition) of any of the four alternatives referenced above: some investigations revealed these methods to lead to significant improvements whereas others did not. Thus, this disadvantage is valid for any kind of treatment.

Summarising, it is a logic step concluding that paper-pencil tasks will be the best way to provide a naming-training for the participants. Among the paper-pencil tasks used in Germany, the NAT (Neurolinguistische Aphasietherapie, Eng.: Neurolinguistic aphasia therapy; Neubert, Rüffer & Zeh-Hau, 2005b) is well known and the most used in hospitals and outpatient departments (Detterer et al., 2012). Therefore, this alternative is the most suitable one for this investigation.

Table 3. Definition of effectiveness and efficiency.

Effectiveness	**Efficiency**
It measures the effect a therapy has on a specific element (Blanco & Mäder, 1999). If the use of a method leads to the expected aim, this method is effective.	It measures the profitability of a method (Blanco & Mäder, 1999). If a method achieves high results in a short time or with little effort, the method is effective.

2.3. Research question and hypotheses

As described above, therapy of aphasia in the chronic phase is only effective when provided high-frequently. In outpatient departments, it is very often impossible to provide this pace. One possible and established method to replenish the logopaedic therapy is the use of paper-pencil tasks as homework. The literature lacks on evidence over the effectiveness of paper-pencil homework-tasks. Consequently, this investigation looks at the effect the alternative “paper-pencil-homework” has on the language outcome. In order to make a comparison possible, the homework assigned had to have a focus. As most people suffering from aphasia have naming problems, it is reasonable to focus on improving the naming and the access to the semantic system.

The following research question arises:

Does paper-pencil homework completed high-frequently by participants suffering from chronic aphasia have a significant effect on the semantic system?

The following hypotheses arise from this research question:

1) *High-frequent homework of the NAT-material has a significant positive effect on the **language outcome**.*
2) *High-frequent homework of the NAT-material has a significant positive effect on **oral naming**.*
3) *High-frequent homework of the NAT-material has a significant positive effect on **written naming**.*

4) *High-frequent homework of the NAT-material has a significant positive effect on **auditory speech comprehension**.*
5) *High-frequent homework of the NAT-material has a significant positive effect on **visual speech comprehension** (i.e. speech comprehension of text).*
6) *High-frequent homework of the NAT-material leads to a significant positive change of the **communication in daily life**.*

These hypotheses require verification. In the following chapter, the method of how to test these hypotheses is described.

3. Method

In this chapter, the entire preparation of the investigation is described, starting with the acquisition of participants and the decisive factors for selecting the tests. Additionally, the material used and the way the participants were supervised is described. An introduction of the participants follows. The last section of this chapter includes a description of the data analysis executed with the participants' outcomes.

3.1. Acquisition of participants and executed tests

In order to avoid effects of spontaneous recovery, participants were only recruited being in the late subacute stage of aphasia (i.e. seven months post onset) initiated by stroke. Gender did not matter. All participants had to be native speakers of German, and 18 years or older. Participants having strong articulatory problems affecting the language outcome (e.g. apraxia of speech), auditory or visual problems which could not be corrected (e.g. blindness, neglect, deafness) were not included. Additionally, participants were excluded when writing letters and words was impossible. The inclusion and exclusion criteria are summed up in Table 4.

Table 4. Inclusion and exclusion criteria of the investigation.

Inclusion criteria	Exclusion criteria
- Late subacute stage of aphasia (after having suffered a stroke)	- Severe uncorrected-to-normal visual or auditory impairment
- German as mother tongue	- Impossible to write letters/words
- 18 years or older	
- Medium speech comprehension deficit in AAT	
- Medium naming deficit in BIWOS	

Note. AAT = Aachen aphasia test (Huber, Poeck, Weniger & Willmes, 1983); BIWOS = Bielefelder screening of word-finding (Benassi, Gödde & Richter, 2012)

In order to find participants, all speech and language departments (including hospitals and outpatient departments) and self-help groups for aphasia in and around Aachen (a city in Western Germany and 18 km radius) were contacted. At least ten participants were required. Investigating whether the potential participants indeed suffered from aphasia, the AAT (Aachener Aphasie Test, Engl.: Aachen aphasia test; Huber, Poeck, Weniger & Willmes, 1983) was used. This measuring instrument was used because it is standardised, objective, reliable, normed and valid (Bartels, 2011; Wehmeyer & Grötzbach, 2010). Furthermore, it is used internationally (see Bhogal et al., 2003). The AAT examines comprehension, reading, writing and verbal production. Using the subtests spontaneous speech, Token Test, repetition, written language, naming and speech comprehension, all four modalities are analysed (Huber et al., 1983). Concerning severity, the AAT distinguishes between minimal, mild, medium, and severe disorder (Huber et al., 1983). For these reasons, the AAT is an appropriate initial diagnostic procedure. Persons were only included in the study with up to medium severity regarding comprehension, because they had to work on their own and thus had to understand written assignments. Hence, the result of the AAT was decisive for including a participant in the study or not (see Figure 5).

Besides the AAT, the outcome of the BIWOS (Bielefelder Wortfindungsscreening, Engl.: Bielefelder screening of word-finding; Benassi, Gödde & Richter, 2012) was a decisive factor for including a participant as well. The test investigates the participant's naming-ability in more detail. The BIWOS examines semantical and lexical naming:

- The *semantical part* includes subtests of finding the opposite word, naming the generic term, finding synonyms and naming words belonging to a generic term.
- The *lexical part* includes subtests of rhyming, naming words to a specific initial letter, adding nouns for word-compositions and finding the corresponding word to an explanation.

The screening was developed for people suffering from mild aphasia and due to that, the scoring system is very sensitive to slight changes. Therefore, changes in the scores of participants suffering from medium or severe aphasia will be recognised faster. Additionally, ceiling effects (see Table 5 for definition) are not likely to occur in participants suffering from stronger aphasias. However, floor effects could be measured in participants with very strong word-finding deficits. As the aim of the research was to test the effectiveness of an intervention on naming and the semantic system, participants were included having at least naming-deficits of medium severity. In conclusion, participants were only invited to take part in this investigation in case their outcome of the AAT and BIWOS fitted the criteria.

Table 5. Definition of ceiling and floor effect.

Ceiling effect	**Floor effect**
Participants score correct on (almost) every item. In case ceiling effects occur, the test used was too easy for the examinees.	Participants score wrong on (almost) every item. In case floor effects occur, the test used was too difficult for the examinees.

Note. Information taken from Ary, Cheser Jacobs, Sorensen & Walker, 2014

The aim of the investigation was to look at the change of the semantic system. In order to name something correctly, the semantic system has to be accessed. Thus, another dedicated test was chosen to examine differences. LEMO 2.0 (Stadie, Cholewa & De Bleser, 2013) was based on the Logogen model, which is very similar to the PALPA-model. The test battery consists of many subtests providing tests for each modality: each subtest examines one particular route or part of a route. The four subtests of the main battery accessing the semantic system were performed; these are:

- 11. Word-Picture matching, auditory,
- 12. Word-Picture matching, visual,
- 13. Oral naming and
- 14. Written naming.

Each subtest investigates naming on a different cognitive route of the PALPA-model (see Table 6). These subtests examine naming and speech comprehension on a basal level: each item requests one single word for the answer. Each subtest contains 20 items, which are divided into frequently and non-frequently occurring words, including 10 per category respectively. The items are the same in each one of the four subtests, but are ordered differently. As there are 10 words high-frequently occurring in everyday life, a floor effect is unlikely to occur. An important reason to perform LEMO 2.0 is that it is the only test including a subtest of written naming. The AAT and BIWOS do not include written naming tasks. However, written naming passes a separate route in the PALPA-model that has to be respected

as well. Performing these four subtests, which include the same items, makes a direct comparison of the different routes possible. Therefore, not only the written subtest was included but also the other three subtests.

An overview of all tests used concerning speech comprehension and naming and their routes in the PALPA-model is provided in Table 6. A colour was matches to each cognitive route (see right-hand side of the table below). These colours can be found in Figure 4 as well: the cognitive route of the table corresponds to the route of the PALPA-model.

Table 6. Overview of comprehension- and naming-tests used in the investigation.

Modality	**Subtest**	**Cognitive route**	
Access to semantic system: word/sentence comprehension (reading, hearing)	LEMO 2.0 11. Word-Picture matching, auditory & AAT Speech comprehension (auditory part)	Phonological input lexicon/ Visual object recognition system → Semantic system	
	LEMO 2.0 12. Word-Picture matching, visual & AAT Speech comprehension (reading part)	Orthographic input lexicon/ Visual object recognition system → Semantic system	
Word retrieval: word/sentence production (writing, speaking)	LEMO 2.0 13. Oral naming & AAT Naming	Visual object recognition system → Semantic system → Phonological output lexicon	
	LEMO 2.0 14. Written naming	Orthographic input lexicon → Semantic system → Orthographic output lexicon	
Access to semantic system and word retrieval	BIWOS	Phonological input lexicon → Semantic system → Phonological output lexicon	

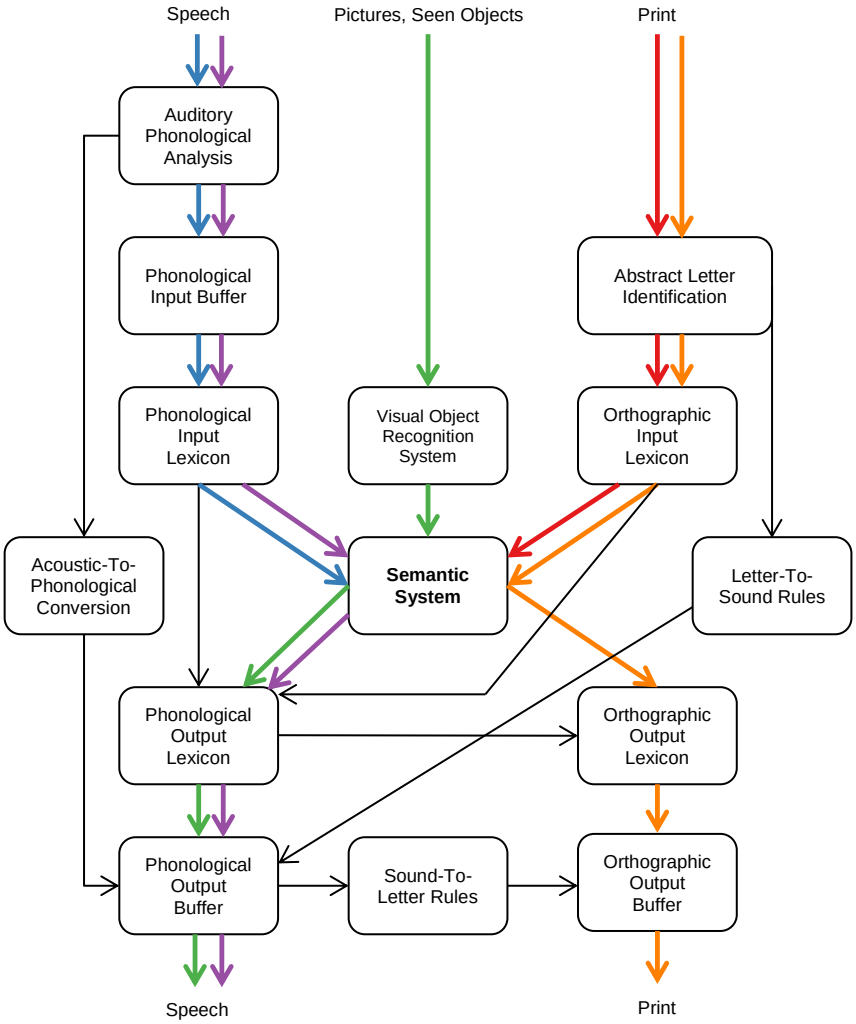


Figure 4. Visualisation of cognitive routes in the PALPA-model.

The AAT, LEMO 2.0 and BIWOS focus on the functional part of the patient. None of these tests are ecologically valid (definition see Beushausen & Grötzbach, 2011, 8). It was explained above, that a patient should be seen as an entity and researchers should take the impairments in daily life into account as well. Furthermore, the communication skills of the patient should be subject to examination. In Germany, two roll-playing tests are used at present to measure the communication skills (see Schwinn, Pieper, Damm-Lunau & Baumgärtner, 2013): the Szenariotest (Van der Meulen, Van Gelder-Houthuizen, Wielaert & Van de Sandt-Koenderman, 2008) and the ANELT (Amsterdam-Nijmegen Everyday Language Test; Blomert & Buslach, 1994). Yet, these tests indirectly measure the speech comprehension of the patient (Schwinn et al., 2013). Therefore, they were not practicable in this investigation, as comprehension problems are frequent in persons suffering from aphasia.

Another option to examine the patient's communication skills in daily life is to ask directly. However, the investigator regarded the workload of the participants as high enough already and therefore, elected another possibility: asking the participants' relatives. One popular method is the Communicative Effectiveness Index (CETI; Lomas et al., 1989). It is an indirect measurement tool, which was translated into German by Schlenck and Schlenck (1994). The questionnaire comprises 16 questions. Below each question a visual-analogue rating scale of 10 mm (horizontal) is drawn. Relatives are asked to judge the ability of the patient per question by marking a point on the line

corresponding to the extent of the ability. The investigator has minimally modified the CETI: some expressions were slightly changed and one question concerning the naming-ability was added (see Appendix A). It should be noted that the reliability of the CETI is insufficiently tested (Huber et al., 2013). The validity of the test is not sufficiently examined (GAB & DGNKN, 2000), but it may have a high sensitivity to real changes (Pedersen, Vinter & Olsen, 2001). However, the outcome of the CETI was not a decisive factor to include a participant in the study. Figure 5 shows the process of including a participant in the investigation.

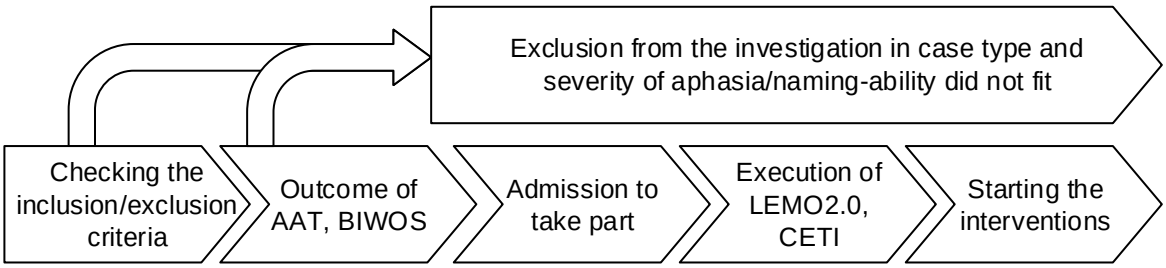


Figure 5. Process of including participants and execution of tests.

3.2. Homework

As described above, the NAT-material (Neubert et al., 2005b) is mostly used and well known in outpatient departments and hospitals. Unfortunately, there is no scientific proof that this material trains what it claims to train. However, there is no scientific evidence for none of the methods concerning the naming-ability in the German language. Each NAT-folder comprises different sorts of assignments, is hierarchically structured (the tasks get harder) and focusses on the training of the same aspect. The fact that the NAT comprises tasks that get harder was an important reason for utilising it in this research. Matching the level of difficulty to the severity of the deficit (Meinzer, Streiftau & Rockstroh, 2007) and continuously increasing the difficulty of a task is called “shaping” (Grötzbach, 2005). Shaping is one of the few methods, which promise effectiveness (Beushausen & Grötzbach, 2011). Because this investigation focusses on changes of the participant’s semantic system, different tasks were used. These tasks were claimed to improve the word retrieval or the correct naming of the word. In the following, some example tasks of the NAT-folders used, chosen on random basis, are described. To illustrate the routes of the PALPA-model trained with the NAT-material, Figure 6 is included.

Firstly, material of the folder *“**lexically-semantically verb-processing disorders**”* (Störungen der lexikalisch-semantischen Verbverarbeitung; Neubert, Rüffer & Zeh-Hau, 2005a) was used. This material combines pictures and words, including different tasks. One basic task is to find among different pictures the corresponding one to the written word (see Appendix B). In all of the tasks, the participant had to identify words and match those to the corresponding picture in the semantic system (red and green route in Figure 6). Secondly, sheets of the folder *“**lexically-semantically disorders**”* (Lexikalisch-semantische Störungen; Neubert, Rüffer & Zeh-Hau, 1992) were handed out to the participants as well. One task was to find the correct generic term for a group of words (see Appendix C). As the participant sometimes had to find and write this generic term on his own, the green and blue routes of Figure 6 were passed. Thirdly, the folder *“**lexically-phonemic disorders**”* (Lexikalisch-phonematische Störungen; Neubert, Rüffer & Zeh-Hau, 1994) was used. These sheets

include sets of two words differing in the first grapheme. Here, the correct word has to be underlined. Another task is to choose between three graphemes the corresponding one and to fill in the gap in a word (see Appendix D). Doing this exercise, the purple, green and blue routes of the PALPA-model (Figure 6) can be passed. Using the three NAT-folders, processing pictures and written words was trained. Furthermore, written naming and consequently word retrieval was trained as well. The auditory and verbal routes were not trained using the material.

Copies of the material were handed out to each participant, always matched to the severity of aphasia. Thus, the difficulty levels of the material varied, but the route trained remained the same. In order to make sure that the participants worked on all of the tasks and did not focus on one sort of exercises, they were asked to work on the sheets in a given order. The participants should have the possibility to check their solutions. As the NAT not comprises solution-sheets, the investigator provided these. A native speaker of German double-checked them. The participants were invited to note remaining questions and to ask them in the supervision meetings.

In literature, various different terms appear for "homework": self-training, home-training, homework-tasks, self-learning, etc. To avoid confusion, the generic term *"**homework**"* is used in this investigation; standing for the paper-pencil tasks of the NAT-material including the solutions, which the participants had to perform high-frequently at home.

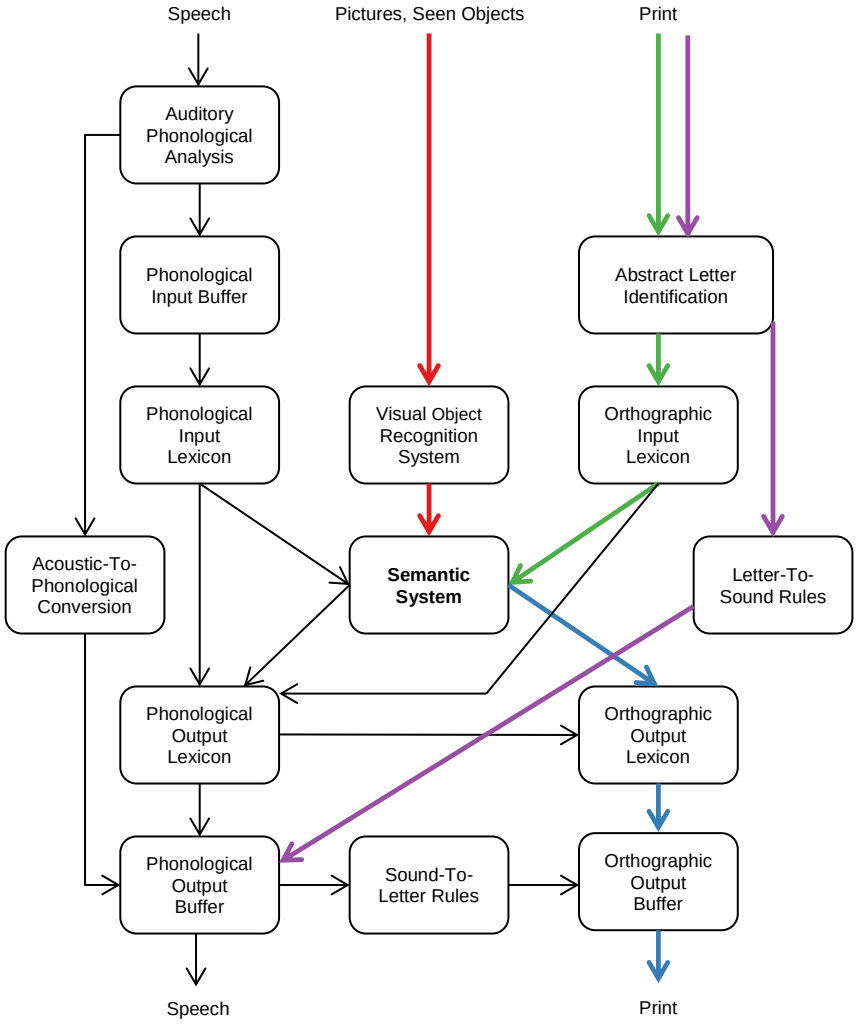


Figure 6. Routes activated because of the NAT-naming-training.

3.3. Supervisions

The supervisions took place in the houses of the participants. During the first meeting, the investigator explained how to work with the sheets. In more detail, every participant was instructed to work on the assigned homework one hour per day, five days a week for three weeks. They were requested to write down the exact times they worked on the tasks and their remaining questions on a timetable (Appendix E). The next date for the supervision as well as the phone number of the investigator (for urgent questions or in case the working-sheets had all been completed) was also noted on this sheet. Having heard the instructions, the participant was invited to start working with the NAT-material. While the participant was working, he was supervised by the investigator. At the end of the meeting, the participant was encouraged by her to continue working with the sheets and was given advice how to improve working. The investigator handed out the material for the following week and exchanged the old timetable for a new one. Finally, the subsequent supervision meeting was planned together with the participant. In addition, the investigator briefed the relatives: they were asked to help the participant only when asked to and then as little as possible. Furthermore, the relatives were asked to provide a quiet environment for the working participant whenever this was possible.

Weekly supervision meetings were planned in order to answer upcoming questions and to make sure that the patient worked correctly on the sheets. Each participant could request additional meetings.

3.4. Research design

Due to the small number of participants, an AB design was chosen for the investigation. Thus, the participants completed three weeks of homework and subsequently had a pause of three weeks (group A). One participant passed through the interventions differently: she had a pause first, followed by the homework (group B). This exception was included in order to be able to considerate variations in the performances without treatment (the first three weeks).

Barthel and colleagues (2008), Kurland, Baldwin and Tauer (2010) and Meinzer and colleagues (2005) stated that an intervention of three hours per day for ten days was leading to a change in language outcomes. However, Brady, Kelly, Godwin and Enderby (2012) concluded in their review that high-intensive therapy (7-20 hours per week) might not suit all patients: the amount of participants dropping out of the intensive speech and language therapy was significantly higher than the dropout of participants of the conventional speech and language therapy. This dropout confounded the potential benefits of the high-intense therapy over low-frequent therapy (Brady et al., 2012). Probably the patients do not want to spend that much time working: either, because they have other appointments or they do not see an improvement. Another reason could be that the patients are confronted with their disability during the working-time and feel too upset to cope with the negative feelings arising. It may be that the participants are even too tired to work over a long period. In that case, the sessions could be split up in shorter sessions. Finally, the patients might not want to have more than one fixed appointment for speech and language therapy per day. Thus, a compromise has to be found between low-frequent and high-frequent therapy to avoid overload of the patients. Earlier research revealed home-training being effective when applied one hour per day for eight weeks (Nobis-Bosch, Radermacher & Springer, 2006). At present, Breitenstein and colleagues (2014) are

executing a randomised controlled trial examining the effectiveness of intensive aphasia-therapy on patients suffering from chronic aphasia. The participants receive ten hours of direct speech and language therapy per week and additionally work five hours per week on the homework assigned. Their interventions last for three weeks. Therefore, the test persons participating in this investigation were instructed to work on the exercises intensively: at least one hour per day (five days a week) for three weeks. The investigator chose not to increase the rate of the conventional speech and language therapy and to maintain the amount of five hours homework per week in order to avoid that participants would discontinue the interventions due to a too high intensity of therapy. The following research design was chosen (see Table 7):

Table 7. Research design.

Group	Test phase I	Intervention phase I (3 weeks)	Test phase II	Intervention phase II (3 weeks)	Test phase III
A	AAT, LEMO 2.0 *(subtests 11-14),* BIWOS, CETI	Intensive homework (5 hours/week)	AAT *(naming, comprehension),* LEMO 2.0 *(subtests 11-14),* BIWOS	Pause	AAT *(naming, comprehension),* LEMO 2.0 *(subtests 11-14),* BIWOS, CETI
B		Pause		Intensive homework (5 hours/week)	

As can be seen in the figure above, the AAT, the subtests 11-14 of LEMO 2.0 and the BIWOS were performed in the first test phase. In the following intervention phase, group A received homework and group B had a pause. Parts of the AAT (naming and comprehension), the subtests 11-14 of LEMO 2.0 and the BIWOS were performed in the subsequent test phase. Following this, group A had three weeks of pause while group B worked on the assigned homework. In the last test phase, the same tests were executed as in the previous test phase. The relatives only completed the CETI in the first and last test phase due to a simple reason: the questionnaire should not be filled in too often in a short interval providing time for the recognition of changes. Furthermore, group B had a pause first and the investigator did not expect this pause leading to changes in the outcome. The supervision meetings are not included in the figure. During the homework intervention phases, there was one supervision meeting per week and patient. When the participants paused, they did not have supervision meetings.

3.5. Test persons

It was mentioned earlier that all participants were recruited via speech and language pathologists or self-help groups. Seven participants (three female, four male) suffering from aphasia were included in the investigation. Their age range was 57-74 (m = 66.7 years). Four of them suffered from amnestic aphasia while the other three aphasias could not be classified. On average, the last stroke was three years ago (range = 0;08 - 10;02 years). The participants' initial letters were changed in order to preserve anonymity and to secure their privacy. The participants are listed in the order they have been included in the investigation.

All except one of the participants (A.N.) received speech and language therapy once, twice or three times a week. Below, each participant is briefly introduced. Table 8 provides information about

the participants' gender, age, duration and type of aphasia, group of intervention and length of education (including school and training courses). All participants used to be or still are right-handed. Four of them suffer from hemiparesis and compensate that writing with the left hand.

Table 8. Participant information.

Partici-pant	Gender	Age [years]	Time post onset [years;months]	Type of aphasia	Group of intervention	Length of education [years]
L.F.	Male	63	0;08	Amnestic	A	12
I.M.	Male	72	3;00	Amnestic	A	15
P.L.	Male	59	2;02	Non classifiable	A	12
A.N.	Female	57	10;02	Amnestic	A	10
E.J.	Male	70	1;10	Non classifiable	A	14
D.O.	Female	72	3;02	Non classifiable	A	13
K.W.	Female	74	1;02	Amnestic	B	11
		m = 66.7	m = 3;02			m = 12.4

Participant L.F.

The first participant, L.F. (male) born in June 1951, had his first stroke at the age of twelve. He attended secondary school, went to the commercial school for two years and worked as an administration employee afterwards. In August 2014, he suffered a second stroke. Due to this, his word retrieval and writing was worse and since then, he has been suffering from a right-sided hemiparesis and has been using a power wheelchair. Today, L.F. lives on his own in a building for disabled persons. He manages a self-help group and visits his friends in the same building. He likes to have visitors at his home, too. Twice a week, he receives speech and language therapy at home. The AAT, executed on 2015/03/31, revealed the patient to suffer from amnestic aphasia (see Appendix F.a). In the Token Test, repeating and speech comprehension he had a mild disorder and writing and naming were minimally disordered. The participant answered all items of LEMO 2.0 subtests 11-14 correct. The BIWOS revealed word-finding problems of medium severity. The results concerning semantics were better than the lexical ones. Due to the fact that Mr F. lives on his own and is irregularly visited by his daughter, it was not possible to ask a relative to fill in the CETI. Therefore, the participant filled in the questionnaire on his own. In spontaneous speech, the participant sometimes uses empty speech and shows word-finding difficulties, as the speech is not fluent. However, he is able to express his thoughts and needs without the help of the dialogue partner.

Participant I.M.

I.M. (male) was born in March 1943. After the high school graduation, he started a degree course, which he did not complete. He worked as an innkeeper and taxi driver. Today he is pensioner and lives together with his wife in a flat. The participant attends speech and language therapy once a week in an outpatient department. The AAT executed on 2015/04/20 showed the participant to suffer from amnestic aphasia (see Appendix F.b). I.M. achieved medium results in the Token Test and repeating.

Concerning writing and speech comprehension the participant is mildly affected. In naming, he achieved the best result: a minimal impairment. Mr M. answered every item of LEMO 2.0 correct, regardless of the subtest. However, the BIWOS revealed a deficit in naming of medium severity. He achieved higher results in the semantical part than in the lexical part. Mr M. did not want his wife to fill in the CETI and consequently he was the one completing the form. The participant speaks fluently, but sometimes shows phonemic paraphasias and does not terminate sentences.

Participant P.L.

Participant P.L. (male) was born in September 1955. After he had attended secondary school, he completed a professional training and worked as a locksmith. He suffered a stroke in 2013 and today, he still suffers from a right-sided hemiparesis and therefore uses a wheelchair. The participant lives in a nursing home attending almost every activity possible. He likes to be active and to receive visitors. The speech and language therapy takes place once a week. His aphasia was not classifiable through the AAT, executed on 2015/04/27 (see Appendix F.c). He performed well at the Token Test and repeating, while naming, writing and speech comprehension were moderately affected. LEMO 2.0 showed problems in oral and written naming; nonetheless, word-picture matching (auditory and visual) was spared. He performed poorly in the BIWOS having strong problems in naming, especially in the lexical part. Mr L. wanted to fill in the CETI on his own. His speech comprehension was yet affected and therefore, he filled in the questionnaire together with the investigator (she asked the questions and made sure they were correctly understood by the participant). Conversations are only possible in case the topic is clear to the dialogue partner, because the participant shows strong word-finding difficulties and needs the help of the dialogue partner to express his thoughts. In spontaneous speech, he shows semantic paraphasias and sometimes phonemic uncertainties as well. Furthermore, stereotypes commonly occur in his speech and he frequently omits the verb in sentences.

Participant E.J.

E.J. (male) was born in January 1945 and worked as a master mechanic after having completed the professional training. In June 2013, he suffered a stroke and subsequently retired. He lives together with his wife, likes to meet friends for a coffee and attends speech and language therapy once a week in an outpatient department. The AAT of 2015/03/30 revealed the participant to suffer from aphasia, which could not be classified (see Appendix F.d). He performed moderately on the Token Test, naming, repeating and writing, while his speech comprehension is mildly affected. The results of LEMO 2.0 showed the participant to have more problems naming objects than matching words and pictures. The BIWOS revealed the participant to have severe problems in word-finding. He achieved more points in the semantical part than in the lexical one. The CETI was filled in by his wife. The participant's spontaneous speech is characterised by phonemic paraphasias and word-finding difficulties. He is able to express his thoughts mostly without the help of the dialogue partner. The participant often does not finish sentences and sometimes uses empty speech.

Participant A.N.

A.N. (female) was born in September 1957 and after secondary school, she started a professional training, which she did not complete. She worked as housewife and cleaning lady. Mrs N. suffered a stroke in 2005 and has been using a wheelchair since then due to her right-sided hemiparesis. She does not attend speech and language therapy and lives together with physically disabled people in a house. She does not receive visitors often and does not leave the house without company. The AAT (2015/04/30) revealed Miss N. to suffer from amnestic aphasia (see Appendix F.e). She performed well at the Token Test, the writing and the naming part. Her speech comprehension was minimally distorted but she had difficulties in repeating. She performed well at LEMO 2.0, not receiving all points because of spelling mistakes. The BIWOS revealed word-finding problems of moderate severity. She performed better in the semantical than in the lexical part. Due to the fact that Mrs N. lives in a residential community with other physically disabled people and only has sporadic contact to her family, the CETI was filled in by her in the presence of the investigator. The spontaneous speech of the participant is fluent. Sometimes she shows phonemic uncertainties and omits verbs or uses the wrong form of the verb in a sentence.

Participant D.O.

Mrs O. was born in February 1943 and completed a commercial training in her youth. She worked full-time as a secretary before she suffered a stroke in 1991. Today, she lives together with her husband in a house and attends speech and language therapy twice a week. The results of the AAT (2015/05/04) revealed the participant to suffer from a non-classifiable aphasia (see Appendix F.f). She performed well at the Token Test and had minimal problems in speech comprehension and writing. Repeating and naming were mildly affected. LEMO 2.0 showed that the participant had no problems in naming objects while the BIWOS showed word-finding problems of medium severity. The participant performed better in the semantical part than in the lexical one. Mr O. filled in the CETI. The spontaneous speech of the participant is characterised by word-finding difficulties (saying ‘äh’) and semantic and phonemic paraphasias. She does not finish sentences or uses complex, entangled structures frequently. However, if given time, the participant can express her thoughts without the help of the dialogue partner.

Participant K.W.

The participant (female) was born in December 1940. She completed a professional training as a businessperson and was gainfully employed before becoming a housewife. In 2014 she suffered a stroke and since then has been using a wheelchair due to her right-sided hemiparesis. She attends speech and language therapy three times a week. The AAT (2015/05/06) showed Mrs W. to suffer from amnestic aphasia (see Appendix F.g). She performed well in the Token Test. Naming, writing and speech comprehension were also mildly affected. Her ability to repeat was moderately distorted. LEMO 2.0 showed the participant to have only minimal problems in object naming. The BIWOS revealed Mrs W. to be strongly affected in word-finding. She performed better in the semantical than in the lexical part of the test. Mrs W. filled in the CETI together with her husband. Her spontaneous speech is characterised by word-finding difficulties and sometimes she shows phonemic paraphasias and does not terminate sentences.

3.6. Data analysis

The investigator digitalised the outcome of each test to allow a statistical analysis using SPSS Statistics 21 (IBM, 2012). The outcomes of the CETI and the language tests were analysed separately. Below, the analysis of the language tests, followed by the analysis of the CETI-data is explained.

This investigation includes the language outcome as a dependent variable and the three measurement points (baseline, after the first intervention and after both interventions) as the three conditions of the independent variable. Because seven individuals participated in this study (n = 7 = <30), a non-parametric test was executed. All participants ran through both interventions and consequently, repeated-measures had to be performed. It was mentioned in the previous section that one participant completed the interventions vice versa. Thus, six participants completed the interventions in the same order. Therefore, the results of these six individuals were compared. A non-parametric, within-subject design can be applied using Friedman's ANOVA. This test assigns a rank to each score of each participant and subsequently compares these ranks among one another. Friedman's ANOVA is denoted by χ^2 (Field, 2009). In case Friedman's ANOVA is significant ($p \leq 0.05$), a non-parametric post hoc test has to be performed in addition (Field, 2009). The Wilcoxon signed-rank test, i.e. the non-parametric alternative of the dependent t-test test, will be used in that case. Its outcome is denoted using *T*, which is the smaller of the two sums of ranks for each of the tests and the effect size *r* (Field, 2009). Here, the Bonferroni correction (see Field, 2009) will be applied to correct the critical level for the number of comparisons. As there were three different measurement points, three comparisons would have to be made. Consequently, the critical value would have to be divided through three: 0.05 / 3 = 0.0167. Additionally, another post hoc test can be executed as well (see Field, 2009, 578). This post hoc test (see Siegel & Castellan, 1988) compares the difference of the mean ranks of the groups to a particular z-value. The z-value is corrected for the number of comparisons, taking *k* (the number of conditions) and *N* (total sample size) into account (see Formula 1):

$$|\overline{R_u R_v}| \geq z_{\propto/k(k-1)} \sqrt{\frac{k(k+1)}{6N}}$$

Note. $\overline{\boldsymbol{R_u}}$ = mean rank of first condition; $\overline{\boldsymbol{R_v}}$ = mean rank of second condition; *z* = z-value; α = critical value; *k* = number of conditions; *N* = total sample size

Formula 1. Post hoc test (Field, 2009, 578).

The left-hand side is the difference between the mean ranks of the two groups being compared, regardless of the sign of the difference. The right-hand side is the critical difference being applied. The critical value of 0.05 was used and therefore, the z-value belonging to 0.05 / 3 * (3 - 1) = 0.00833 was looked up. The corresponding z-value was between 2.39 and 2.40, thus: 2.395.

In the analysis, the outcome of all tests and participants together were added up, forming the overall change in language outcome. In addition, the outcomes of the tests were split into four different categories, corresponding to the hypotheses:

- Oral Naming: AAT Naming + LEMO 2.0 Oral Naming + BIWOS
- Written Naming: LEMO 2.0 Written Naming
- Auditory Speech Comprehension: LEMO 2.0 Speech Comprehension, auditory + AAT Speech Comprehension, auditory
- Visual Speech Comprehension: LEMO 2.0 Speech Comprehension, visual + AAT Speech Comprehension, visual

The CETI was filled in by the relatives of the participants twice: at the beginning and in the last test phase. Therefore, the same participants took part in the same test twice. Thus, there is one independent variable and one dependent variable with two categories; hence, the Wilcoxon matched-pairs test had to be used (Field, 2009). Here, a critical value of 0.05 was used to look for a significant effect of the treatment.

In addition to the statistical tests, descriptive statistics will be included to represent the outcomes. Due to this, the maximal amount of points, which could have been achieved in each test, is displayed in the Table 9.

Table 9. Maximal amount of points for each test.

Test	Maximal amount of points		
	Total	**Speech comprehension**	**Naming**
AAT Speech comprehension	120	120	
AAT Naming	120		120
LEMO 2.0 Naming	40		40
LEMO 2.0 Speech comprehension	40	40	
BIWOS	184		184
CETI	170		
Total	634	160	344

4. Results

In this chapter, the statistical results of the language tests are presented, followed by the statistical analysis of the CETI. The last part of this chapter provides a detailed description of each participant's language outcome.

Before analysing the outcomes of the language tests, the duration the participants spent working on the homework is considered. Table 10 lists the duration the participants claimed to have spent on the assigned tasks. Furthermore, the table lists the total minutes the participants worked on the material and the mean time per week. Every participant was asked to work minimally 300 minutes per week. In each supervision meeting, the investigator encouraged the participant to adhere to this amount of minutes. Due to this, some of them balanced their workload over the three weeks (e.g. participant L.F. or K.W.). Nevertheless, it is apparent that not every participant worked consequently on the NAT-material. While participants L.F., I.M., P.L., D.O. and K.W. worked about 300 minutes (+/- 60 minutes) per week, participant A.N. worked more than she was asked to. On average, she spent 466 minutes per week on her homework. Still, she was the only participant not receiving speech and language therapy. The other participants received speech and language therapy on average twice a week with each session lasting 45 minutes. Therefore, 90 minutes were subtracted from the default 466 minutes, leading to an amount of 376 minutes. Even after this correction, A.N. still worked about an hour per week more than expected. However, there was no maximum amount of minutes given to the participants. Therefore, her results were included in the analysis. In contrast to A.N., E.J. worked on average only 171 minutes per week, which is less than three hours of work per week (180 minutes > 171 minutes). The participant therefore did not achieve a high-frequent working mode. In total, he is missing 385 minutes; that is more than one full week of working on the sheets. Consequently, the data of F.J. were excluded from the inductive statistical analysis in order to prevent a distortion of the results. Nevertheless, his language outcomes will be included in the descriptive statistics to show what low-frequent speech and language therapy can achieve.

Table 10. Duration of homework per participant.

Participant	Total duration [minutes]	Mean duration per week [minutes]	Duration per week [minutes]		
			Week 1	Week 2	Week 3
L.F.	900	300	365	240	295
I.M.	895	298	290	300	305
P.L.	1080	360	495	345	240
A.N.	1400	467	590	470	340
E.J.	515	172	120	200	195
D.O.	810	270	300	280	230
K.W.	1025	342	245	420	360
Mean	946	315	344	322	281

4.1. Inductive statistics

The data used for the analysis can be found in the appendix (Appendix G, H and I). As mentioned above, Friedman's ANOVA was executed for the overall language outcome and for each language outcome independently (Appendix J).

The ***overall language outcome*** of the participants changed significantly over the six weeks of intervention $\chi^2(2) = 8.4$, $p < 0.01$ (see Table 12). It can be concluded by looking at the means (see Table 11) that the outcomes of the language tests increased over time (mean before the interventions = 359, mean after the homework = 384, mean after the pause = 389).

Table 11. Descriptive Statistics of the overall language outcome.

	N	Mean	Standard deviation	Minimum	Maximum
Before the interventions	5	359,40	59,496	254	397
After the homework	5	384,40	38,772	316	411
After the pause	5	389,60	45,774	310	428

Table 12. Friedman's ANOVA of the overall language outcome.

Ranks	
	Mean Rank
Before the interventions	1,00
After the homework	2,20
After the pause	2,80

Test Statistics	
N	5
Chi-Square	8,400
df	2
Asymp. Sig.	,015
Exact Sig.	,008
Point Probability	,008

The Wilcoxon signed-rank test was used to follow up the significant result of Friedman's ANOVA. In this non-parametric post hoc analysis, a Bonferroni correction was applied and therefore a critical value of 0.0176 (for calculation see 3.6 Data analysis) was used to correct for the number of comparisons. The test revealed that the naming ability of the participants did neither change significantly in the pause $T = 3$, $r = -0.38$ (moderate effect), nor during the three weeks of intensive homework $T = 0$, $r = -0.64$ (strong effect; see Appendix J.a). Furthermore, both interventions taken together (i.e. the homework and the pause) did not lead to a significant change in naming ability, $T = 0$, $r = -0.64$.

The second post hoc test was executed using Formula 1. Calculating the critical difference, *k* and *N* had to be entered in the right-hand side. The number of comparisons, *k*, was 3 and the total number of participants, *N*, was 5 (due to the exclusion of two participants). Using these numbers, the critical difference was calculated:

$$\text{Critical difference} = z_{\propto/k(k-1)}\sqrt{\frac{k(k+1)}{6N}}$$

$$= 2.395\sqrt{\frac{3(3+1)}{6*5}}$$

$$= \underline{1.51}$$

The differences between mean ranks were compared to the critical difference subsequently. The mean ranks can be found in the results of Friedman's ANOVA (see above). The following differences between mean ranks for the data were calculated:

Table 13. Differences between mean ranks (post hoc test change in overall language outcome).

Comparison		$\overline{R_u}$	$\overline{R_v}$	$\overline{R_u} - \overline{R_v}$	$\lvert\overline{R_u} - \overline{R_v}\rvert$
1	Before the interventions – After the homework	1	2.2	-1.2	1.2
2	Before the interventions – After both interventions	1	2.8	-1.8	1.8
3	After the homework – After both interventions	2.2	2.8	-0.6	0.6

Consequently, the values 1.2, 1.8 and 0.6 were compared to the critical difference of 1.51. The test revealed the differences in comparison one (Before the interventions – After the homework) and in comparison three (After the homework – After both interventions) not to be significant ($0.6 < 1.2 < 1.51$; see Table 13). However, the difference in comparison two (Before the interventions – After both interventions) was significant ($1.8 > 1.51$). Consequently, both interventions together led to a significant change in language outcome.

The ability to ***name*** something ***orally*** increased significantly over the six weeks of intervention $\chi^2(2) = 7.6$, $p < 0.025$ (see Table 14 and Table 15). However, the changes were neither significant in the Wilcoxon signed-rank test, nor in the second post hoc test (see Appendix J.b and J.c). Contrastingly, the ability to ***name*** something in ***writing*** did not change significantly over the six weeks of intervention (see Appendix J.d).

Table 14. Descriptive Statistics of Oral Naming.

	N	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**
Oral Naming Baseline	5	203,20	45,724	124	238
Oral Naming After the homework	5	221,60	28,157	175	250
Oral Naming After both interventions	5	225,60	34,997	167	261

Table 15. Friedman's ANOVA of Oral Naming.

Ranks	
	Mean Rank
Oral Naming Baseline	1,00
Oral Naming After the homework	2,40
Oral Naming After both interventions	2,60

Test Statistics	
N	5
Chi-Square	7,600
df	2
Asymp. Sig.	,022
Exact Sig.	,024
Point Probability	,015

The interventions did not lead to a significant change in the outcome of the ***auditory speech comprehension*** (see Appendix J.e). The participants' ***visual speech comprehension*** (ability to comprehend written language) did not change significantly during the intervention phases (see Appendix J.f).

For the statistical analysis of the CETI-data, the Wilcoxon matched-pairs test was used. The analysis revealed the ***communication ability*** of the participants from the first and second measurement not to differ significantly (see Appendix J.g).

4.2. Descriptive statistics

Due to the small number of participants in this investigation, it is useful to look at the language outcomes in more detail. In order to make comparisons of all language outcomes possible, the point values have been converted into percentages. At first, the overall changes in language outcomes are described. Here, only the results of the five participants, who have been included in the statistical analysis, have been entered. In the subsection thereafter, the outcome of each of the seven participants is illustrated and described one by one.

4.2.1. Overall changes of language outcome

In the following, three diagrams showing the overall language ability are included:

- The first figure (Figure 7) provides an overview of the overall change in language outcome.
- The second one (Figure 8) demonstrates the overall change in language outcome sorted by test and
- The third one (Figure 9) shows the outcome of the BIWOS in more detail.

Figure 10 shows the overall change in language outcome sorted by modality. A figure depicting the mean amount of points of the CETI (Figure 11) as well as a table showing the points achieved in the BIWOS word fluency part (Table 16) follow. Each figure is based on the results of the five participants (L.F., I.M., P.L., A.N. and D.O.).

Figure 7 shows the overall change in language outcome. For each point in time, the point values of the three different language tests were added and then converted into percentages. At the baseline, 80% of all answers were correct. After the homework, that number increased up to 84%. Thus, the participants gave more correct answers than before. After the second intervention, the number of overall correct answers had gained one percentage point and increased up to 85%.

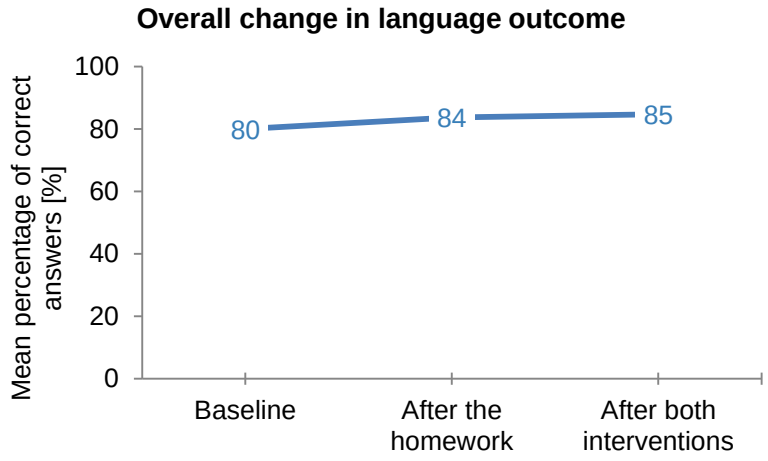


Figure 7. Overall change in language outcome.

Although Figure 7 already showed a change of the overall language outcome over the intervention time, Figure 8 proves whether the mean percentage of correct answers increased in each test. Except of LEMO 2.0 Speech comprehension, the scores of each test increased. On average, all participants answered correctly in LEMO 2.0 Speech comprehension. Thus, there is a ceiling effect. However, the scores of the other subtests do not show ceiling effects. Concerning the BIWOS, the participants gained six percentage points in the first intervention phase (to 53%) and two percentage points in the second intervention phase (55%). In AAT Naming, the mean percentage of correct answers rose from 81% to 88% in the first intervention phase and was constant in the second intervention phase. Regarding AAT Speech comprehension, the mean percentage increased from 83% to 89% after the homework and was constant afterwards, too. In LEMO 2.0 Naming, the participants gained on average three percentage points in the first intervention phase (92%) and achieved one percentage point more in the second intervention phase (93%).

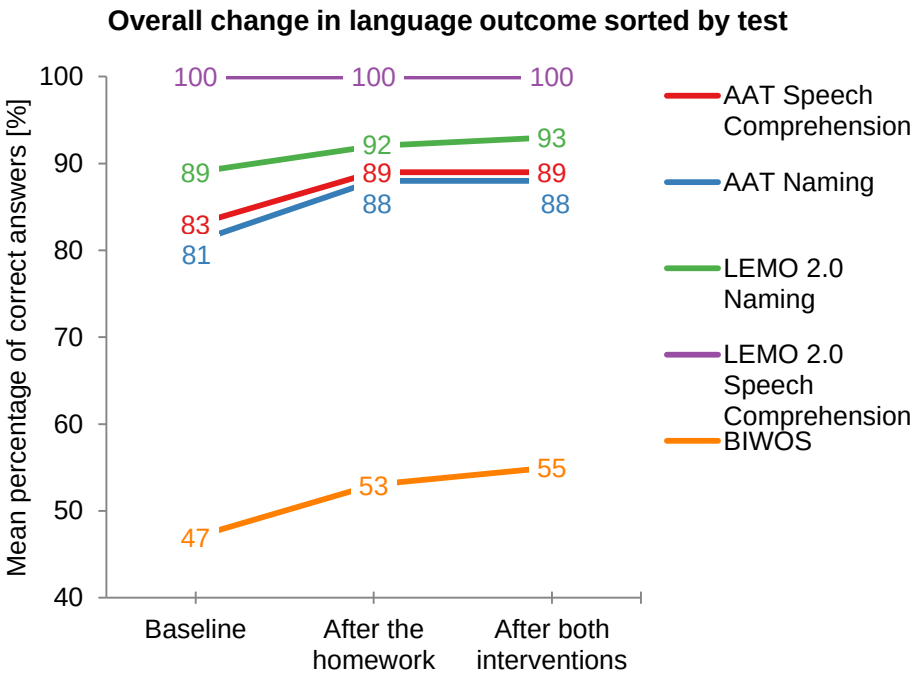


Figure 8. Overall change in language outcome sorted by test.

The BIWOS-outcome can be split into the semantically and the lexically part (see Figure 9). Looking at the alteration, the average amount of correct answers in the lexical part changed over both interventions while the average amount of correct answers in the semantical part only changed in the first intervention phase. The participants achieved on average 38% correct answers in the lexical part of the BIWOS in the baseline. In the subsequent measurement point, their results had increased by eleven percentage points (49%) and increased to 53% correct answers in the last measurement point. Regarding the semantical part, the participants gained one percentage point in the first intervention phase (from 55% to 56%) and kept that amount constant. The mean amount of correct lexical answers approached to the mean amount of correct semantical answers. Nevertheless, the average amount of correct answers in the semantical part was higher than the average amount of correct answers in the lexical part at each measurement point.

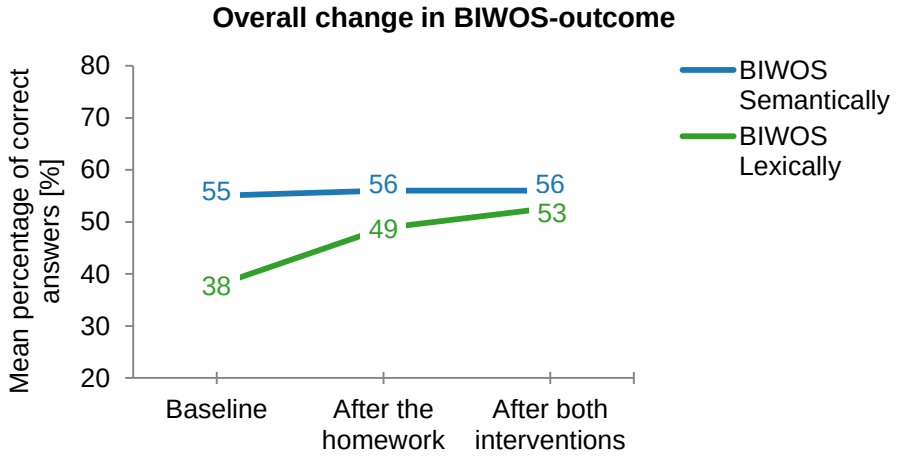
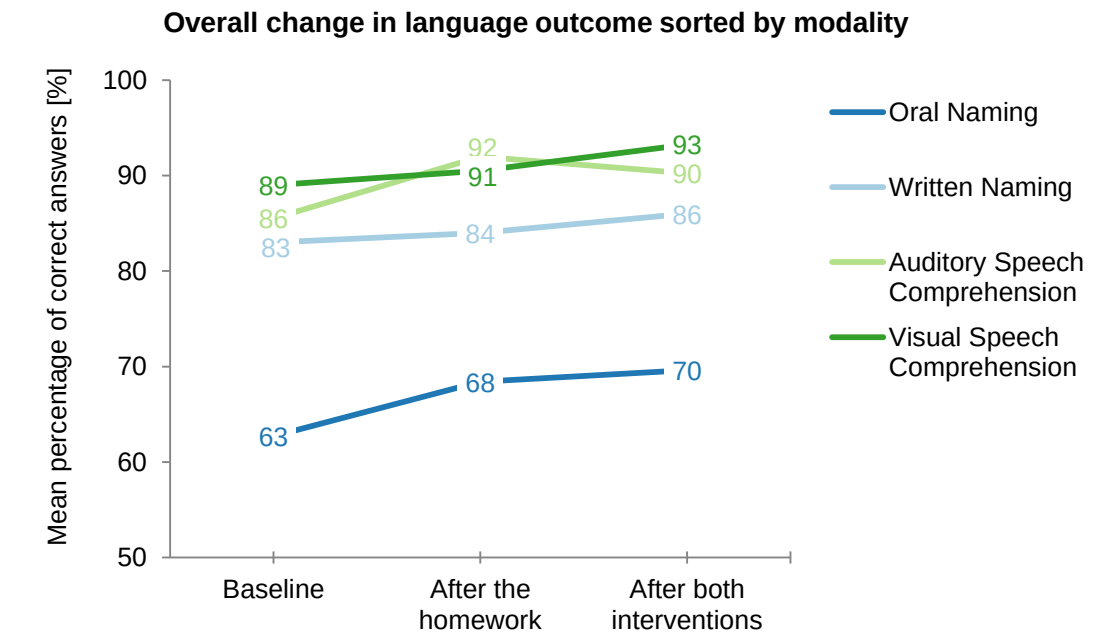


Figure 9. Overall change in BIWOS-outcome.

Figure 10 demonstrates the overall outcome of the language tests split by modality. In comparison to the baseline, the percentages of correct answers of each modality were higher after the intensive homework. Oral Naming increased from 63% to 68% correct, while Written Naming increased one percentage point (to 84%). Auditory Speech Comprehension increased eight percentage points (to 92%) and Visual Speech Comprehension increased two percentage points (to 91%). The average amount of correct answers in three of the four modalities increased after the pause, too. In total, 70% of the Oral Naming-items were answered correctly. Concerning Written Naming, 86% were correct and the percentage of correct answers using Visual Speech Comprehension increased to 93% correct. The average amount of correct answers in Auditory Speech Comprehension decreased from 92% to 90%.



Note. Oral Naming = AAT Naming + LEMO 2.0 Oral Naming + BIWOS; Written Naming = LEMO 2.0 Written Naming; Auditory Speech Comprehension = LEMO 2.0 Speech Comprehension, auditory + AAT Speech Comprehension, auditory; Visual Speech Comprehension = LEMO 2.0 Speech Comprehension, visual + AAT Speech Comprehension, visual

Figure 10. Overall change in language outcome sorted by modality.

The CETI-data for each participant is given in the following subsection (see also Appendix H). The individual outcomes of this test are not provided in figures. However, for the five participants together, the means of the two measurement points were calculated, converted to percentages and are provided in Figure 11. The CETI comprises 17 questions, each one counting maximal ten points. Thus, regarding the CETI, a participant could achieve a maximum of 170 points per measurement point. In the baseline, the mean amount of points the participants achieved was 97. That is equal to achieving 57% of all points. Converted, that would be assigning a line at 5.7 cm to each horizontal line of each question. After both interventions, the mean amount of points was higher: 108 points. Converted to percentages, that is 64% of all points, which is equivalent to assigning a line on 6.4 cm at each question. The total difference of the measurement points is eleven points, which is equivalent to 0.7 cm. On average, the participants received more points in the second measurement.

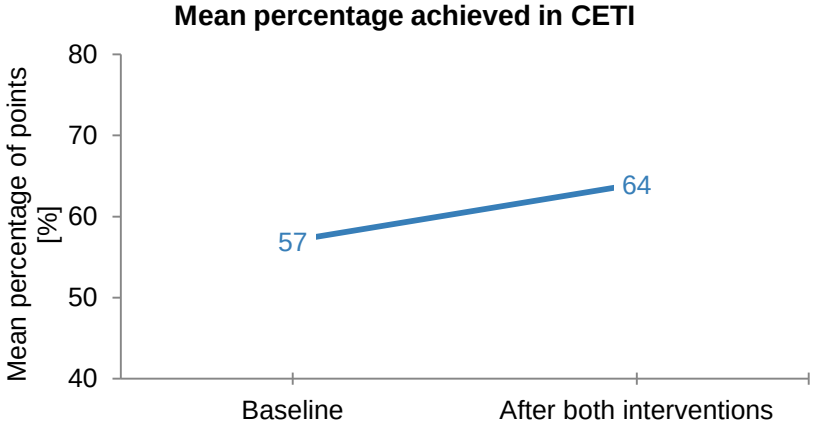


Figure 11. Mean points achieved in the CETI.

Table 16 shows the points the participants achieved in the word fluency parts of the BIWOS. The most participants achieved the same scores in the first and second measurement point. Two participants achieved exactly the same amount of points, while two others gained points in the semantical part of word fluency. Only one participant lost points in the semantical part while gaining points in the lexical part (L.F.). After the second intervention, most participants improved or achieved the same amount of points as before. Only one participant lost some points in the semantical part of word fluency (I.M.). Three participants improved their semantical word fluency while two improved the lexical word fluency. D.O. achieved the same amount of points in each measurement point.

Table 16. Points achieved in BIWOS word fluency.

Participant	BIWOS word fluency part	Points achieved [max. 6 points]				
		Baseline	Difference between baseline and after the homework	After the homework	Difference between after the homework and after both interventions	After both interventions
L.F.	Semantical	3	-2	1	+1	2
	Lexical	0	+2	2	/	2
I.M.	Semantical	2	+4	6	-3	3
	Lexical	2	/	2	+1	3
P.L.	Semantical	1	+1	2	-1	1
	Lexical	0	/	0	+1	1
A.N.	Semantical	3	/	3	+1	4
	Lexical	4	/	4	/	4
D.O.	Semantical	1	/	1	/	1
	Lexical	0	/	0	/	0

4.2.2. Individual changes of language outcome

In this section, the outcomes of each participant are described one after another. A diagram showing the language outcome sorted by language test is displayed and described. In addition, a second diagram demonstrating the categorised language outcomes is provided for each participant. The order in which the participants' outcomes are displayed is the same that was used before. Please note that in case only the outcome for one data point of a line is given, the outcome simply did not change and therefore is displayed only once.

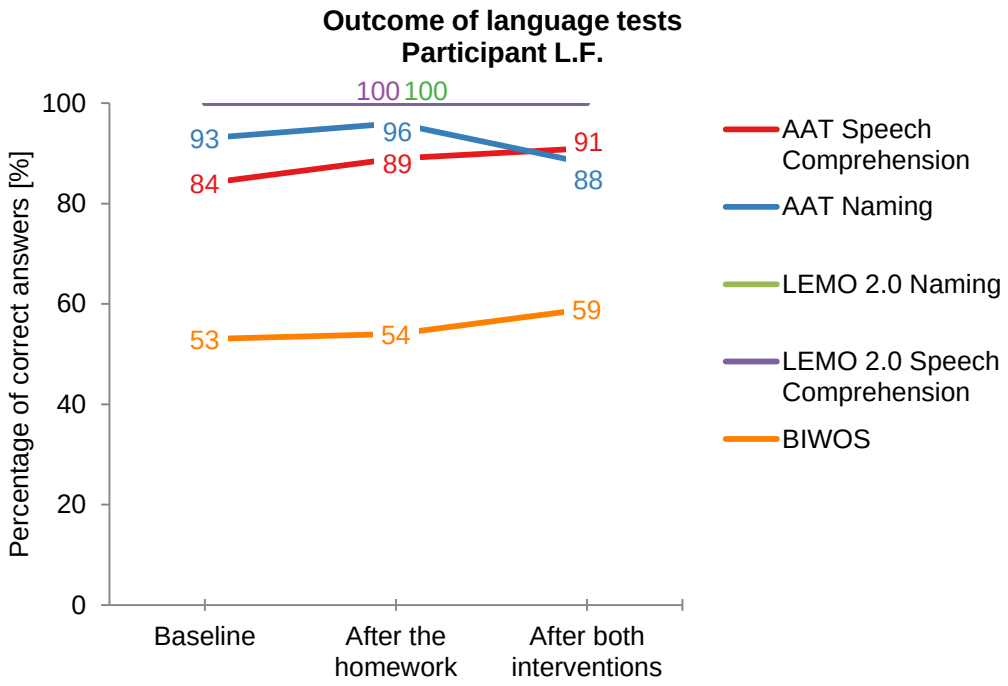


Figure 12. Outcome of language tests, participant L.F.

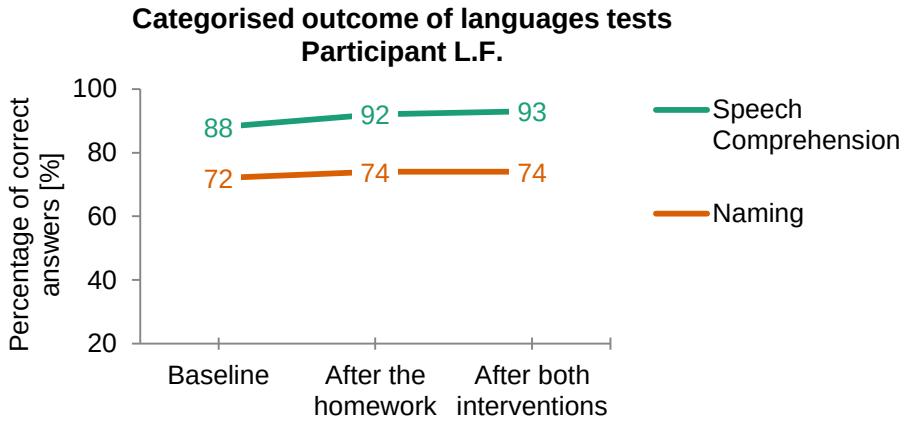


Figure 13. Categorised outcome of language tests, participant L.F.

After the homework, L.F. answered more items correctly than before in the speech comprehension part (89% > 84%) and the naming part (96% > 93%) of the AAT (see Figure 12). Additionally, he improved one percentage point in the BIWOS (54% > 53%). However, after the pause, his naming-ability measured with the AAT worsened (88%) while it improved measured with the BIWOS (59%). After both interventions, the AAT Speech Comprehension improved to 91% correct. It can easily be seen that Mr F. scored all items in LEMO 2.0 Naming and Speech Comprehension correct in each point in time. Therefore, there is no variation in percentage. In other words, a ceiling effect can be perceived here. In short, L.F. gave slightly more answers that are correct after the intensive homework in both: Speech Comprehension (92% > 88%) and Naming (74% > 72%; see Figure 13). His scores in Naming were constant while his Speech Comprehension improved one percentage point, to 93%, after the pause.

Mr F. achieved 57% correct in the semantical part and 49% correct in the lexical part of the BIWOS in the baseline (see Appendix K.a). He improved in the lexical part, gaining three percentage

points (52%), while he lost one percentage point in the semantical part (56%) in the second measurement point. In the last test phase, Mr F. improved in the lexical (59%) and semantical part (60%). Thus, at the end he achieved more correct answers in the lexical than in the semantical part.

Regarding the scores of the CETI, L.F. achieved 100 points in the baseline and 89 points after both interventions. Hence, the outcome of the questionnaire decreased over the interventions.

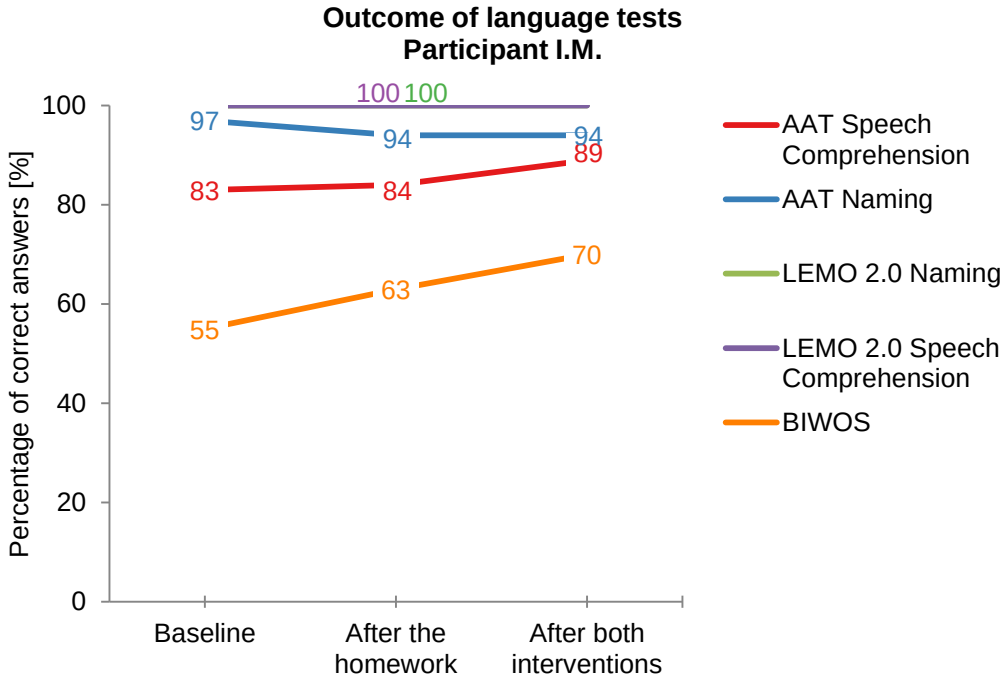


Figure 14. Outcome of language tests, participant I.M.

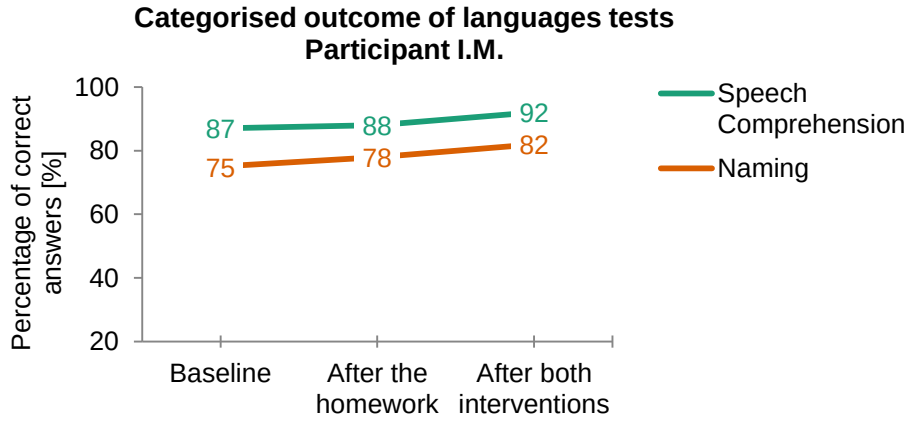


Figure 15. Categorised outcome of language tests, participant I.M.

In the first test period, participant I.M. scored 55% in the BIWOS, 83% in AAT Speech Comprehension and 97% in AAT Naming correctly (see Figure 14). After the intensive homework, he achieved higher language outcomes in the BIWOS (63%) and in AAT Speech Comprehension (84%). However, his score in AAT Naming decreased three percentage points, to 94%. After the pause, he improved in the BIWOS (70%) and in the AAT Speech Comprehension (89%), while the score of AAT Naming was constant (94%). Participant I.M. answered every item of both LEMO 2.0-parts on every point in time correctly. Thus, a ceiling effect can be perceived here. To summarise, I.M. constantly improved in

both: Speech Comprehension (87% < 88% < 92%) and Naming (75% < 78% < 82%) over the experimental time (see Figure 15).

Mr M. improved constantly in each part of the BIWOS. In the baseline, he achieved 63% correct in the semantical part and 46% correct in the lexical part (see Appendix K.b). He gained three percentage points in the semantical part (66%) and fifteen percentage points in the lexical part (61%) in the second test phase. In the last test phase, Mr M. achieved 68% in the semantical and 72% in the lexical part of the BIWOS. Thus, the outcomes increased again. At the end, the participant achieved a higher percentage of correct answers in the lexical part than in the semantical part.

Looking at the scores of the CETI, Mr M. achieved 68 points in the baseline and 76 points after both interventions causing this outcome to increase over the interventions.

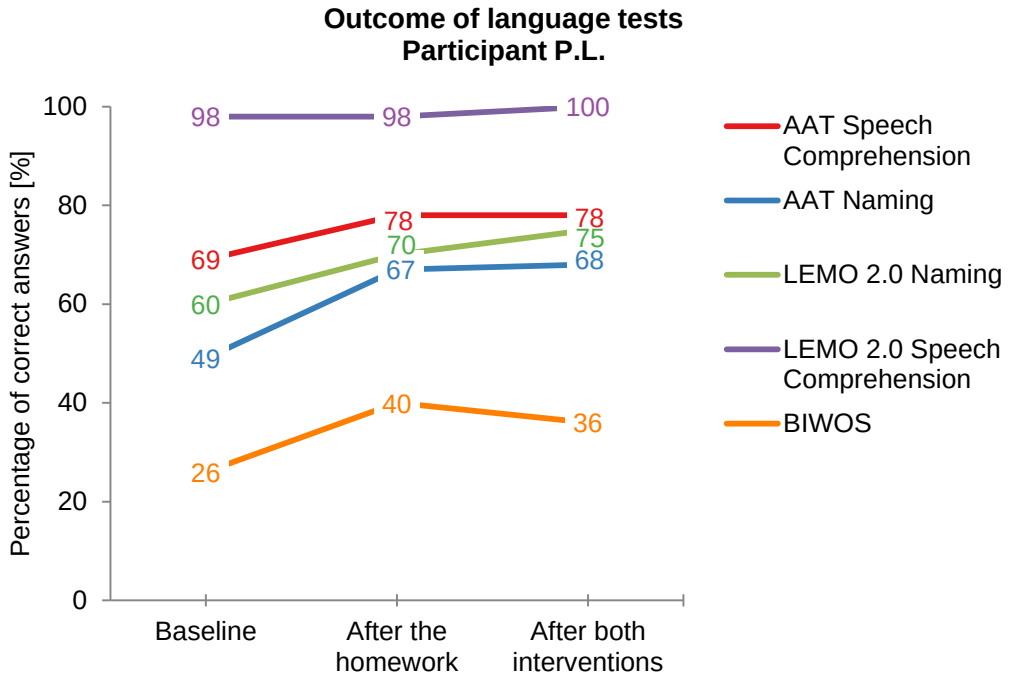


Figure 16. Outcome of language tests, participant P.L.

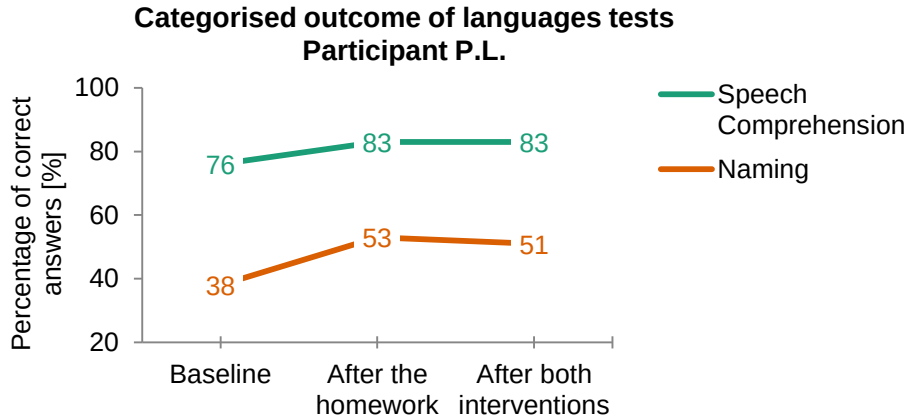


Figure 17. Categorised outcome of language tests, participant P.L.

Mr L. improved on every language test except LEMO 2.0 Speech Comprehension after the intensive homework (see Figure 16). In the BIWOS, he gained fourteen percentage points after the first intervention (40% > 26%). In LEMO 2.0 Naming, he achieved ten percentage points more (70% > 60%), in AAT Naming eighteen percentage points more (67% > 49%) and in AAT Speech Comprehension nine percentage points more (78% > 69%). However, his Speech Comprehension was constant in LEMO 2.0 (98%). After the pause, the percentage of correct answers in the BIWOS decreased from 40% to 36%, while it rose in LEMO 2.0 Naming (75% > 70%), AAT Naming (68% > 67%) and LEMO 2.0 Speech Comprehension (100% > 98%). However, the score of AAT Speech Comprehension was constant (78%). To conclude, P.L. improved in Naming in the first intervention phase (see Figure 17). He achieved fifteen percentage points more than in the baseline (53% > 38%). Regarding Speech Comprehension, he gained seven percentage points (83% > 76%). From the intermediate measurement point until the last P.L.'s Speech Comprehension was constant (83%) while his Naming-scores dropped a little (51% < 53%).

P.L.'s outcome in the BIWOS increased in the first intervention phase but decreased in the second (see Appendix K.c). Looking at the outcome in more detail, Mr L. achieved in the lexical part of the BIWOS constantly more points. At the baseline, he scored 20% correct and after the homework, he achieved 35% correct. After both interventions, he achieved 37% correct. However, his language outcome did not increase constantly in the semantical part of the BIWOS. Here, the mean percentage of correct answers increased from 32% in the first measurement point to 45% in the second one. However, it decreased to 35% in the third measurement point again. In the last test phase, P.L. scored better in the lexical than in the semantical part of the BIWOS.

In the CETI, Mr L. achieved 120 points at the baseline and 143 points after both interventions. Accordingly, the effectiveness index rose from the first to the second measurement point.

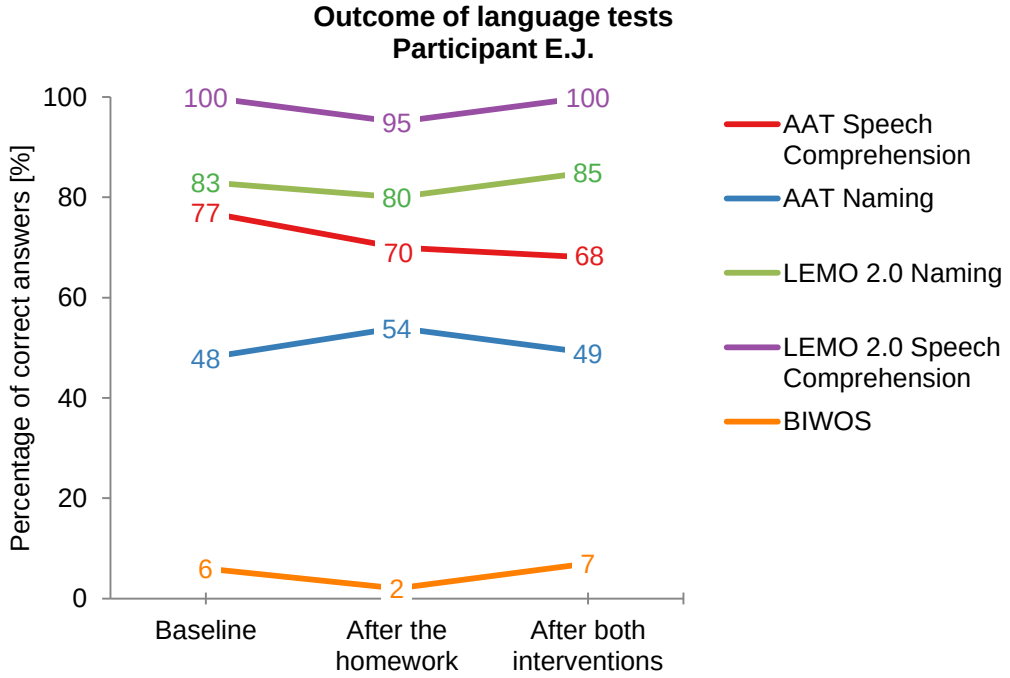


Figure 18. Outcome of language tests, participant E.J.

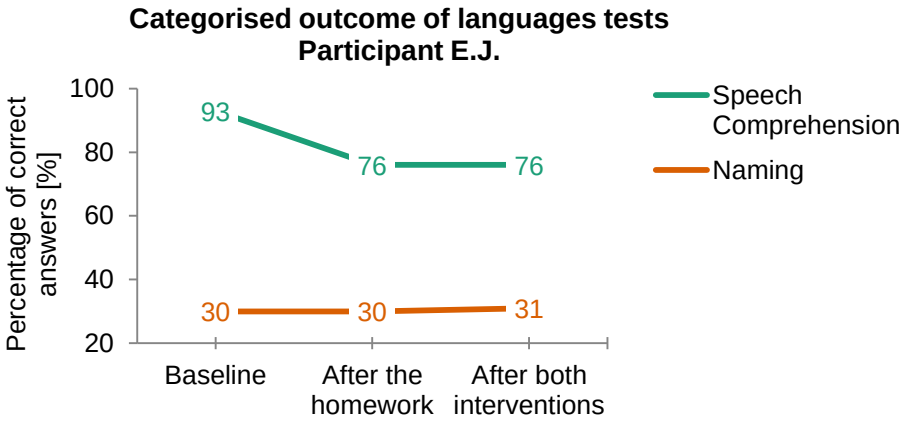


Figure 19. Categorised outcome of language tests, participant E.J.

Participant E.J. had been excluded from the analysis because he did not work sufficiently intense on the homework. Nevertheless, the outcomes of the tests are displayed and described in the following.

Comparing the outcomes of the baseline to the ones measured after the homework, E.J. achieved less items correct in the second test phase on all tests except AAT Naming (see Figure 18). His Speech Comprehension worsened measured with LEMO 2.0 (100% > 95%) and AAT (77% > 70%). Furthermore, his Naming-ability in LEMO 2.0 and BIWOS decreased (83% > 80%; 6% > 2%), while it increased measured with the AAT (48% < 54%). E.J. achieved the same or almost the same percentages in the last test phase than in the first one in BIWOS (7%), AAT Naming (49%), LEMO 2.0 Naming (85%) and LEMO 2.0 Speech Comprehension (100%). Only the value of AAT Speech Comprehension dropped further (to 68%). On average, it can be seen in Figure 19 that E.J.'s Speech Comprehension was worse in the second test phase compared to the first one (76% < 93%). The pause did not lead to changes in Speech Comprehension (76%). His ability to name something correctly was constant in the first two measurement points (30%) and increased one percentage point in the last measurement point (to 31%).

E.J. achieved in the first measurement point 10% correct answers in the semantical part and 1% in the lexical part of the BIWOS (see Appendix K.d). In the second measurement point, his values dropped. He achieved only 5% correct answers in the semantical part and did not answer any item correctly in the lexical part, thus he achieved 0%. After both interventions, he achieved 10% of correct answers in the semantical part again and 5% in the lexical part. The semantical naming of E.J. was better than lexical naming in each measurement point.

Mr J. achieved 139 points in the first measurement point in the CETI and 144 in the second one. Therefore, his wife rated his communication skills slightly better after both interventions.

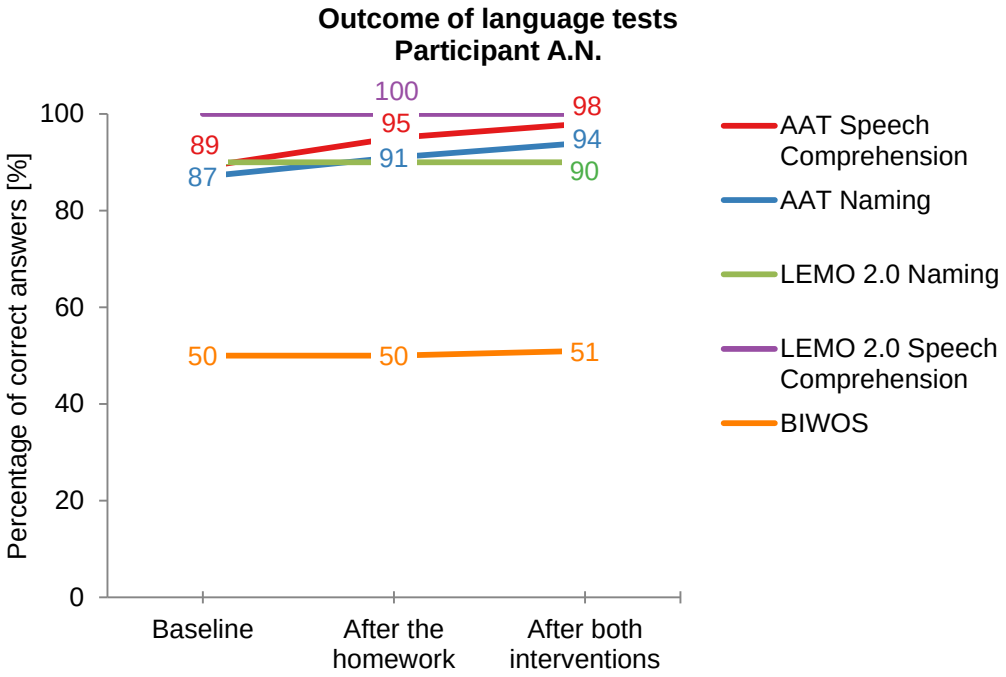


Figure 20. Outcome of language tests, participant A.N.

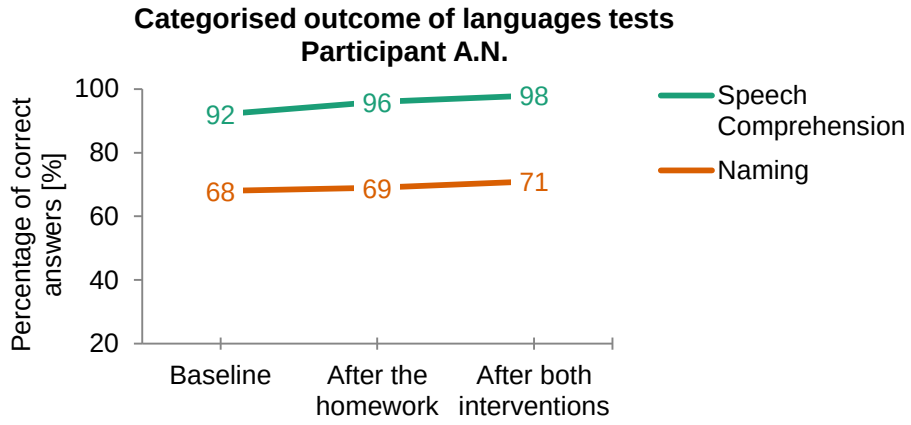


Figure 21. Categorised outcome of language tests, participant A.N.

The participant A.N. improved after the homework in AAT Naming (91% > 87%) and AAT Speech Comprehension (95% > 89%; see Figure 20). Her outcome in BIWOS did not change (50%). However, the pause led to an improvement of three percentage points in both AAT parts (Naming 94%, Speech Comprehension 98%). Moreover, she achieved one percentage point more in the BIWOS (51%). A.N. scored 90% correct in LEMO 2.0 Naming in all points in time while there was a ceiling effect concerning LEMO 2.0 Speech Comprehension (100%). Figure 21 shows the overall changes in language outcome. Mrs N. improved in both: Speech Comprehension (92% < 96% < 98%) and Naming (68% < 69% < 71%) over the experimental time.

Mrs N.'s Naming-ability measured with the BIWOS did not change constantly (see Appendix K.e). In the baseline, she achieved 59% correct answers in the semantical part and 40% correct answers in the lexical part. In the subsequent measurement, Mrs N. lost two percentage points in the semantical part (57%) and gained four points in the lexical part (44%). This trend was not maintained: A.N. gained four percentage points in the semantical part (61%) and lost three percentage points in

the lexical part (41%) in the last point of measurement. She always scored more items correct in the semantical than in the lexical part.

Mrs N. received 116 points in the first measurement point of the CETI and 109 in the second one. She rated her communication skills better in the baseline than after the interventions.

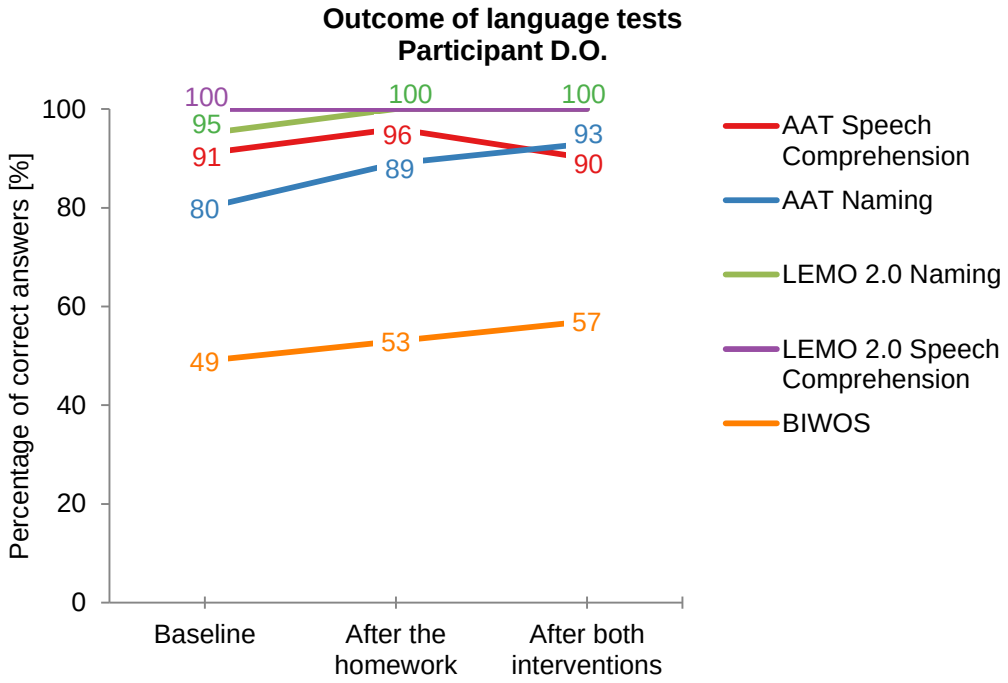


Figure 22. Outcome of language tests, participant D.O.

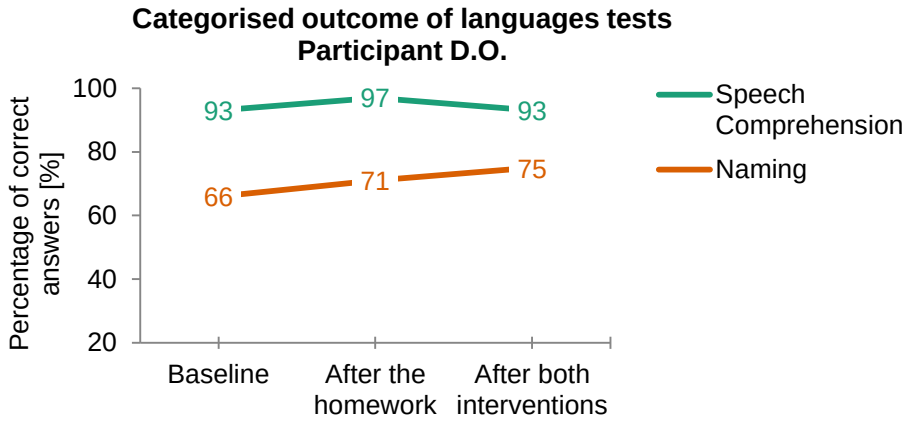


Figure 23. Categorised outcome of language tests, participant D.O.

Regarding LEMO 2.0 Naming, Mrs O. gained five percentage points after the homework and kept the achieved 100% constant until the third measurement point (see Figure 22). Mrs O. scored all items of LEMO 2.0 Speech Comprehension in each point in time correct. Thus, a ceiling effect can be seen. In the AAT, Mrs O. improved her Speech Comprehension (96% > 91%) and Naming (89% > 80%) after the homework. Furthermore, she improved in the BIWOS, gaining four percentage points (53% > 49%). After the pause, D.O. scored worse in AAT Speech Comprehension than before (90% < 96%). However, she improved in AAT Naming and BIWOS and gained four percentage points in each of them (AAT: 93%; BIWOS: 57%). In brief, Mrs O. constantly improved in Naming (66% < 71% < 75%; see Figure 21). Concerning Speech Comprehension, the participant improved

after the homework (97% > 93%), but deteriorated after the pause and achieved the same value than at the beginning (93%).

Mrs O.'s amount of correct answers in the lexical part of the BIWOS increased constantly, while the amount of correct answers in the semantical part decreased first and increased subsequently (see Appendix K.f). The participant achieved 64% correct answers in the semantical part and 34% correct answers in the lexical part in the baseline. Subsequently, she lost nine percentage points in the semantical part (55%) and gained seventeen percentage points (51%) in the lexical part. In the following measurement point, D.O.'s amount of correct answers in the semantical part increased to 60% and in the lexical part to 54%. Mrs. O achieved higher percentages in the semantical than in the lexical part in each measurement point.

D.O. achieved 82 points in the CETI in the first measurement point and 124 in the second one. D.O.'s husband rated her communication skills to be higher after the interventions.

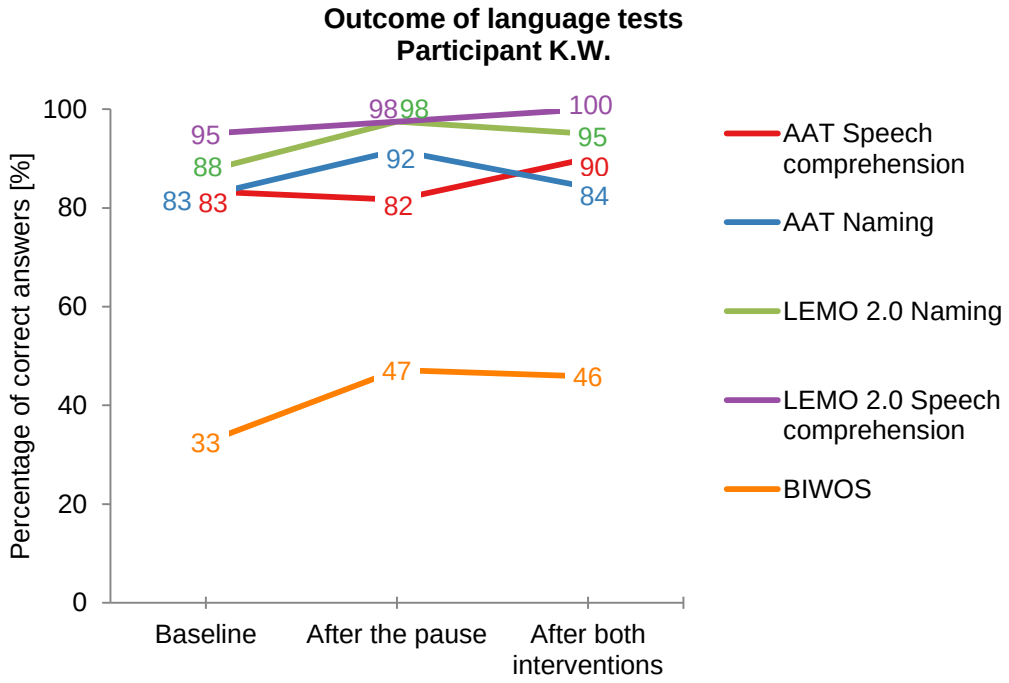


Figure 24. Outcome of language tests, participant K.W.

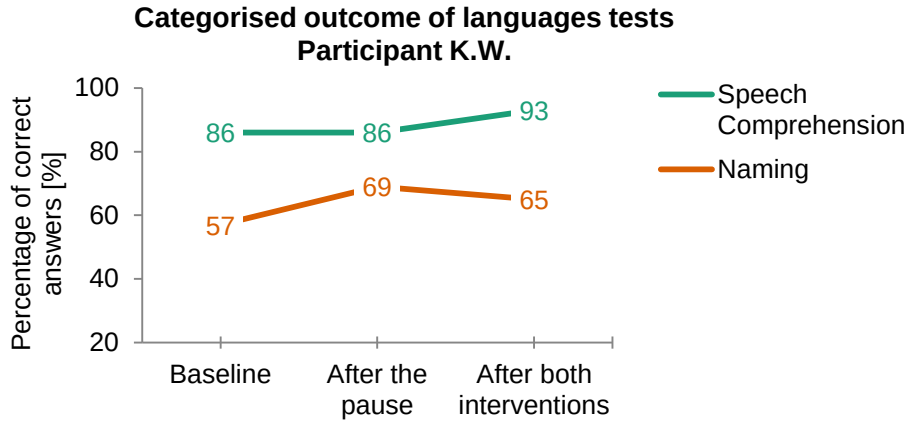


Figure 25. Categorised outcome of language tests, participant K.W.

Mrs W. had a pause first and subsequently worked intensively on the homework. Her language outcomes before and after the pause differed (see Figure 24). She achieved higher Naming-values in LEMO 2.0 (98% > 88%), AAT (92% > 83%) and BIWOS (47% > 33%). Regarding Speech Comprehension, she improved in LEMO 2.0 (98% > 95%) but deteriorated in the AAT (82% < 83%). After the intensive homework, the participant achieved lower Naming-scores measured with AAT (84% < 92%), LEMO 2.0 (95% < 98%) and BIWOS (46% < 47%). However, her Speech Comprehension was better than before the homework in LEMO 2.0 (100% > 98%) and AAT (90% > 82%). All in all Mrs W. improved her Naming-ability in the pause (69% > 57%) while her Speech Comprehension remained constant (86%; see Figure 25). After the homework, her Speech Comprehension improved seven percentage points (93%), but her Naming-ability decreased again (65%).

In the BIWOS, K.W. improved constantly in the semantical part, but not in the lexical part (see Appendix K.g). She achieved 38% correct in the semantical part and 27% correct in the lexical part in the baseline. The amount of correct answers in the semantical part increased ten percentage points (48%) and 19 percentage points in the lexical part (46%) after the pause. After the homework, K.W. achieved 54% correct answers in the semantical part and 38% correct answers in the lexical part. The amount of correct answers was always higher in the semantical part.

K.W. achieved 95 points in the first measurement point of the CETI and 94 points in the second one.

5. Discussion

Most patients suffering from aphasia attend speech and language therapy once or twice a week (Asmussen et al., 2013). Literature shows that speech and language therapy provided two times a week is not effective, even in case given in sustained periods (e.g. half a year; Bhogal et al., 2003). It is likely that only high-frequent therapy leads to significant improvement in language outcome (Bhogal et al., 2003). Consequently, the gap between the preferable therapy supply at high frequency and the 90 minutes sessions per week observed to be performed should be filled. A viable option is the use of homework. This investigation looked at the effect high-frequent homework performed by participants suffering from chronic aphasia had on the semantic system. The participants in this investigation worked independently and on average 300 minutes per week for three consecutive weeks on paper-pencil tasks of the NAT-material. The results provide necessary information for evidence-based speech and language therapy. With the help of the results, the hypotheses are tested successively. In the subsequent section, remaining facts and findings are discussed.

5.1. Checking the hypotheses

The **first hypothesis** was:

> *High-frequent homework of the NAT-material has a significant positive effect on the language outcome.*

Although Friedman's ANOVA revealed the scores of the participants to differ significantly on the three measurement points, the post hoc tests did support the finding. The Wilcoxon signed-rank test revealed none of the interventions, neither separately, nor collectively, leading to a significant change in the language outcome. In contrast, the second post hoc test showed that the difference in language scores of the first compared to the last test phase was significant. Hence, the results are contradictory and consequently, the hypothesis is not supported by the findings (see Figure 26). Nevertheless, the overall change in language outcome of the five participants shows positive trends. In total, the participants achieved four percentage points of correct answers more after the homework than at the baseline. The amount of correct answers increased only one percentage point over the three weeks of pause. In addition, the same positive trend is observed in the percentages of correct answers split by modality. Each of them increased after the first three weeks (after the homework). In the subsequent three weeks, the percentages of correct answers increased as well, but with the same gradient or even flatter than before. Accordingly, the homework led to a change of the overall language outcome and it can be assumed that the tasks led to a change in the semantic system. Again, this trend was not significant.

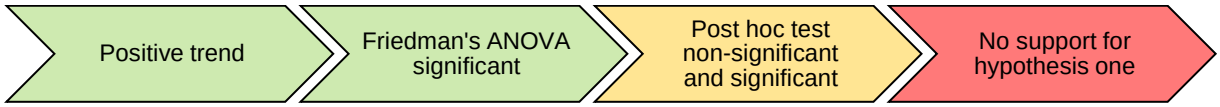


Figure 26. Process of testing hypothesis one.

The **second hypothesis** was:

High-frequent homework of the NAT-material has a significant positive effect on oral naming.

The ability to name something orally correct changed significantly over the six weeks of intervention. However, post hoc tests did not support this finding. Possibly the post hoc tests were not significant because there were not enough changes in oral naming. Two participants achieved ceiling-effects in LEMO 2.0 Naming in all measurement points. Thus, there was no chance seeing an increase of the naming ability in that subtest because they had already achieved the maximum amount of points: the subtest was too easy for these participants as they shew ceiling effects. However, ceiling effects did not occur in the other subtests. A positive trend is observed looking at the overall change in language outcome sorted by modality. The averaged ability of all participants to name something orally correct increased five percentage points over the three weeks of homework. After the pause, it only increased two percentage points. Looking at the added point values of all oral naming tests, each participant improved in oral naming after the homework. Three participants improved during the pause as well. However, the participants' improvement was higher in the first intervention than in the second one. Consequently, the homework led to a positive change of the oral naming ability, although this trend was not significant (see Figure 27).

In order to name something orally correct, the word/picture or the explanation has to be recognised and comprehended correctly and the corresponding word has to be retrieved from the semantic system. The participants in this investigation did not have strong speech comprehension problems. Therefore, the recognition and identification of a word/picture was not distorted. Thus, in case a participant was able to name something correctly, which he could not name before, a change in the semantic system probably occurred: connections between the picture/the heard or written word have been made to the corresponding word in the semantic system. After the intervention(s), the participants of this investigation were able to name words they could not name before. This is clear proof that changes happened in the semantic system of the participants. Nevertheless, the findings do not support the hypothesis.

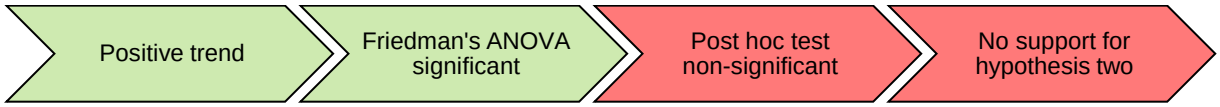


Figure 27. Process of testing hypothesis two.

The **third hypothesis** was:

High-frequent homework of the NAT-material has a significant positive effect on written naming.

The investigator expected the ability of the participants to name something in writing to increase, because the homework consisted of paper-pencil tasks in which the participants had to write something down. However, the participants' ability to name something in writing did not increase significantly. Friedman's ANOVA did not show a significant difference between the three points of measurement. This is in accordance with the findings of the descriptive statistics. Written naming only increased one percentage point after the homework and again two percentage points after both interventions. Thus, the third hypothesis is not supported (see Figure 28). It should be noted that two

participants achieved ceiling effects on each measurement point in LEMO 2.0 Written Naming. Therefore, they did not have the chance to improve their ability to name something in writing. Two of the remaining three participants improved this ability during the experimental time. The remaining participant did not achieve the full amount of points due to spelling mistakes. She improved spelling of some words and got worse on spelling others. Thus, it could be that the number of participants was too low or that the participants were too good to see significant changes.

Another reason could be that the amount of 20 items was too low to possess explanatory power. An increase of the amount and the complexity of the items would have probably led to a significant change in written naming. Still, LEMO 2.0 is the only test in the German language including a subtest for written naming. Bergmann, Dassek, Kiehn and Kipshoven (2014) bypassed the problem of not disposing of a test measuring written naming: they used a common naming test and asked the participants to answer half of the items orally and half of the items in writing. However, the participants in their investigation did not answer consequently using one modality (speaking/writing). Hence, a test examining written naming not only based on nouns is still missing in the German language. Further research should look at the necessity of such a test before creating one.

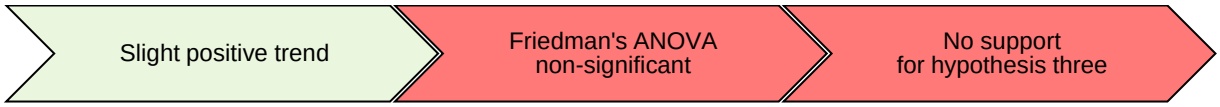


Figure 28. Process of testing hypothesis three.

The investigator expected the high-frequent homework indirectly leading to an improvement of the speech comprehension. Thus, there were two hypotheses testing this (i.e. hypothesis four and five, respectively).

The **fourth hypothesis** was:

High-frequent homework of the NAT-material has a significant positive effect on auditory speech comprehension.

Friedman's ANOVA revealed the outcome of auditory speech comprehension not to differ significantly. Thus, the fourth hypothesis is not supported by the findings (see Figure 29). Nonetheless, the test was not significant looking at the exact score (p=0.054). Considering the asymptotic significance, the difference would just have been significant (p=0.05). According to that, Figure 10 demonstrates that there was a considerable increase in auditory speech comprehension. Hence, working high-frequently on the homework, led to a change of the outcome of this modality. This is interesting, because the homework did not train the route of auditory speech comprehension. Therefore, the change might have occurred in the semantic system itself, indirectly leading to a change in auditory speech comprehension. Possibly, some participants learned new words during the homework that were examined in the test phases. However, it is not striking that the participants' speech comprehension increased due to homework. A healthy person always comprehends more words than he/she speaks (Siegmüller, 2011) and consequently, a person would comprehend a word before using it. Still, the question remains whether auditory speech comprehension would have changed significantly if the homework had included tasks of auditory speech comprehension. According to this, the investigation

of Nobis-Bosch and colleagues (2006) showed that intensive naming-training including auditory speech comprehension leads to a significant increase in oral naming.

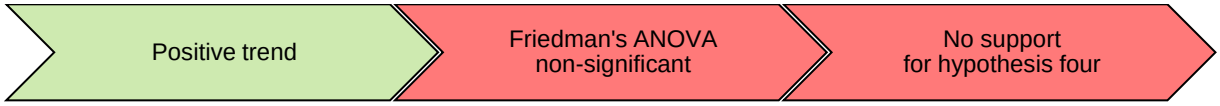


Figure 29. Process of testing hypothesis four.

The **fifth hypothesis** was:

> *High-frequent homework of the NAT-material has a significant positive effect on visual speech comprehension (i.e. speech comprehension of text).*

On average, the participants achieved only two percentage points more of correct answers after having completed the three weeks of homework. Their ability to comprehend written words and sentences increased again two percentage points after the three weeks of pause. However, these results were not expected. The route of visual speech comprehension was used in each task of the homework. The participants either had to recognise a picture or a word before giving the answer to the task. Thus, the reading-route and the picture-recognition-route were the only ones used permanently. Consequently, the investigator expected that the participants' visual speech comprehension would improve more. However, the participants' ability to comprehend written language did not change significantly over the six weeks of intervention. This is in accordance with the findings of the descriptive statistics. Hence, the results do not support hypothesis five (see Figure 30).

The reason that the participants did not improve that much can be due to the tests/the material as well: the visual speech comprehension tests use the combination of pictures and words/sentences only, as a word/sentence was provided and the participant had to find the corresponding picture. All items of LEMO 2.0 are single nouns. The items of the AAT Speech comprehension (visual) testing single words are nouns, too. Nevertheless, this test further includes sentences, which comprise short descriptions of situations and questions. In brief: all of the single words tested were nouns. However, the NAT-material used in this investigation did not include the recognition of nouns/sentences in relation to pictures. The material used included the relation of verbs to pictures, because the focus of the NAT-material was on verb processing (NAT lexically-semantically verb-processing disorder). Consequently, it is not exceptional that the participants did not improve their visual speech comprehension significantly. As a result, a test examining verb-naming or material including the naming of nouns should be used in a following investigation. Alternatively, different material focussing on nouns could be used as well.

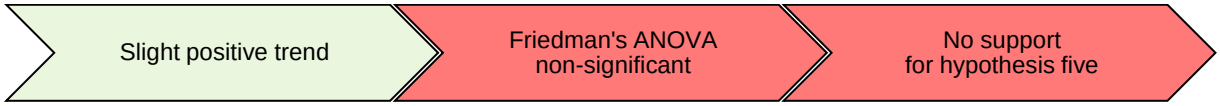


Figure 30. Process of testing hypothesis five.

The **sixth hypothesis** was:

> *High-frequent homework of the NAT-material leads to a significant positive change of the communication in daily life.*

The average amount of points achieved in the CETI increased over the six weeks of intervention. At the beginning, the mean amount of points achieved was 97 of maximum 170. After both interventions, this amount increased to 108 points. Converted to the CETI-line, that is a difference of 7 mm and thus, a difference of 7%. The findings do not support the hypothesis (see Figure 31), because the difference between the first and second measurement point were not significant in Friedman's ANOVA. Nevertheless, the interventions led to a positive trend concerning the participants' communication skills.

The fact that the change was not significant could be due to the short period in which the relatives had to fill in the CETI twice. Baumgärtner (2015) mentioned that it is not useful to let relatives fill in a questionnaire about the daily life shortly after interventions. Instead, some time has to pass before a change in the behaviour is recognised. However, she and her colleagues (2013) measured the effect of an intervention on daily life three weeks after the end of the intervention; this is analogically to the interval of this investigation (except for participant K.W. who was not included in the measurement because she ran through the interventions vice versa). Nevertheless, the changes in this investigation were not significant.

The investigator asked the participants whether something in their daily life changed over the six weeks of intervention. None of them reported moving events. Although three relatives/participants rated the communication skills higher after the interventions, two of them rated them lower. The investigator expected the values either to stay stable or to increase after the interventions. As the changes are unlikely due to moving events, other reasons have to play a role. One possible explanation is that the relatives/the participants thought more critically about the communication skills. At the baseline, they thought about the questions and filled in the CETI. In the first intervention phase, the relatives saw their partners working on the homework every day and the participants felt what intensive working meant. Possibly, the relatives/participants reconsidered the word-finding deficits and communication skills and consequently viewed them in a different way. It is possible that the participants thought more critically about their communication skills at the second time of the CETI-measurement and therefore rated their skills lower. As the test-retest reliability has only been examined insufficiently (Huber et al., 2013), there is no proof that the relatives judge the skills of the participants similar in different points in time. Furthermore, the relatives' mood possibly influenced the outcome of the CETI. In case they were in good mood, it is possible that they rated their relatives' communication ability higher than in case they would have been in bad mood (see Blumenthal, 2005). In addition, the mood of the participant on the test day could have had an influence on the outcomes as well: in case the participants were in bad mood and did not want to talk a lot the relatives possibly rated the communication skills lower than they would have rated them on days of good mood. Furthermore, it is interesting to note that the wife of one participant mentioned not to recognise any differences between the first and second measurement point. Consequently, it is possible that the interventions did not lead to a change in the daily communication.

The reason for rating a participant higher in the second CETI-measurement could be due to the interventions. Possibly, these participants/relatives really saw an increase in the communication

skills because the participant retrieved words more easily for example. However, the findings do not support this hypothesis.

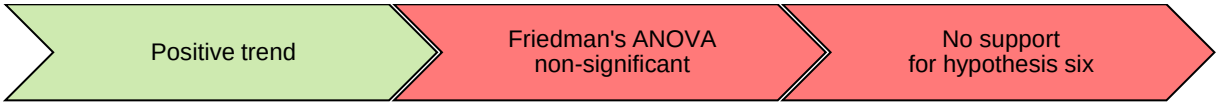


Figure 31. Process of testing hypothesis six.

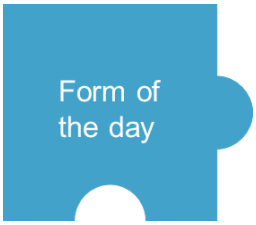
To ensure an overview about the results of testing the hypotheses, Table 17 is included. In conclusion, none of the hypotheses was supported by the findings in this investigation. However, positive trends were observed for most of the hypotheses.

Table 17. Results of testing the hypotheses.

Hypothesis	Friedman's ANOVA	Post hoc tests	Trend	Result
1	Significant	Non-significant, significant	Positive	Hypothesis not supported
2	Significant	Non-significant	Positive	Hypothesis not supported
3	Non-significant	–	Slightly positive	Hypothesis not supported
4	Non-significant	–	Positive	Hypothesis not supported
5	Non-significant	–	Slightly positive	Hypothesis not supported
6	Non-significant	–	Positive	Hypothesis not supported

5.2. Discussing influencing factors

To conclude, intensive homework did not lead to significant changes in language outcome. However, compared to the baseline, the participants achieved higher results in each modality. This may have several reasons that are elaborated below.



The first factor influencing the number of correct answers is the participants' ***form of the day***. In patients suffering from chronic aphasia, changes in language outcome are unlikely to occur without intensive therapy (see Salter et al., 2013). Participant K.W. ran through the interventions vice versa: she had a pause first and the period of homework afterwards. Thus, she only received speech and language therapy in the first three weeks. Therefore, the investigator did not expect her language outcome of the first and second measurement point to differ a lot as she suffered from chronic aphasia. Nevertheless, the outcomes differed more than expected: up to 14 percentage points per subtest. The participant was able to improve her language outcome in each of the tests except AAT Speech comprehension, without receiving intensive speech and language therapy. The reason for this considerable difference is not evident. Possibly, the low frequent speech and language therapy worked so well that it had such a big influence on the language outcome. However, this is not likely, as therapy of chronic aphasia is expected to lead to changes in language outcome in case provided high-frequently (Lee, Kaye & Cherney, 2009; Robey, 1998). It is more likely that these changes in outcome

are due to the form of the day of the participant. The investigator noticed the participant K.W. to be more relaxed in the second test phase than in the first one. This attitude may have significantly contributed to finding more words and answering correctly. Another proof for the importance of the form of the day is participant E.J. He was not included in the statistical analysis because he did not work 300 minutes per week on the homework. However, he attended speech and language therapy and worked a certain number of hours on the assigned tasks. Therefore, the investigator expected his language outcome to be stable or to improve at least a little. During the second test phase, the investigator had the impression that the participant did not want to go on working. Nonetheless, the participant denied the proposal of the investigator to postpone the second test phase. His language outcome dropped considerably from the first to the second measurement point. He only improved in one subtest (AAT Naming).

In short, the mood of the participants and their form of the day may have high influences on the performance in language tests. As the mood of the participants cannot be modified by the investigator directly, enough participants should be included in an investigation to rule out influences of the individual forms of the day. Investigations with many participants (n > 30) do have advantages compared to smaller ones: including more participants, influences of the mood of the day of an individual would be ruled out.

Inevitably, this leads to considering another aspect: the ***number of participants***. At least ten participants were required for this investigation. The investigator contacted all outpatient departments and self-help groups in and around Aachen. The response rate was low (5%). After having called all of the contacted persons repeatedly, most of them refused to take part in an investigation or simply negated to attend patients suffering from chronic aphasia. The investigator tested all patients claimed to be potential participants by the speech and language therapists. Fortunately, each one of them was included in the investigation because they fitted the inclusion and exclusion criteria. Still, only seven participants could be invited to take part. Recruiting participants is challenging for researchers (Hershberger et al., 2011). Investigations with only a few participants have less explanatory power than investigations with bigger samples. Thus, a subsequent investigation should include as many participants as possible.

One participant reported to feel an ***overload during the test phase***. The second and third test phase lasted about one hour to one and a half. The investigator tried to reduce the workload of each participant by simultaneously performing LEMO 2.0 Oral Naming and Written Naming: she asked the participants to look at the picture, say aloud what they saw and subsequently write down the word. Still, this did not save much time. The outcome of LEMO 2.0 showed that the speech comprehension part was too easy for the participants because some shew ceiling effects and others achieved nearly 100%. In the naming part of LEMO 2.0, some participants reached ceiling effects as well, while others achieved about 90% correct. Again, LEMO 2.0 was too easy for some of the participants. Matching the test material accurately to the severity of deficit is very important to avoid overload and boredom or floor and ceiling effects. Reducing the amount of tests

would have probably avoided an overload during the test phase. Nevertheless, it was reasonable to execute these tests. Table 18 shows the reasons for the importance of the execution of each test.

Table 18. Reasons for the execution of tests.

Test	Reason
Subtests of LEMO 2.0	- LEMO 2.0 is based on the PALPA-model; each subtest focusses on one route. Thus, examining a route using this test is easier than using another test. - LEMO 2.0 is the only test including a subtest examining written naming. - Each subtest contains the same items (ordered differently). In case different items would have been used: ○ the participants probably would have been bored later, but would have been exhausted earlier and ○ it would not be possible to refer directly to a change of a PALPA-model route → It would not have been clear whether the participant was not able to name the word because of the channel he should use (speak/write; read/hear) or due to problems in the semantic system (word retrieval/finding problems). With the use of the same items in different subtests, it was easier to compare the outcomes.
AAT*	- Many researchers use the entire AAT or some of its subtests in their investigation → using the same tests (and experimental design) makes outcomes of different investigations more comparable - The AAT investigates the production and recognition of sentences
BIWOS	- BIWOS looks at many facets of oral naming: ○ *semantical part*: finding the opposite word, naming the generic term, finding synonyms and naming words belonging to a generic term • these tasks are often used in everyday language ○ *lexical part*: rhyming, naming words to a specific initial letter, adding nouns for word-compositions and finding the corresponding word to an explanation • these tasks are hardly found in everyday language - BIWOS includes many aspects that have been trained in the homework (rhyming, naming the generic term, finding synonyms and naming words belonging to a generic term)

Note. AAT* = AAT Speech comprehension and AAT Naming

In each test phase, the same subtests were performed. As the interval between the tests was only three weeks, it could be that a certain ***training effect*** occurred and was measured: the participants memorised some test items of the first measurement point in the second or third measurement point. This way, participants would not know the items, but would remember their answer from the last test phase. The training effect can occur in every investigation in which the same tests are used. The only way to examine the clinical trial while avoiding training effects is the use of parallel versions (Grimm, 2008). However, parallel versions of tests for aphasia are rare, especially in German language (Huber et al., 2013).

A crucial factor of the investigation is the ***length of the interventions***. Possibly the language outcome did not change significantly but rather indicated trends induced by too short interventions. Bhogal and colleagues (2003) revealed therapy of 8.8 hours for 11.2 weeks to be effective. Thus, it is possible that the interventions would have led to significant changes in language outcome in case they had been lasting longer (e.g. for eleven instead of three weeks). However, Baumgärtner (2015) showed an intervention of three weeks leading to significant changes in language outcome. They provided at least two hours per day direct therapy with a language-systematic and communicative-pragmatic focus and replenished that assigning homework for one hour per day (Baumgaertner et al., 2013). Thus, either the length or the intensity of the training could have changed the language outcome significantly. In the course of the best length and intensity, it is interesting to look at guidelines for the therapy of aphasia.

The German Association for Neurology (Deutsche Gesellschaft für Neurologie) recommend different intensities for the different stages of aphasia (DGN, 2012):

- In the first weeks post onset, a patient should receive intensive speech and language therapy.
- Subsequently up to six months post onset, a patient should attend speech and language therapy at least three times a week for 60 minutes. In addition to that, the patient should be provided with homework to support the effect of the therapy.
- In the chronic stage of aphasia (>six months post onset), a patient may receive speech and language therapy. In case therapy takes place, it should be stationary and intensive: daily sessions over 6-8 weeks. Therapy in this stage is not obligatory.

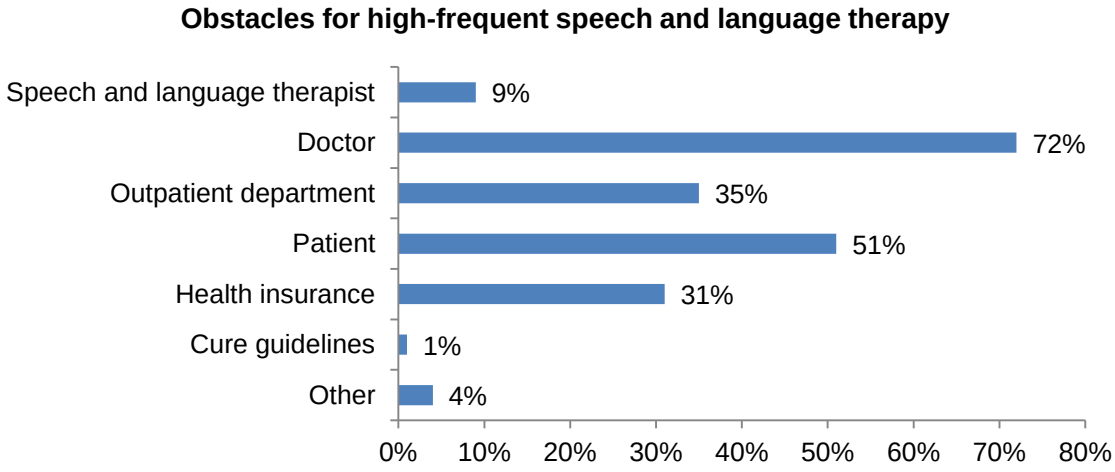
The guideline was adopted in 2012, prolonged two times and is still valid for 2015. Thus, in the chronic stage, an intensive therapy of 6-8 weeks including daily sessions is recommended. The German pension insurance also mentions intensive speech and language therapy possibly leading to significant changes, even in the chronic stage (Deutsche Rentenversicherung, 2010). The Dutch Association for Neurology (Nederlandse Vereniging voor Neurologie, 2008) recommends starting speech and language therapy as early as possible after the aphasia-inducing event and mentions that therapy given twice a week leads to a greater effect than once a week. Therefore, therapy should be provided at least twice a week. It should be replenished using homework or the help of the relatives in order to provide a therapy-intensity of one hour per day. The guidelines for the speech and language therapists in the Netherlands (Berns et al., 2015) recommend the same: speech and language therapy should start as early as possible and should be provided at least two times per week. However, these two recommendations are independent from the type, the severity and the phase of aphasia. The guidelines promote that a therapist should provide more therapy if possible and that speech and language therapists are obligated trying to replenish the direct therapy with homework or with the help of the relatives. Furthermore, the guidelines name computers as another possibility to replenish logopaedic therapy. A last and very important point in these guidelines is the fact that a speech and language therapist is asked to create possibilities for intensive care for a patient suffering from chronic aphasia expressing a specific wish concerning his disability. In Switzerland, the speech and language therapists are asked to start the interventions as early as possible with an intensity suiting the patient's ability and needs (Aphasie Suisse, 2006). According to this guideline, speech and language therapy

should be provided three times a week after one year. In addition, the authors claim that in the chronic stage of aphasia, intensive interventions can lead to significant changes, too.

Taken together, the guidelines all mention that speech and language therapy given intensively in the chronic stage can possibly lead to significant changes. Before increasing the workload, the fact that not every patient is willing to spend more than an hour per day on the assigned tasks should be duly considered. Brady and colleagues (2012) mentioned in their review of 39 randomised controlled trials that there was a significantly higher dropout of participants in the intensive speech and language therapy than in the conventional one. Accordingly, four participants in this investigation were fine when the working-intervention was over. Some of them mentioned that one hour per day was too much: despite being able to organise their time independently, they had too many appointments to continue working intensively. Furthermore, one participant claimed to feel frustrated working on the tasks, because he could not find the answers. Only three participants regarded the amount of workload to be appropriate.

As a result, it should be considered to give participants suffering from chronic aphasia the possibility to work over consecutive periods (weeks) intensively on homework, whilst receiving speech and language therapy to support and supervise the progress in parallel. The exact amount of therapy/work should be determined in agreement with the participant and should have a fixed duration (amount of weeks) to avoid an overload or even the refusal of the participant. Generally, the participants in this investigation are able and willing to work intensively on their language ability provided their private timetable and the spatial circumstances permit that.

Nevertheless, Asmussen and colleagues (2013) investigated obstacles for an increase of the therapy frequency, shown in Figure 32:



Note. Multiple answering possible

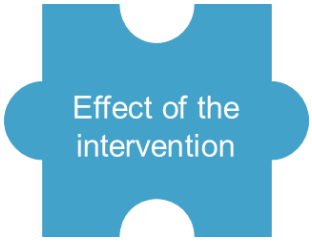
Figure 32. Obstacles for high-frequent speech and language therapy (Asmussen et al., 2013, 17).

In Germany, a doctor prescribes if and to what extend a patient receives speech and language therapy. If he does not prescribe accordingly, a patient has to pay on his own. Thus, he is the one responsible for the intensity of the therapy. Asmussen and colleagues (2013) found out that doctors are the most common obstacle for receiving high-frequent therapy. The patient is in the second place of inhibiting high-frequent therapy and the outpatient department and the health insurance seem to

play important roles as well. Concluding, it is contradictory and not acceptable that the guidelines recommend high-frequent therapy but doctors would not adhere.

Participant A.N. worked more than she was asked to. It could be suspected that her language outcome might have had a significant effect on the overall result, distorting the true average. However, although A.N. is the only participant having improved her language outcome in both interventions, she did not improve more than other participants did. Her maximum improvement was six percentage points in AAT Speech Comprehension. Participant P.L. improved nine percentage points in this subtest. Averaged, the remaining participants improved five percentage points. In AAT Naming A.N. improved four percentage points while the others improved about seven percentage points. Consequently, the fact that A.N. worked more than she was expected to, did not lead to a distortion of the language outcome and therefore, it was reasonable to include her outcome in the statistical analysis.

Nevertheless, Mrs N. claimed to work a lot on the paper-pencil tasks. Perhaps she did not list the times she worked on the material well. However, during the supervision meetings, A.N. noted the times carefully and therefore, the investigator negated this possibility. It is more likely that A.N. needed more time for the homework than the other participants. She never received speech and language therapy, does not fill in crosswords or other language-related tasks and finished school years ago. Thus, she neither is used to work on paper-pencil tasks, nor is she used to work mentally for a long period. Probably she needed more time than the other participants needed for one sheet and in total that led to a considerable increase in working time.



Another reason influencing the participants' results is the ***effect of the intervention*** in that it may have had an immediate effect on the participants' semantic system. That is what this investigation wanted to prove. In this case, the training of words of different semantic fields in various tasks and the repetition of some words would lead to a change in the semantic system. The participant would be able to comprehend or retrieve words (faster). Some participants improved their word fluency after the homework, while others did not. Thus, the results did not prove that the participants retrieved words from the semantic system faster. That occurred neither in the semantical part, nor in the lexical part.

As all of the participants in this investigation are retired, none of them is used to work high-frequently on one specific task. Some of them (e.g. L.F. or P.L.) are very active and fill their time with plenty of different leisure activities. However, all participants are free in planning their days and thus do not have to work on something. As mentioned above, only three participants regarded the workload of one hour a day over three weeks as appropriate. Speech and language therapy, both, direct and indirect, require the patients' free time and motivation to work on deficits. Possibly, the participants who do not work anymore have to get accustomed working on a specific task for a prescribed time again. It is likely, that patients who work voluntary on tasks at home or who still gainfully work will easier cope with the amount of work.

The fact that the participants did not retrieve words faster could be due to the test method as well. In all tests, the participants had to name something directly or to answer questions with the

desired word as the answer. Gelb (1937) claimed that there is a huge difference between the answer of a participant to a specific question (reactive speech) and spontaneous speech. In Gelb's view, it is much easier for a patient suffering from aphasia to talk about something happening in the here and now than answering abstract questions that have nothing to do with the present situation. Goldstein and Mamor (1938) and Gelb (1937) both proved aphasic symptoms to change in different situations: patients converse more fluently in concrete situations than in abstract situations. Goldstein and Mamor (1938) described a patient who was not able to name a specific object. Contrastingly, he was able to use the desired word when talking about the object without the need to name it directly. Thus, he was not able to name an object, but when talking about it freely, he used the desired word naturally. This supports the earlier findings of Gelb and Goldstein (1924) proving aphasic symptoms to change in relation to the situation in which the patient is located. In summary, it is possible that the participants would have been able to name the objects or to answer the questions in case these items would have been embedded into a natural talking situation.

In addition, Grötzbach and Spitzer (in print) discuss the position of Goldstein and Gelb in their article. They mention that possibly the way therapy is provided is not appropriate. It was mentioned above that Goldstein and Mamor (1938) and Gelb (1937) proved aphasic symptoms to change in different situations. Thus, following Grötzbach and Spitzer instead of an abstract and de-contextualised therapy, a context-sensitive therapy is desirable. It would probably be easier for a patient to name an object in a context-sensitive therapy, than in a de-contextualised therapy. Consequently, in case their theory is true, the homework would not have been appropriate for the participants, as it asked the participant to name something or find a generic term. Thus, the participant was not given room to talk freely about something and then finding the word, but the material rather strictly asked to give one specific word as an answer.

Further research is needed in order to prove the theory of Goldstein, Mamor and Gelb. In case their theory is true, it would be necessary to change the entire training and test material, giving the examinees an appropriate training and a fair test in which they can show their ability.

The homework was chosen based on the relevance for daily communication. In accordance with this prerequisite, the participants received more semantically focused material than lexically focused material, as the relation to everyday language is stronger. Therefore, it is not surprising that averaged all participants scored better on the semantical part than on the lexical part of the BIWOS on each measurement point. Looking at the data of each participant individually, there were two exceptions: participants L.F. and I.M. achieved higher values in the lexical part compared to the semantical part in the last measurement point. Averaged, the amount of correct answers in the lexical part increased more than in the semantical part. Due to this, the outcome of the lexical part approached to the outcome of the semantical part. However, the overall amount of the semantical part was higher and this is in accordance with the investigator's expectations.

Another factor having an influence on the language outcome after the training is the ***used material***. The NAT-material is well known and many speech and language therapists in Germany use it (Asmussen et al., 2013). The authors invented the material based on their linguistic experience (Neubert et al., 2005a). Nevertheless, there is no scientific evidence for the effectiveness of this material. The authors based the material on the assumption that language problems of persons suffering from aphasia are directly related to the lesion and the functional disorder of the neuronal structures (Neubert et al., 2005a). The question arises whether this lesion-deficit-approach is true and in case it is, a second question arises: does working with the material lead to a change of the functional disorder? It seems reasonable to assume that small zones of the brain are responsible for executing narrow functions (Bookheimer, 2002). These zones may highly interact with each other (Bookheimer, 2002). However, there is no clear proof that working with the material leads to changes in the functional disorder.

Moreover, the NAT focusses on the functional part of the disorder. According to the ICF, the focus of the therapy should be on the level of participation of the participant: tasks executed in everyday life are more important to the patient and should be chased using functional tasks. Hence, speech and language therapists should not randomly make use of logopaedic material. They should support the patient's wish for daily communication by using functional tasks leading to the patient's aim (Grötzbach, 2004; Grötzbach, 2006). Doing this, different patients probably want to learn different words. It is possible that older patients want to use words that were frequently used years ago, while younger patients want to learn words, which are frequently used today. Considering this, it should be emphasised that the NAT-material already exists for some years. The material used in this investigation was published in 1992, 1994 and 2005. Thus, the oldest material used was created twenty-three years ago and therefore includes some words that are outdated or not used frequently anymore. In case participants regard words as useless to know or stronger, they do not recognise words because they are outdated, they will probably not be motivated to learn these words and to work on the corresponding material.

Bhogal and colleagues (2003) as well as Wisenburn and Mahoney (2009) compared several studies with one another. It was not possible to find the best method for therapy because the investigations included, compared many different methods using several language tests. In the end, there is not any technique or method scientifically proven to be effective.

Consequently, it cannot be excluded that the NAT used in this investigation did not train the naming ability of the participant and therefore did not lead to significant changes. Hence, future investigations should examine the effectiveness of training with the NAT. Only in case the training really leads to an increase of the naming ability (turns out to be effective), it is reasonable to utilise it in speech and language therapy. However, it is not only important that a method is effective – it should lead to considerable long-term effects as well. Methods that lead to considerable effects immediately after the intervention, but not six/twelve months after the end of the training, cannot claim to lead to long-term effects (Beushausen & Grötzbach, 2011). Only in case the training effect of a method leads to long-term effects (lasting until six/twelve months after the end of the therapy), this method is desirable to utilise and should be applied in the speech and language therapy rather than using methods leading to short-term effects only. Consequently, investigations including follow-up studies,

testing participants after six or twelve months again, are needed to examine possible long-term effects. Beushausen and Grötzbach (2011) mention two important reasons for the fact that there are only a few studies investigating the long-term effects:

- Research funds are often only provided for a short time and
- The more time passes between the last measurement point and the follow-up measurement point, the harder it gets to win the participants to take part in a last test phase.

Again, methods claiming to lead to significant changes even after a long period without training (i.e. long-term effect) are desirable to utilise in the speech and language therapy. Therefore, future investigations should consider measuring the long-term effects. In addition, scientific evidence is needed for material used in speech and language therapy. Otherwise, it is possible that patients work a lot but, as the material does not lead to changes, they will not see any improvement in their ability to communicate. This effect is strongly not desirable.

Summing up, several circumstances influenced the outcome of the investigation. Some of them have been discussed above. However, it is likely that more factors have had an influence on the outcome. As each factor is regarded as a piece of a puzzle, only all factors together form a complete figure. Figure 33 shows all the pieces together forming the entire jigsaw. The coloured pieces represent the factors discussed and the grey ones represent the unknown factors that have had an influence, too.

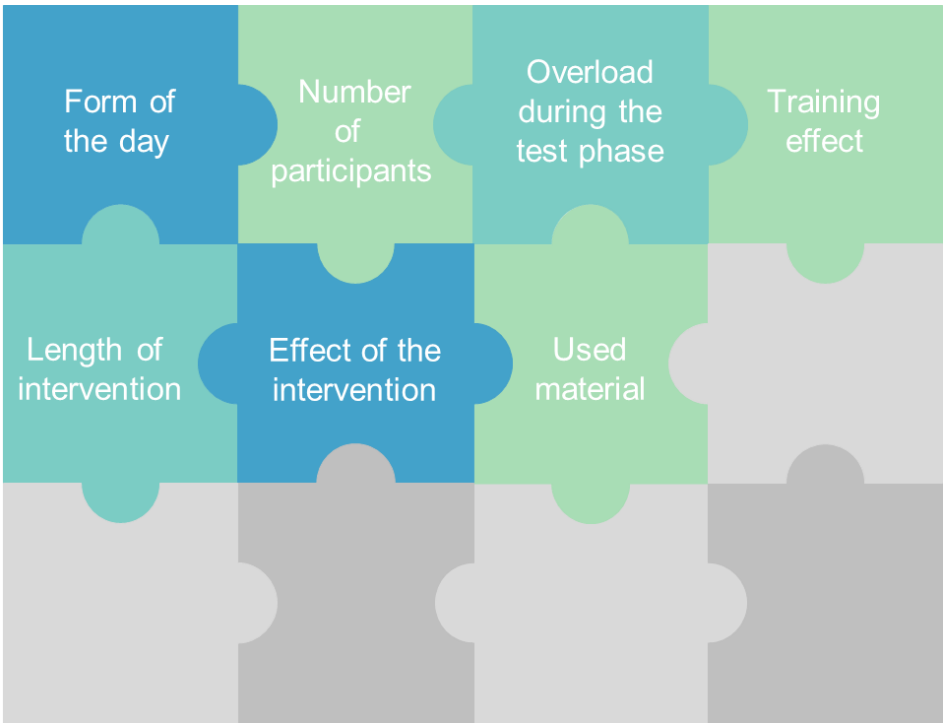


Figure 33. Factors influencing the outcome of the investigation.

At the end, it is important to reflect the investigation critically. Table 19 and Table 20 show the disadvantages and advantages of this investigation and gives advice for future research.

Table 19. Disadvantages of the investigation and recommendations for future research.

	Aspect	Explanation/possible reason(s)	Recommendation for future investigations
Disadvantages	The investigation did not look at **long-time effects**.	The limitation of time did not allow a follow-up.	Follow-up measurements are important in order to measure long-term effects that are required for an effective method. Future investigations should ensure them.
	The **tests** were not in **accordance** with the **material used**.	The investigator chose for common tests and had to make compromises in order to overcome an overload during the test phase.	The tests used should be directly related to the aspects trained with the material used.
	There is **no evidence** that the **NAT-material** is effective/**effect of intervention**.	As there is no evidence for any training method improving naming, the investigator chose for the most common one.	Subsequent investigations should examine the effectiveness of training methods and test whether a method really leads to changes of aspects it claims to improve.
	This investigation only included **seven participants** and thus effects of **form of the day** have possibly been measured.	Recruiting participants is always challenging for researchers. In case there had been more time to recruit participants, more would possibly have taken part. Including a greater amount of participants would increase the probability to rule out effects of individual deviations.	Investigations including more participants have more explanatory power and can rule out individual deviations than investigations including a small amount of participants. Thus, an investigation should include as many participants as possible.
	It was not possible to see changes in the **daily communication** of the participants.	Either the intervals between the measurement points were too short to note possible effects or the intervention did not lead to a change in the daily communication.	Changes in daily communication of participants should not be measured directly after finishing the training-intervention and the intervention itself should improve the daily communication of the participant at least indirectly.
	A **training effect** of the tests could have been measured.	As tests including parallel versions are very rare in the German language, the investigator had to abandon this option.	Tests including parallel versions should be created and used in future investigations to avoid a certain training effect.
	One participant mentioned an **overload during the test phase**.	Although the investigator tried to minimise the workload of the participants, one of the seven felt a certain overload.	It is useful to examine several language aspects in one investigation. However, the amount of tests should be kept minimal to avoid an overload of the participants.

Table 20. Advantages of the investigation and recommendations for future research.

	Aspect	Explanation/possible reason(s)	Recommendation for future investigations
Advantages	The **dropout rate** in this investigation was 0%.	The investigator motivated the participants to go on working and the intervention time was short enough to avoid earlier dropout.	The motivation of the participants has a huge influence on their will to take part. Researchers should try to keep the participants' motivation high.
	The **intervention time** of this investigation was adequate for most participants.	The investigator tried to find a middle course between frequencies and chose a lower amount of hours per week to avoid dropout.	Future investigations should find a middle course between high-intensity and low-intensity to avoid a high dropout and to avoid that the interventions do not lead to effects.
	The training-intervention was very **easy to apply**.	As the speech comprehension of the participants was good enough to work on the sheets and they were free to plan when to work on the sheets and had received solutions to the tasks, the participants were able to work independently. The investigator supervised them once a week.	Participants should be able to work on the tasks given independently. Obviously, the tasks should not be too easy or too difficult. In subsequent investigations, the difficulty of the tasks should be matched to the severity of disorder as in this investigation. Furthermore, the tasks should get harder to ensure "shaping".

6. Conclusion

This investigation examined the effect of high-frequent homework on the semantic system. The participants suffered from aphasia due to stroke, which occurred at least six months ago. The participants completed two interventions:

- First intervention: The participants worked independently at least 300 minutes per week (i.e. one hour a day for five days) over three weeks on paper-pencil tasks of the lexical and semantical material of the NAT. Once a week, they were supervised by the investigator.
- Second intervention: The participants had a pause of three weeks.

During the interventions, the participants received low-frequent direct speech and language therapy. The focus of the sessions was not on naming or speech comprehension. All participants have been tested immediately before the first intervention and directly after the first and second intervention. The tests examined changes in language outcome (AAT: Naming and Speech Comprehension, BIWOS, LEMO 2.0: Oral Naming, Written Naming, Word-Picture matching, auditory and visual) and the communication ability in daily life (CETI). The overall language outcomes, as well as its four aspects (oral naming, written naming, auditory speech comprehension and visual speech comprehension) were examined. Finally, the outcomes of five participants were included in the statistical analysis.

A positive trend was measured concerning the overall change in language outcome. Thus, the participants improved their language scores. However, the difference was not significant.

Concerning oral naming, a positive trend was perceived in the difference of the scores. After the interventions, the participants were able to name words they were not able to name before the interventions. Thus, word retrieval seems to be easier having performed intense homework over a period of three weeks. Nonetheless, the effect was not significant. In addition, averaging, there was a considerable increase in auditory speech comprehension. This route was not trained during the interventions. Consequently, it can be assumed cautiously that a change occurred in the semantic system of the participants, because they were able to answer more items correctly. Working high-frequently on paper-pencil tasks may have an indirect effect on the auditory speech comprehension.

A slight positive trend rather than a significant change was observed regarding written naming. This is probably due to the choice of the tests, as some participants showed ceiling effects already at the first measurement point and therefore did not have the possibility to improve in this part.

The participants' visual speech comprehension did not change significantly. This outcome could be due to the choice of the test, too: the test examined nouns but the homework did not train these. As the participants were not offered the possibility to practise nouns during the intensive homework, they were not given the chance to increase the number of nouns they know. Nevertheless, the participants improved their ability to comprehend written language, but this trend was not significant.

It might be assumed that the interventions had a considerable effect on daily communication, as the scores increased. However, this difference was not significant. Maybe the participants were able to name more words or were more confident in their way to communicate and therefore achieved more points after the high-frequent intervention.

Concluding, the intensive homework using the NAT-material did not lead to significant changes in language outcome or to significant changes in the communication in daily life. Nevertheless, the language outcomes and the scores of the daily communication increased over the

intervention time and positive trends were observed. The results indicate that high-frequent homework could have a significant influence on the (access to the) semantic system and on the way to communicate in daily life. Paper-pencil homework may be one alternative to achieve high-frequent therapy. It can be accessed fast and is easy to apply.

Yet, further research must be performed in order to prove intensive paper-pencil tasks being an effective alternative replenishing direct speech and language therapy to assure high-frequent treatment. In subsequent investigations, the homework should be easy to apply and the used material should be effective; the tests and homework-material should be matched even better and an attempt should be made to use parallel versions of the language test avoiding training effects. In addition, the interventions should last longer or be more intense and a follow-up measurement should be included investigating long-term effects. Furthermore, in case measuring the effect of an intervention on daily life, the interval of the end of the intervention and examining the influence should be long enough. If possible, the samples of subsequent investigations should include more participants to avoid individual deviations (e.g. effects of the mood of the day), to rule out outliers and to provide more explanatory power. In case future research respects all these factors, the probability to measure the real effect of high-frequent homework increases.

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Appendix

A. The CETI

CETI

(Communicative Effectiveness Index)

Englische Erstversion: Lomas et al. (1989)
Deutsche Übersetzung: Schlenck et al. (1994)
Angepasste Version von: Kiehn (2014)

Name des Probanden: _____ Datum:_____

Verwandtschaftsverhältnis: _____

In diesem Fragebogen geht es um Ihre Einschätzung zur alltäglichen Kommunikation des Probanden. Bitte beurteilen Sie die genannten Fähigkeiten Ihres Angehörigen durch Setzen eines Striches auf der Linie.

1. Die Aufmerksamkeit anderer auf sich lenken, wenn er/sie dies möchte:

Kann er/sie überhaupt nicht |——————————————————| Kann er/sie sehr gut

2. An Unterhaltungen teilnehmen, in denen es um ihn/sie geht:

Kann er/sie überhaupt nicht |——————————————————| Kann er/sie sehr gut

3. Fragen mit „ja“ und „nein“ richtig beantworten:

Kann er/sie überhaupt nicht |——————————————————| Kann er/sie sehr gut

4. Gefühle ausdrücken:

Kann er/sie überhaupt nicht |——————————————————| Kann er/sie sehr gut

5. Deutlich machen, dass er/sie versteht, was man ihm sagt:

Kann er/sie überhaupt nicht |——————————————————| Kann er/sie sehr gut

6. Mit Bekannten einen Kaffee trinken und sich dabei unterhalten:

Kann er/sie überhaupt nicht |——————————————————| Kann er/sie sehr gut

7. Ein persönliches Gespräch mit Ihnen führen:

Kann er/sie überhaupt nicht |——————————————————| Kann er/sie sehr gut

8. Den Namen von jemanden aussprechen, der vor ihm/ihr steht:

Kann er/sie überhaupt nicht — Kann er/sie sehr gut

9. Mitteilen, wenn er/sie gesundheitliche Probleme hat (z.B. sagen, wo er/sie Schmerzen hat):

Kann er/sie überhaupt nicht — Kann er/sie sehr gut

10. Eine spontane Unterhaltung führen (z.B. Eine Unterhaltung beginnen):

Kann er/sie überhaupt nicht — Kann er/sie sehr gut

11. Irgendetwas (z.B. „ja" oder „nein") ohne Worte ausdrücken:

Kann er/sie überhaupt nicht — Kann er/sie sehr gut

12. Ein Gespräch mit Menschen beginnen, die nicht zum engen Familienkreis gehören:

Kann er/sie überhaupt nicht — Kann er/sie sehr gut

13. Geschriebenes (Wörter, Sätze und Texte) lesen und verstehen:

Kann er/sie überhaupt nicht — Kann er/sie sehr gut

14. An einem Gespräch teilnehmen, das schnell und mit mehreren Gesprächspartnern geführt wird:

Kann er/sie überhaupt nicht — Kann er/sie sehr gut

15. An einem Gespräch mit Fremden teilnehmen:

Kann er/sie überhaupt nicht — Kann er/sie sehr gut

16. Einzelne Gegenstände benennen:

Kann er/sie überhaupt nicht — Kann er/sie sehr gut

17. Etwas ganz genau beschreiben oder besprechen:

Kann er/sie überhaupt nicht — Kann er/sie sehr gut

B. Examples of tasks of lexically-semantically verb-processing disorder (task 1.3)

C. Example task of lexically-semantically disorders (task 1.3)

Welches Wort ist der Name für die aufgezählten Dinge?

Beispiel: Kirche
Gebäude
Haus
Schloß
Villa

Schrank	Maus	Pflaume
Sofa	Tier	Erdbeere
Möbel	Schaf	Apfel
Tisch	Löwe	Obst
Regal	Hase	Banane
Bein	Zug	Hammer
Arm	Motorrad	Werkzeug
Körperteil	Auto	Meißel
Knie	Traktor	Beil
Hand	Fahrzeug	Bohrer
Sellerie	Kleidung	Puppe
Bohne	Jacke	Spielzeug
Weißkohl	Hemd	Dreirad
Gemüse	Strumpf	Ball
Erbse	Pullover	Bauklotz
Milch	Jahreszeit	Metzger
Kaffee	Sommer	Postbote
Getränk	Frühling	Beruf
Saft	Winter	Zahnarzt
Bier	Herbst	Schneider
Hummel	Teller	Nelke
Fliege	Tasse	Blume
Insekt	Schüssel	Tulpe
Schmetterling	Kanne	Rose
Mücke	Geschirr	Primel

D. Example task of lexically-phonemic disorders (task 1.6)

Welcher Buchstabe passt? Setzen Sie bitte ein:

M	K	S
____ern	____aske	____ehl
____ack	____oße	____oos
____ade	____önig	____amen
____amm	____iegel	____och
____aft	____atze	____irup
____ais	____üll	____ulde
____eks	____eide	____ilch
____ieb	____eller	____albe
____aler	____eer	____ugel
____alk	____ehne	____ünze
____enf	____äse	____äge
____alb	____arkt	____abel
____eife	____umpf	____ond
____antel	____äfer	____onne
____offer	____und	____arte

Übungsplan

Aufgabe: 5 Tage pro Woche, jeweils 60 Minuten üben

	Montag	Dienstag	Mittwoch	Donnerstag	Freitag	Samstag	Sonntag
Zeit pro Tag gesamt							

Keine Übungsblätter mehr?

Kristina Kiehn anrufen: 0241-[redacted]

Handy: 0163-[redacted]

Nächster Termin: _____

Fragen? _____

_____

F. Results of the AATs

F.a. Participant L.F.

Age and gender: 63;09 years, male
Duration of aphasia: 0;10 years
Test date: 2015/03/31

	Point value	Percentile	Overall severity (stanine)	Syndrome severity (tercile)
Spontaneous speech	3 3 3 3 5 3	---	---	---
Token Test	8	86	7 L MI	64 M L
Repeating	138	83	7 L MI	59 S M L
Written language	82	91	8 L MI	64 M L
Naming	111	96	8 L MI	68 M L
Comprehension	101	86	7 L MI	61 S M L

Legend: MI: Minimal; L: Slight; M: Medium; S: Strong

Diagnosis	
Aphasia	100%
Global aphasia	0%
Wernicke aphasia	2.6%
Broca aphasia	7.3%
Amnestic aphasia	90.1%

F.b. Participant I.M.

Age and gender: 72;01 years, male
Duration of aphasia: 3;00 years
Test date: 2015/04/20

	Point value	Percentile	Overall severity (stanine)	Syndrome severity (tercile)
Spontaneous speech	4 4 5 4 4 4	---	---	---
Token Test	28	48	5	49
Repeating	105	46	5	49
Written language	78	86	7	61
Naming	116	99	9	72
Comprehension	99	83	7	60

Legend: MI: Minimal; L: Slight; M: Medium; S: Strong

Diagnosis	
Aphasia	100%
Global aphasia	0%
Wernicke aphasia	0.1%
Broca aphasia	0%
Amnestic aphasia	99.9%

F.c. Participant P.L.

Age and gender: 59;04 years, male
Duration of aphasia: 2;02 years
Test date: 2015/04/27

	Point value	Percentile	Overall severity (stanine)	Syndrome severity (tercile)
Spontaneous speech	2 3 2 3 4 3	---	---	---
Token Test	8	86	7 L MI	
Repeating	134	77	6 L	
Written language	28	35	4 M	
Naming	59	40	4 M	
Comprehension	83	56	5 M L	

Legend: MI: Minimal; L: Slight; M: Medium; S: Strong

Diagnosis	
Aphasia	100%
Global aphasia	0%
Wernicke aphasia	0%
Broca aphasia	46.6%
Amnestic aphasia	53.4%

F.d. Participant E.J.

Age and gender: 70;03 years, male
Duration of aphasia: 1;10 years
Test date: 2015/05/02

	Point value	Percentile	Overall severity (stanine)	Syndrome severity (tercile)
Spontaneous speech	3 3 4 4 2 3	---	---	---
Token Test	27	50	5 M	
Repeating	112	51	5 M	
Written language	60	61	5 M L	
Naming	58	40	4 M	
Comprehension	92	70	6 M L MI	

Legend: MI: Minimal; L: Slight; M: Medium; S: Strong

Diagnosis	
Aphasia	100%
Global aphasia	0%
Wernicke aphasia	62.4%
Broca aphasia	37.6%
Amnestic aphasia	0%

F.e. Participant A.N.

Age and gender: 57;06 years, female
Duration of aphasia: 10;02 years
Test date: 2015/04/30

	Point value	Percentile	Overall severity (stanine)	Syndrome severity (tercile)
Spontaneous speech	4 5 5 5 4 4	---	---	---
Token Test	8	86	7 L MI	61 M L
Repeating	117	56	5 M L	51 S
Written language	68	70	6 M L	55 S M
Naming	104	86	7 L MI	61 M L
Comprehension	107	94	8 L MI	66 M L

Legend: MI: Minimal; L: Slight; M: Medium; S: Strong

Diagnosis	
Aphasia	100%
Global aphasia	0%
Wernicke aphasia	0%
Broca aphasia	0%
Amnestic aphasia	100%

F.f. Participant D.O.

Age and gender: 72;02 years, female
Duration of aphasia: 3;02 years
Test date: 2015/05/04

	Point value	Percentile	Overall severity (stanine)	Syndrome severity (tercile)
Spontaneous speech	3 3 4 3 4 3	---	---	---
Token Test	0	99	9 MI	
Repeating	130	72	6 M L	
Written language	81	90	7 L MI	
Naming	96	74	6 M L	
Comprehension	109	96	8 L MI	

Legend: MI: Minimal; L: Slight; M: Medium; S: Strong

Diagnosis	
Aphasia	100%
Global aphasia	0%
Wernicke aphasia	0%
Broca aphasia	58.4%
Amnestic aphasia	41.6%

F.g. Participant K.W.

Age and gender: 74;07 years, female
Duration of aphasia: 1;02 years
Test date: 2015/05/06

	Point value	Percentile	Overall severity (stanine)	Syndrome severity (tercile)
Spontaneous speech	3 3 5 3 4 4	---	---	---
Token Test	7	89	7 L MI	62 M L
Repeating	120	60	5 M L	52 S
Written language	75	80	6 L	58 S M
Naming	99	79	6 M L	58 S M
Comprehension	100	85	7 L MI	60 S M L

Legend: MI: Minimal; L: Slight; M: Medium; S: Strong

Diagnosis	
Aphasia	100%
Global aphasia	0%
Wernicke aphasia	0.3%
Broca aphasia	0%
Amnestic aphasia	99.6%

G. Results of the language tests in points

	Test	Subtest	L.F.	I.M.	P.L.	E.J.	A.N.	D.O.	K.W.
Baseline	AAT	Speech Comprehension	101	99	83	92	107	109	100
		Naming	111	116	59	58	104	96	99
	LEMO 2.0	Oral Naming	20	20	16	17	20	19	18
		Written Naming	20	20	8	16	16	19	17
		Word-Picture matching, auditory	20	20	20	20	20	20	19
		Word-Picture matching, visual	20	20	19	20	20	20	19
	BIWOS	Semantically	58	64	33	10	60	65	39
		Lexically	40	38	16	1	33	28	22
After first intervention	AAT	Speech Comprehension	107	101	94	84	114	115	98
		Naming	115	113	80	65	109	107	110
	LEMO 2.0	Oral Naming	20	20	20	17	20	20	20
		Written Naming	20	20	8	15	16	20	19
		Word-Picture matching, auditory	20	20	19	18	20	20	20
		Word-Picture matching, visual	20	20	20	20	20	20	19
	BIWOS	Semantically	57	67	46	5	58	56	49
		Lexically	43	50	29	0	36	42	38
After second intervention	AAT	Speech Comprehension	109	107	93	82	117	108	108
		Naming	106	113	81	59	113	112	101
	LEMO 2.0	Oral Naming	20	20	20	17	20	20	20
		Written Naming	20	20	10	17	16	20	18
		Word-Picture matching, auditory	20	20	20	20	20	20	20
		Word-Picture matching, visual	20	20	20	20	20	20	20
	BIWOS	Semantically	59	69	36	10	62	61	55
		Lexically	49	59	30	4	34	44	31

H. Results of the CETI

Participant	Baseline	After both interventions
L.F.	100	89
I.M.	68	76
P.L.	120	143
E.J.	139	144
A.N.	116	109
D.O.	82	124
K.W.	95	94
Mean of five participants	97	108

I. Data for the statistical analysis [total amount of points]

Participant	Baseline	After the homework	After both interventions
L.F.	390	402	403
I.M.	397	411	428
P.L.	254	316	310
A.N.	380	393	402
D.O.	376	400	405

J. SPSS-results

J.a. Wilcoxon signed-rank test (Overall Language Outcome)

Descriptive Statistics (Overall Language Outcome)

	N	Mean	Standard deviation	Minimum	Maximum
Before the interventions	5	359,40	59,496	254	397
After the homework	5	384,40	38,772	316	411
After the pause	5	389,60	45,774	310	428

Wilcoxon Signed Ranks Test

		N	Mean Rank	Sum of Ranks
After the homework - Before the interventions	Negative Ranks	0[a]	,00	,00
	Positive Ranks	5[b]	3,00	15,00
	Ties	0[c]		
	Total	5		
After the pause - After the homework	Negative Ranks	1[d]	3,00	3,00
	Positive Ranks	4[e]	3,00	12,00
	Ties	0[f]		
	Total	5		
After the pause - Before the interventions	Negative Ranks	0[g]	,00	,00
	Positive Ranks	5[h]	3,00	15,00
	Ties	0[i]		
	Total	5		

Note. **a**. After the homework < Before the interventions; **b**. After the homework > Before the interventions; **c**. After the homework = Before the interventions; **d**. After the pause < After the homework; **e**. After the pause > After the homework; **f**. After the pause = After the homework; **g**. After the pause < Before the interventions; **h**. After the pause > Before the interventions; **i**. After the pause = Before the interventions

Test Statistics[a]

	After the homework - Before the interventions	After the pause - After the homework	After the pause - Before the interventions
Z	-2,023[b]	-1,214[b]	-2,023[b]
Asymp. Sig. (2-tailed)	,043	,225	,043
Exact Sig. (2-tailed)	,063	,313	,063
Exact Sig. (1-tailed)	,031	,156	,031
Point Probability	,031	,063	,031

Note. **a**. Wilcoxon Signed Ranks Test; **b**. Based on negative ranks.

J.b. Post hoc test (Oral Naming)

Comparison		$\overline{R_u}$	$\overline{R_v}$	$\overline{R_u} - \overline{R_v}$	$\lvert\overline{R_u} - \overline{R_v}\rvert$
1	Before the interventions – After the homework	1	2.4	-1.4	1.4
2	Before the interventions – After both interventions	1	2.6	-1.4	1.4
3	After the homework – After both interventions	2.4	2.6	-0.2	0.2

J.c. Wilcoxon signed-rank test (Oral Naming)

Descriptive Statistics (Oral Naming)

	N	Mean	Standard deviation	Minimum	Maximum
Oral Naming Baseline	5	203,20	45,724	124	238
Oral Naming After the homework	5	221,60	28,157	175	250
Oral Naming After both interventions	5	225,60	34,997	167	261

Wilcoxon Signed Ranks Test

		N	Mean Rank	Sum of Ranks
Oral Naming After the homework - Oral Naming Baseline	Negative Ranks	0[a]	,00	,00
	Positive Ranks	5[b]	3,00	15,00
	Ties	0[c]		
	Total	5		
Oral Naming After both interventions - Oral Naming Baseline	Negative Ranks	0[d]	,00	,00
	Positive Ranks	5[e]	3,00	15,00
	Ties	0[f]		
	Total	5		
Oral Naming After both interventions - Oral Naming After the homework	Negative Ranks	2[g]	2,00	4,00
	Positive Ranks	3[h]	3,67	11,00
	Ties	0[i]		
	Total	5		

Note. **a**. Oral Naming After the homework < Oral Naming Baseline; **b**. Oral Naming After the homework > Oral Naming Baseline; **c**. Oral Naming After the homework = Oral Naming Baseline; **d**. Oral Naming After both interventions < Oral Naming Baseline; **e**. Oral Naming After both interventions > Oral Naming Baseline; **f**. Oral Naming After both interventions = Oral Naming Baseline; **g**. Oral Naming After both interventions < Oral Naming After the homework; **h**. Oral Naming After both interventions > Oral Naming After the homework; **i**. Oral Naming After both interventions = Oral Naming After the homework

Test Statistics[a]

	Oral Naming After the homework - Oral Naming Baseline	Oral Naming After both interventions - Oral Naming Baseline	Oral Naming After both interventions - Oral Naming After the homework
Z	-2,032[b]	-2,023[b]	-,944[b]
Asymp. Sig. (2-tailed)	,042	,043	,345
Exact Sig. (2-tailed)	,063	,063	,438
Exact Sig. (1-tailed)	,031	,031	,219
Point Probability	,031	,031	,063

Note. **a**. Wilcoxon Signed Ranks Test; **b**. Based on negative ranks.

J.d. Friedman's ANOVA (Written Naming)

Descriptive Statistics (Written Naming)

	N	Mean	Standard deviation	Minimum	Maximum
Written Naming Baseline	5	16,60	5,079	8	20
Written Naming After the homework	5	16,80	5,215	8	20
Written Naming After both interventions	5	16,80	4,604	10	20

Friedman's ANOVA (Written Naming)

Ranks

	Mean Rank
Written Naming Baseline	1,80
Written Naming After the homework	2,10
Written Naming After both interventions	2,10

Test Statistics

N	5
Chi-Square	,667
df	2
Asymp. Sig.	,717
Exact Sig.	1,000
Point Probability	,556

J.e. Friedman's ANOVA (Auditory Speech Comprehension)

Descriptive Statistics (Auditory Speech Comprehension)

	N	Mean	Standard deviation	Minimum	Maximum
Auditory Speech Comprehension Baseline	5	68,40	7,635	57	74
Auditory Speech Comprehension After the homework	5	73,60	4,278	68	77
Auditory Speech Comprehension After both interventions	5	72,20	4,147	67	77

Friedman's ANOVA (Auditory Speech Comprehension)

Ranks

	Mean Rank
Auditory Speech Comprehension Baseline	1,20
Auditory Speech Comprehension After the homework	2,70
Auditory Speech Comprehension After both interventions	2,10

Test Statistics

N	5
Chi-Square	6,000
df	2
Asymp. Sig.	,050
Exact Sig.	,054
Point Probability	,019

J.f. Friedman's ANOVA (Visual Speech Comprehension)

Descriptive Statistics (Visual Speech Comprehension)

	N	Mean	Standard deviation	Minimum	Maximum
Visual Speech Comprehension Baseline	5	71,20	4,494	65	75
Visual Speech Comprehension After the homework	5	72,40	6,309	63	79
Visual Speech Comprehension After both interventions	5	74,60	5,367	66	80

Friedman's ANOVA (Visual Speech Comprehension)

Ranks

	Mean Rank
Visual Speech Comprehension Baseline	1,50
Visual Speech Comprehension After the homework	1,80
Visual Speech Comprehension After both interventions	2,70

Test Statistics

N	5
Chi-Square	4,105
df	2
Asymp. Sig.	,128
Exact Sig.	,139
Point Probability	,028

J.g. Wilcoxon matched-pairs test

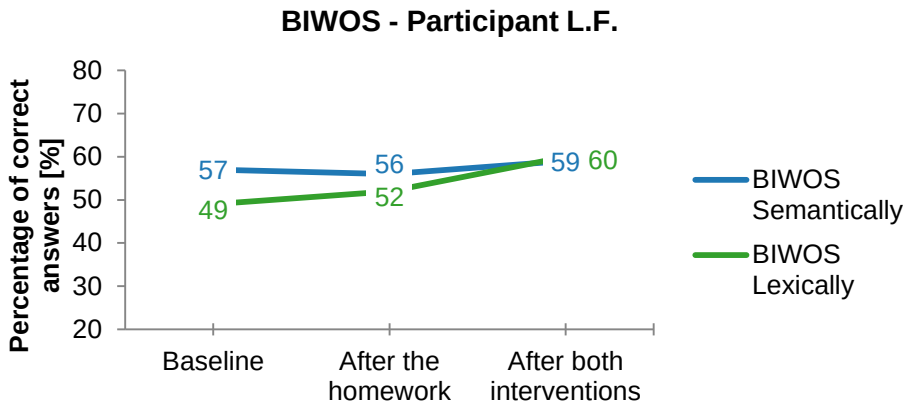
Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Pre and Post equals 0.	Related-Samples Wilcoxon Signed Rank Test	,398	Retain the null hypothesis.

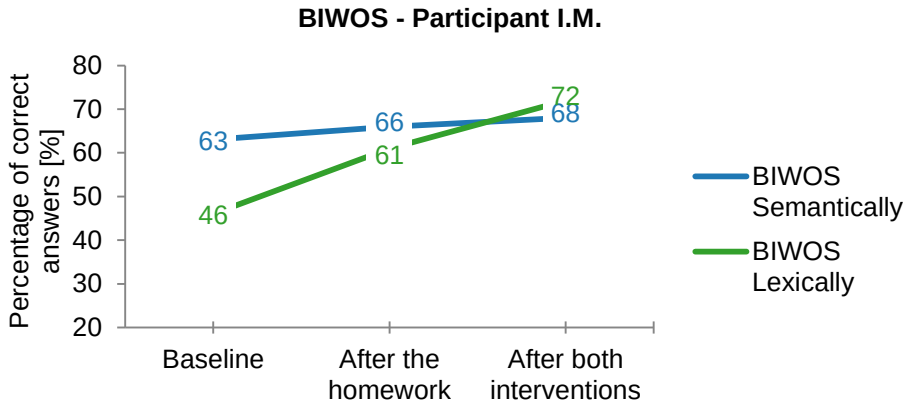
Asymptotic significances are displayed. The significance level is ,05.

K. BIWOS-outcome of the participants

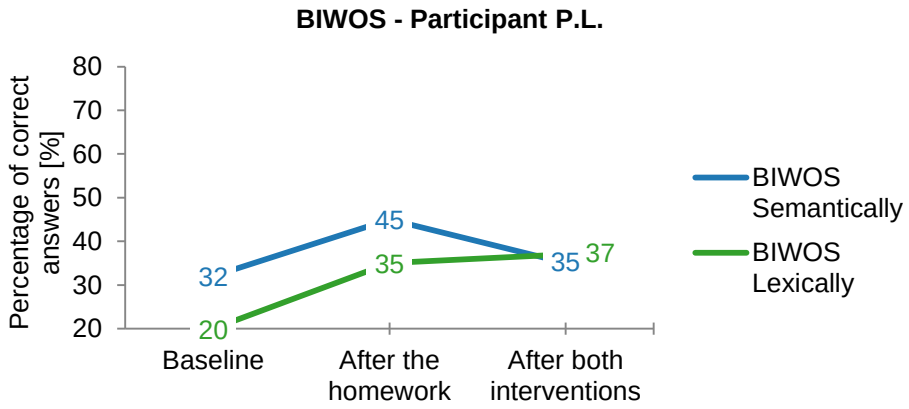
K.a. BIWOS-outcome, participant L.F.



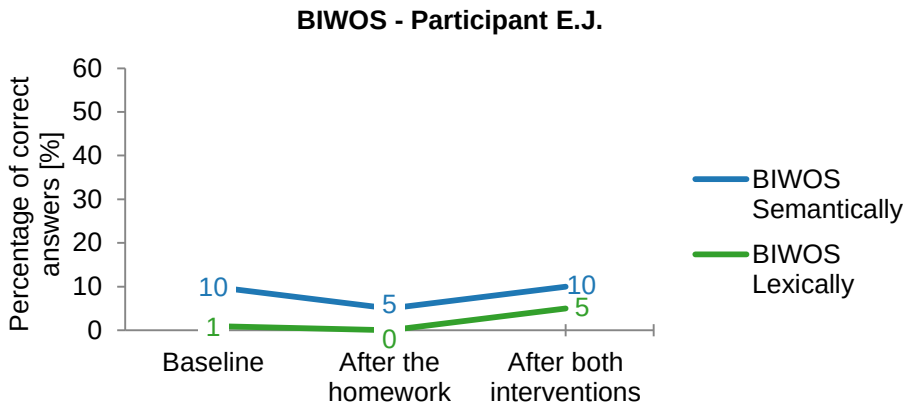
K.b. BIWOS-outcome, participant I.M.



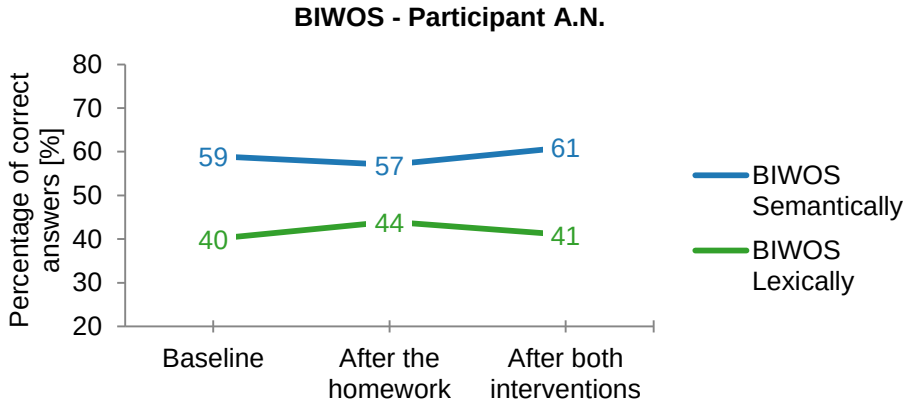
K.c. BIWOS-outcome, participant P.L.



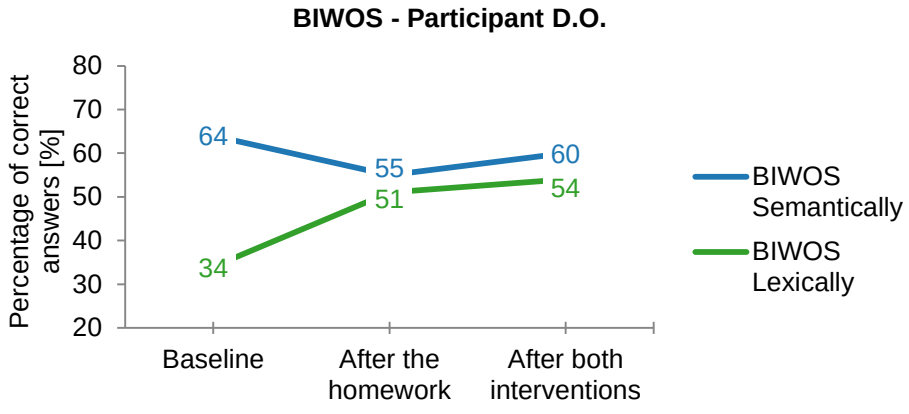
K.d. BIWOS-outcome, participant E.J.



K.e. BIWOS-outcome, participant A.N.



K.f. BIWOS-outcome, participant D.O.



K.g. <u>BIWOS-outcome, participant K.W.</u>