Efficacy of Reading Strategies on Text Level Reading Comprehension in People with Post-Stroke Chronic Aphasia: A Repeated Measures Study

Sarah-Maria Thumbeck [a]*, Philipp Schmid [b], Sophie Chesneau [c] and Frank Domahs [a]

[a] *Department of Linguistics, University of Erfurt, Erfurt, Germany*

[b] *Centre for Language Studies, Radboud University Nijmegen, Nijmegen, The Netherlands*
Institute for Planetary Health Behaviour, University of Erfurt, Erfurt, Germany
Department of Implementation Research, Bernhard-Nocht-Institute for Tropical Medicine, Hamburg, Germany

[c] *Département d'Orthophonie, Université du Québec à Trois-Rivières, Trois-Rivières, Québec, Canada*

*Corresponding author: Sarah-Maria Thumbeck (ST), Department of Linguistics, University of Erfurt, Erfurt, Germany, ORCID-ID: 0000-0001-8856-3155, sarah-maria.thumbeck@uni-erfurt.de

Co-author details:
Philipp Schmid (PS), ORCID-ID: 0000-0003-2966-0806, philipp.schmid@ru.nl
Sophie Chesneau (SC), ORCID-ID: 0000-0001-6322-718X, sophie.chesneau@uqtr.ca, phone: +1-819-376-5011
Frank Domahs (FD), ORCID-ID: 0000-0002-5583-4681, frank.domahs@uni-erfurt.de, phone: +49-361-737-4391

Running head: Efficacy of reading strategies in aphasia

Keywords: reading; text comprehension; reading strategies; aphasia; alexia; strategy-based treatment

Data availability statement: The data that support the findings of this study are openly available in Open Science Framework at https://doi.org/10.17605/OSF.IO/F6T5B.

Funding: This work was supported by a Christoph-Martin-Wieland scholarship of the University of Erfurt granted to ST. This source of funding did not and will not influence any aspects in study design, conduct, data analysis, interpretation, manuscript writing, and dissemination of results.

Conflict of interest disclosure: The authors declared no conflict of interest.

Ethics approval statement: This study was approved by the ethics committee of Deutscher Bundesverband für akademische Sprachtherapie und Logopädie (dbs) (20-10074-KA-MunmErw+Ko).

Patient consent statement: Participants had to provide written informed consent prior to inclusion as approved by the ethics committee. Patient consent for publication is not applicable as no details relating to individual persons have been included.

Permission to reproduce material from other sources: Not applicable.

ABSTRACT

Background. People with aphasia (PWA) frequently experience difficulties in understanding longer written content such as paragraphs or books. Reading strategies are a promising approach to treat text level reading comprehension deficits in PWA. Nevertheless, empirical evidence for their efficacy remains rare.

Aims. The primary objective of this study was to analyse the efficacy of a strategy-based intervention on text level reading comprehension in PWA. Secondary objectives were to compare the effects of two strategy-based intervention components and to explore potential moderator effects.

Methods & Procedures. A protocol was published prior to data acquisition. In a repeated measures trial, 26 German participants with chronic, post-stroke aphasia participated in a waiting period without aphasia treatment (control condition) followed by a strategy-based intervention called "*Strategiebasierte Textverständnis-Therapie bei Aphasie" (StraTexT*, 14 face-to-face-sessions, twice per week, 60 minutes each). Two strategy combinations, *Intervention Micro* targeting microstructure and *Intervention Macro* targeting macrostructure, were applied to newspaper and magazine articles. Participants were randomly allocated to two parallel groups that received these strategy combinations in interchanged sequences. Assessments were implemented before and after each period as well as three and six months after the intervention. The primary outcome measure was text level reading comprehension measured with the total score of a German version of the *Test de Compréhension de Textes* (TCT-D). Secondary outcome measures addressed the self-reported perception of reading abilities, reading activities, and feelings about reading (German version of the *Comprehensive Assessment of Reading in Aphasia CARA* reading questionnaire) as well as selected cognitive functions.

Outcomes & Results. The per-protocol-analysis included data from 22 participants. We found significant small improvements up to 6 months post-intervention compared to pre-intervention in the TCT-D Total (d = 0.35 – 0.46) as well as medium to large improvements in the CARA questionnaire (d = 0.68 – 0.96). Up to three months after the intervention, treatment-induced improvements in the TCT-D Total were significantly larger than change without treatment during the control condition. There was no evidence of moderator effects. Furthermore, we found improvements in several cognitive functions.

Conclusions & Implications. Reading strategies can lead to long-term improvements in text level reading comprehension and in self-reported reading abilities, feelings about reading, and reading activities in aphasia. In regular clinical settings, it seems reasonable to implement both

Intervention Micro and Intervention Macro. It remains important to investigate participant characteristics that contribute to treatment success.

WHAT THIS PAPER ADDS

What is already known on this subject. Systematic reviews and multiple case studies suggest that reading strategies are a promising approach to treat text level reading comprehension in aphasia. The efficacy of reading strategies has been demonstrated for different populations. However, to date no group study has evaluated the efficacy of reading strategies on text level reading comprehension in people with aphasia.

What this study adds. This study provides the first group-level evidence about the efficacy of a systematic strategy-based intervention in 22 people with post-stroke chronic aphasia. During 14 treatment sessions, participants applied four reading strategies to newspaper and magazine articles within two intervention components called Intervention Micro and Intervention Macro (two strategies per intervention component). We found improvements in text level reading comprehension for at least 3 months post-intervention, as well as effects on selected cognitive functions and self-reported reading abilities, thoughts and feelings about reading, and the ability to engage in reading activities.

Clinical implications of this study. The strategies and materials evaluated in this study could be used in clinical practice with people with aphasia. In order to replicate treatment effects in clinical practice, we suggest applying the strategy combination with the same protocol features (e.g. frequency, duration, homework, product-orientation) as in this study, implementing Intervention Micro and Intervention Macro sequentially in either order. As treatment response was not equal in all individuals, it seems important to investigate individual features that contribute to treatment success.

INTRODUCTION

Background and rationale

Text level reading comprehension

Reading literacy can be defined as “understanding, using and reflecting on written texts, in order to achieve one’s goals, to develop one’s knowledge and potential and to participate in society” (OECD, 2006, p. 46). This definition highlights the importance of reading in major domains of life.

From a psycholinguistic perspective, reading involves initial visual processes that are complemented with linguistic as well as highly generalized non-linguistic comprehension processes (Perfetti, 1999). The interactive model of text comprehension by Verhoeven and Perfetti (2008) outlines two major components: word identification and word-to-text integration. The identification of individual words within a text is enhanced by precise knowledge on their orthography, phonology, morphology, and meaning. Automatic word recognition allows readers to shift and allocate cognitive resources to the meaning of a text. Word-to-text integration entails the construction of text models and situation models by analysing syntactic structures as well as integrating word meanings, information read up to that point, and prior knowledge (Verhoeven & Perfetti, 2008).

According to Kintsch (2018), the outcome of text comprehension can be described in three levels of mental representation: the *surface level* for exact wording, the *textbase* for the semantic content expressed by a text, and the *situation model* which integrates textual information with a reader’s background knowledge.

The surface level refers to the short-lived memory for exact wording and syntactic structures (Kintsch, 2018).

The textbase is the representation of semantic content in a propositional, idea-level format. Propositions – “linguistic units consisting of a relational term (or predicate) and one or more arguments" (Kintsch, 2018, p. 180) – allow to work with semantic content regardless of specific wording (Kintsch, 2018). Propositions in a text are linked to one another by shared relational terms or arguments, which results in local coherence (Chesneau, 2012). Following the *Construction-Integration-Model* (Kintsch, 2018), the textbase consists of *microstructure* and *macrostructure*. Whereas microstructure contains the whole “network of propositions that represent the meaning of a text” (Kintsch, 2018, p. 181), i.e. all detailed information of a text, macrostructure describes more global propositions or the gist constructed by reducing microstructure based on *macrorules*: Relevant propositions are selected and irrelevant ones are deleted (*selection*), subordinate propositions are replaced by superordinate propositions

(*generalisation*), or sequences of propositions are replaced by general propositions (*construction*) (Kintsch, 2018).

Finally, readers construct a mental situation model by continuously integrating the content represented in the textbase, the context and individual pre-existing knowledge taking into account *cognitive schemata* like *scripts* (e.g. processes) and *frames* (e.g. situations, objects, institutions or character types). Thus, according to cognitive models, readers construct meaning by integrating text contents and prior knowledge (Jesch, 2010). These individual coherent situation models in the episodic memory are a form of inference and can be considered the actual outcome of the reading process (Kintsch, 2018; Rosebrock & Nix, 2020).

Cognitive functions such as short- and long-term memory, inference making, and executive functions including working memory, inhibition and attention are necessary to bridge gaps, to generate or retrieve information not explicitly stated in the text, and to construct a coherent text representation: In working memory, text information is maintained and processed, whereas inhibition processes and attention allocation help a reader to focus on structurally central information in a text, to inhibit irrelevant information, and to monitor comprehension. Inference making allows a reader to connect text contents and background information (Kendeou et al., 2014; Kintsch, 2018).

Apart from these complex interactions between linguistic and cognitive resources, text level reading in everyday life is usually embedded in a sociocultural context and influenced by individual factors such as motivation, reading goals, or specific reading activities (Rosebrock & Nix, 2020; Snow, 2002).

Text level reading comprehension in aphasia

In PWA, receptive and productive language skills (e.g. phonology, lexicon, semantics) as well as cognitive resources such as verbal working memory, episodic memory, monitoring, cognitive flexibility, attention, and executive functions may be impaired (Chesneau & Ska, 2015; Meteyard et al., 2015; Purdy et al., 2018; Schumacher et al., 2019). Differences in underlying impairments go along with heterogenous manifestations of reading difficulties (Purdy et al., 2018). Deficits in lexical and syntactic information processing, local and global inferencing skills, and macrostructural processes may affect the construction of the propositional textbase, especially the microstructure, but also macrostructures and situation models (Chesneau & Ska, 2015; Meteyard et al., 2015; Riedel, 2014). PWA may thus experience text comprehension difficulties including a reduced reading speed even though these difficulties may not be detected in general aphasia tests that often focus on more basic linguistic levels (Chesneau, 2012; Chesneau & Ska, 2015).

Webster et al. (2021) collected data on the subjective perception of reading abilities in 81 participants with varied types, post-onset times, and severity of aphasia. More than 70% of their participants reported problems in reading and understanding longer units such as paragraphs or books. Only less than 20% considered reading to be easy and experienced no problems in reading-related cognitive functions such as concentrating when reading and remembering what was read (Webster et al., 2021).

In line with these impairments, everyday life reading activities such as reading schedules, instructions on food or on laundry, formal letters, or books may become more difficult, which affects domestic, work, social, and leisure roles (Parr, 1995; Webster et al., 2021). Considering that reading remains important for the majority of PWA (Webster et al., 2021), it is concerning that many stroke patients reported that their needs with regard to their reading difficulties are not or only partially met (McKevitt et al., 2011).

Treatment of text level reading comprehension and the use of reading strategies in aphasia

Current evidence on the efficacy of different types of text level reading comprehension interventions for PWA does not allow general conclusions (Purdy et al., 2018): In their systematic reviews, Purdy et al. (2018) and Watter et al. (2016) call for further research and more rigorous study designs.

Purdy et al. (2018) distinguish oral, strategy-based, cognitive, and hierarchical reading treatments. A brief overview of these treatment approaches is provided in Thumbeck et al. (2021). Cognitive and strategy-based interventions have been explored in a few (multiple) case studies, while oral and hierarchical reading treatments have been investigated in randomized controlled trials (RCTs) (Purdy et al., 2018; Watter et al., 2016).

The present study evaluated the efficacy of a systematic strategy-based treatment called "*Strategiebasierte Textverständnis-Therapie bei Aphasie" (StraTexT)*. Reading strategies are specific, target-oriented techniques applied either consciously and flexibly or automatically. They facilitate reading comprehension including linguistic and cognitive processes such as the maintenance of text contents or the construction of the textbase and the situation model (Artelt et al., 2005; Jesch, 2010; Watter et al., 2016). Watter et al. (2016) distinguish visual strategies (e.g. underlining, highlighting), content strategies (e.g. identification of key words, summarisation, preview of headings), and (meta)cognitive strategies (e.g. re-reading, recall, self monitoring).

We focussed on reading strategies because we think that they have several advantages. In fact, the first results of case studies with PWA are promising (Purdy et al., 2018; Watter et al., 2016). Reading strategies have been related to both linguistic and cognitive processes (Lynch et al., 2013), they might be cost-effective due to a relatively low dosage (Watter et al., 2016),

they can be adopted flexibly across languages, and they are not confined to specific texts, text types, or language-specific software. The ability of PWA to apply reading strategies in authentic reading situations was demonstrated by Lynch et al. (2013).

Even though current evidence suggests that reading strategies may be effective, cost-efficient, generalisable, and acceptable to PWA, in their systematic review Purdy et al. (2018) identified only four case studies that evaluated strategy-based treatments including a total of six PWA. Reading comprehension improved in four of the participants (Purdy et al., 2018). In addition, Rogalski & Edmonds (2008) and Rogalski et al. (2013) applied *Attentive Reading and Constrained Summarization (ARCS)* containing the strategy of summarisation. Two out of their three participants improved in text-related measures. None of the strategy-based treatments was explored in larger group studies with PWA yet. The type of strategies most frequently used were content strategies (identifying / writing down key words and key messages, summarizing paragraphs and chapters, creating mind-maps and using advance organisers), followed by some visual strategies (highlighting key words, using cards to block lines above and below focused lines), and the cognitive strategy of (re-)reading sections aloud and silently (Thumbeck et al., 2021). Further strategies, such as discussions, foreshadowing, or answering given questions, are only accessible with the help of a second person or text specific material, which may not be available to all PWA in autonomous everyday reading situations. Note that the previously explored strategies focus mainly on the macrostructure, on the situation model as well as on the integration of background knowledge and (meta)cognitive abilities, whereas barely any strategies targeted the microstructure.

Reading strategies in other populations

Extensive evidence, including meta-analyses, supports the impact of reading strategies on reading comprehension for various populations, such as readers with regular reading abilities, developmental reading difficulties or learning disabilities, and readers in a second language context (e.g. Lenhard et al., 2013; A. Mayer & Marks, 2019; Souvignier & Antoniou, 2007; Yapp et al., 2021). Overall, it has been shown that strategy combinations are more effective than the use of single strategies (Mayer & Marks, 2019). Also, the autonomous and flexible use of reading strategies in everyday life requires metacognitive abilities to monitor, plan, and control reading behaviour (Rosebrock & Nix, 2020).

Meta-analyses regarding students with learning disabilities and readers in second language contexts suggest strongest effects for the activation of prior knowledge, connecting new information to what is already known, comprehension monitoring, summarisation, asking questions, identification of the topic, guessing meanings from headings and pictures as well as strategies focussing on the text structure (Souvignier & Antoniou, 2007; Yapp et al., 2021).

Watter et al. (2021) combined similar strategies in an evidence-based reading intervention for persons with non-aphasic cognitive-communication reading comprehension deficits resulting from acquired brain injury: They proposed a multiple-strategy reading intervention with a 3-level hierarchical progression of reading complexity and text length combining the following strategies: identifying key words / wh strategy (who, what, where, when, why, how); summarizing information; underlining / highlighting key information; and self-checking ('Have I understood it?') (Watter et al., 2021).

Strategy-based concepts in educational contexts include SQ3R (survey, question, read, recite, review), PQ4R (preview, question, read, reflect, recite, review) and reciprocal teaching (prediction, clarification, summarisation, question generation) (Rosebrock & Nix, 2020). Furthermore, Schmidt (2007) proposed the use of referential links as a reading strategy.

Integration of theory and evidence in StraTexT

Based on current evidence and cognitive models, we designed *StraTexT*, a multiple-strategy intervention to treat text level reading comprehension in aphasia. We took into account potential impairments in functions relevant for text comprehension, i.e. linguistic as well as cognitive functions and processes such as inference making, shifting attention to relevant information, inhibiting irrelevant information, maintaining and processing information, and cognitive flexibility. StraTexT consists of two components – *Intervention Macro* and *Intervention Micro* – with two strategies each. The selected strategies are described in more detail in the Methods section. For *Intervention Macro* targeting macrostructure and the situation model, we modified strategies that have already been explored with PWA in the case studies described above, resulting in the strategies a) use of advance organisers and key words to create a mind map before and while reading, and b) summarisation and re-reading. For *Intervention Micro* targeting surface structure and microstructure, we selected strategies that have been explored in other populations and are applicable without a second person or additional text-specific material, i.e. a) generating questions and answers, and b) using referential links and elaboration. To facilitate the use of these reading strategies, they were embedded in a product-oriented approach (see below).

Action- and product-orientation in language teaching and language learning

The step-by-step-procedures and the tasks implemented in StraTexT were inspired by an action-oriented (and particularly product-oriented) approach. Action-oriented approaches are a key concept in the *Common European Framework of Reference for Languages: Learning, Teaching, Assessment* (Council of Europe, 2020) and intend to enable language learners to communicate in the target language. Therefore, they integrate real-life situations and authentic materials in teaching and learning (Piccardo, 2014). As one of the features, learners are

instructed to apply knowledge within projects and tasks to create meaningful products (e.g. posters, videos, magazines, or exhibitions) that they can present or share with others. Instructions and procedures become easier and clearer to grasp within these product-oriented tasks compared to abstract instructions. Furthermore, experiencing the progress and the final product can be very motivating (Gudjons, 2014).

Considering language barriers in instruction comprehension in PWA, a product-oriented approach may have several advantages: First, the goal to construct a familiar product may facilitate the comprehension of the procedures. Second, the use of authentic materials may promote transfer to real-life situations. Third, reading in real life is often connected to activities and goals which – as products do – require individuals to apply the read information.

Objectives

The primary objective of this study was to investigate whether the effects of a systematic strategy-based intervention on text level reading comprehension and on reading-related activities and feelings in PWA are superior to a waiting period without treatment (control condition) in short and long term.

Secondary objectives were (1) to compare the effects of two types of strategy-based interventions on the comprehension of the microstructure and the macrostructure and (2) to explore the influence of potential moderator effects such as sociodemographic variables and cognitive functions on treatment efficacy.

We anticipated the intervention to be superior compared to a waiting period regarding improvements in text level reading comprehension and in activities and feelings related to reading. Furthermore, we expected that *Intervention Micro* would particularly contribute to improvements in the microstructure, while *Intervention Macro* would particularly contribute to improvements in the macrostructure.

METHODS

This study was approved by the ethics committee of *Deutscher Bundesverband für akademische Sprachtherapie und Logopädie* (dbs; 20-10074-KA-MunmErw+Ko) and preregistered on *Deutsches Register Klinischer Studien* (DRKS; DRKS00021411). We published the study protocol (Thumbeck et al., 2021) prior to data acquisition and conducted the study as prespecified in the protocol. In this article, we present information guided by the *CONSORT 2010 Checklist* (Schulz et al., 2010). We describe our participants using the *DESCRIBE checklist* (Wallace et al., 2022), and our intervention following the *template for intervention description and replication (TIDieR) checklist and guide* (Hoffmann et al., 2014). Data supporting the findings of this study is available on *Open Science Framework* (OSF; Thumbeck, Schmid, et al., 2023).

Trial Design

As suggested in systematic reviews, in our preregistered, group-based study we ensured a more rigorous design than previous studies that explored reading strategies in PWA using case studies: We compared the effects of a strategy-based intervention to a waiting period in a repeated measures, single group design with six measurements and a primary endpoint of text level reading comprehension (see Figure 1). During the control condition, i.e. waiting period, participants did not receive any aphasia treatment for four weeks. The strategy-based intervention consisted of two phases with different types of strategies (Intervention Micro and Intervention Macro; seven sessions each). To explore strategy-specific effects and to control for potential order and sequence effects, participants were allocated to two parallel groups who completed these two phases in counterbalanced order after the waiting period. Assessments took place before the waiting period (T1), directly before the start of the intervention (T2), after the first intervention phase (T3), immediately after the second intervention phase (T4), and three and six months after the second intervention phase (follow-ups T5 and T6).

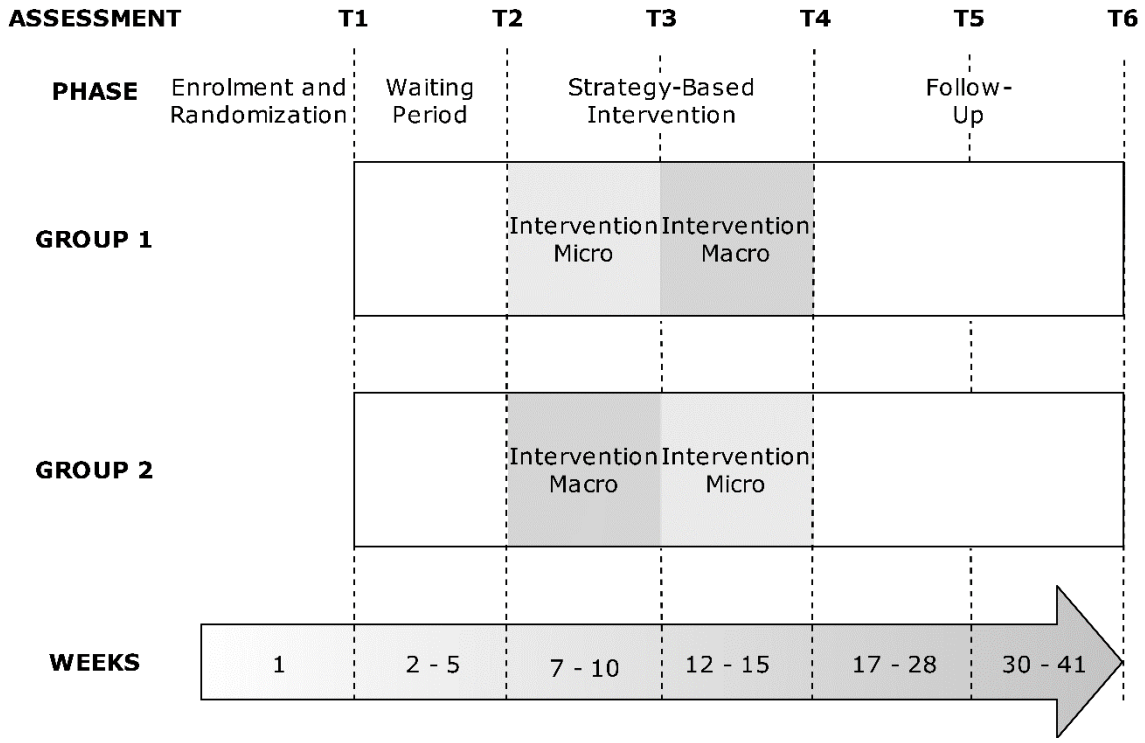

Figure 1: Trial Design (see Thumbeck et al., 2021).

Participants

Inclusion was based on the criteria specified in Table 1. The inclusion and exclusion criteria aimed to identify PWA in the chronic phase without severe problems in reading comprehension on the word level. We also included people with residual aphasia, i.e. people with the current classification “no aphasia or residual aphasia" according to the standardised aphasia assessment Aachener Aphasie Test (AAT; Huber et al., 1983) if medical records confirmed a previous diagnosis of aphasia. Due to the complexity of the approach and the focus on text level reading comprehension, global aphasia and severe reading problems were exclusion criteria (Table 1).

Table 1: Inclusion and exclusion criteria as specified in Thumbeck (2021).

Inclusion criteria	• age of at least 18 years • aphasia according to *Aachener Aphasie Test (AAT)* (Huber et al., 1983) OR no current symptoms / only residual aphasia according to the latest *AAT* assessment but previously diagnosed aphasia and current language difficulties (subjective or perceived by a speech and language pathologist) • scores outside normal range in the German version of *Test de Compréhension de Textes* (Chesneau, 2012) (*TCT-D*) • first language: German • at least 3 months post-onset
Exclusion criteria	• global aphasia AND / OR severe problems in word level reading (score < 12 in *AAT* subtest "single word reading comprehension") AND / OR severe problems in written language processing (score < 22 in category "written language" in *AAT*) • neurological, psychiatric or any other disease that impedes a (repeated) assessment and valid interpretation with the AAT or TCT-D (particularly if the disease can result in decreasing or strongly fluctuating linguistic or cognitive performance) • pre-morbid dyslexia

An a-priori power analysis revealed a requirement for a minimum of n = 21 participants. Participants were recruited and allocated to the two groups in three waves between December 2020 and July 2021, from all over Germany with a regional focus on rural and urban Munich. After wave three, 26 participants were enrolled, and recruitment was stopped because the prespecified number of participants was reached. Interventions were completed by December 2021. Follow-Up assessments T5 (n = 23) and T6 (n = 20) were completed by June 2022. Three participants dropped out due to medical reasons unrelated to the study (P25 before starting the intervention, P4 and P12 before completing the intervention). P5 had to be excluded from the per protocol analyses because information on a pre-existing neurological disease was only provided after all intervention sessions and assessments had been completed. Figure 2 shows the participant flow diagram.

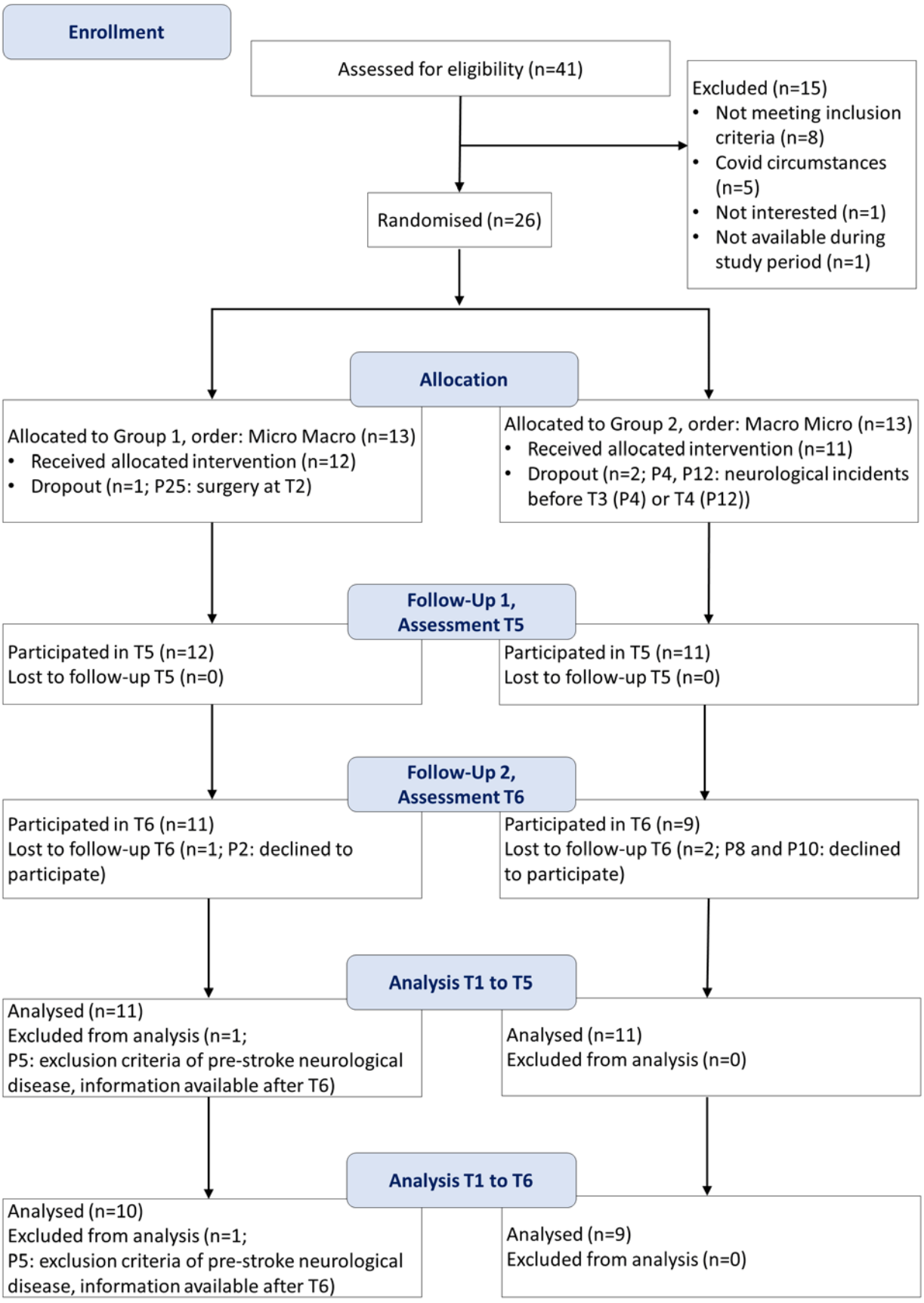

Figure 2: Participant flow diagram.

Table 2 provides an overview of participant characteristics of the 22 participants included in the main analyses up to assessment T5. The participants included in the analyses had a mean age of 59 years. All participants were in the chronic phase with a minimum of six months and an average of 6 years post-onset, and the majority presented with mild to moderate impairments according to the Token Test (Huber et al., 1983). Characteristics about individual participants, additional information on their aphasia, and baseline characteristics of the two groups including the stratification parameters age, severity of aphasia, and text comprehension are provided in Supplementary Tables 1, 2 and 3. At T1, no statistically significant differences in these parameters were found between the two groups (Supplementary Table 3).

Table 2: Participant descriptors for all 22 participants included in the primary analysis.

Age	Mean = 58.6 years SD = 10.6 Range: 28.5 - 76.3 years
Gender	13 male 9 female
Formal education	8 less than twelve years 14 twelve years or more
Age at onset of aphasia	Mean = 52.4 years SD = 13.2 Range: 13.3 - 74.5 years
Time post-onset	Mean = 6.2 years SD = 6.3 Range: .5 - 25.7 years
Aphasia syndrome according to AAT (Huber et al., 1983)	2 Wernicke 5 Broca 5 Amnestic 2 not classifiable 5 residual aphasia 3 unknown
Severity of aphasia (Token Test in AAT, T-Score)	Mean = 62.0 SD = 9.1 Range =42.0 – 73.0
Severity of aphasic impairment in Token Test, AAT	13 minimal / none 4 mild 4 moderate 1 severe
Text comprehension (TCT-D Total in per cent)	Mean = 61.1 SD = 19.1 Range = 16.7 – 92.2
Self-reported perception of reading (CARA Total in per cent)	Mean = 68.1 SD = 10.9 Range = 46.1 – 91.2

Note. Information based on assessment T1; AAT: Aachener Aphasie Test (Huber et al., 1983); TCT-D Total: Total score in the German version of Test de Compréhension de Textes (Chesneau, 2012); CARA Total: Total score in

the German version of the Comprehensive Assessment of Reading in Aphasia reading questionnaire (Thumbeck, Webster, et al., 2023).

Setting

In Germany, outpatient speech and language therapy for PWA in the chronic phase is typically prescribed according to directives called "Heilmittelrichtlinie", diagnosis group SP5. These directives recommend scheduling language therapy sessions between one and three times per week, with each session lasting 30 to 60 minutes. Protocol features (frequency, dosage, duration of the sessions) were designed to be compatible with this context. To recruit participants, we contacted rehabilitation centres and support groups, and advertised the study in newsletters of professional associations for speech and language pathologists (SLPs). Prior to inclusion, participants had to give written informed consent. Participants who were already receiving speech and language treatment took part in the experimental intervention with their existing SLP, otherwise treatment sessions were arranged with an SLP local to them or with ST. Sessions were scheduled individually. 12 certified SLPs including ST and four supervised SLP-students conducted intervention and assessment sessions after completing a three-hour preparatory workshop (theoretical training and role play to practice StraTexT). All SLPs met qualification standards required by the German health insurance system. Due to its novelty, none of the SLPs had previous experience with StraTexT. Between T1 and T4, the participants did not receive any other aphasia treatment, whereas (routine) treatment after the experimental intervention (i.e. after T4) was not controlled for due to ethical reasons. Covid measures (e.g. face masks) were implemented as required by state regulations and did not vary between groups.

Procedure

Participants were allocated to two parallel groups with the ratio 1:1 by stratified permuted block randomisation to control for order and sequence effects, and to explore strategy-specific effects in a secondary between-group analysis. We stratified for age, severity of aphasia (age-adjusted score in the subtest *Token Test* of *AAT*, Huber et al., 1983), and the *TCT-D Total* score. In three waves, SLPs screened and enrolled participants. Participants' identification numbers along with their stratification factors were reported to the scientific managing director of the *ErfurtLab* at the University of Erfurt, Germany, who was not involved in the study otherwise. He generated blocks and randomly allocated the participants to one of the two groups without disclosing the allocation algorithm or the block sizes. Due to the nature of behavioural speech and language therapy, neither participants nor SLPs could be blinded about the intervention they received or provided.

Intervention

The strategy-based intervention StraTexT – Strategiebasierte Textverständnis-Therapie bei Aphasie consisted of two components, *Intervention Macro* targeting macrostructure and the situation model and *Intervention Micro* targeting microstructure and the surface structure. *Intervention Micro* and *Intervention Macro* each consisted of seven 60-minute sessions, provided twice a week in German language in face-to-face individual therapy in the participants' regular rehabilitation centres or at participants' homes. Additionally, the participants practiced the same strategies as homework for 60 minutes after each intervention session. Homework was monitored with a timetable. At least 75% of the assigned homework had to be completed to allow inclusion in the analysis. To promote transfer, we selected strategies that do not require a second person, and we encouraged participants to apply reading strategies in everyday reading activities. Considering the complexity of reading strategies outlined in the introduction as well as potential difficulties in instruction comprehension in PWA, we embedded the strategies in product-oriented tasks to raise motivation and to use possibly unimpaired schemata (i.e. knowledge on familiar products) as facilitators (Gudjons, 2014): By applying the reading strategies, the participants created familiar products (i.e. a mind map, a quiz, news in short and fake news). The step-by-step procedures and the target products demanded the use of specific reading strategies. Strategies, products, step-by-step procedures, rationales, and examples are provided in Table 3 (Intervention Macro) and Table 4 (Intervention Micro).

Table 3: Intervention Macro: strategies, procedures, rationales, and examples (Thumbeck et al., 2021).

Strategy Macro 1: Use of advance organisers and key words to create a mind map before and while reading	
Product	Mind map
Procedures	1. PWA finds out the topic of the text by using advance organisers such as title, pictures or subtitles from the text 2. PWA inserts five associations to that topic into the template of a mind map 3. PWA starts strategy 2 (summarisation). Throughout the course of reading, PWA integrates one to three key words from memory about each paragraph into the mind map
Rationale	The activation of background knowledge is expected to facilitate the integration of the reader's knowledge and the new information from the text (and therefore the construction of the situation model) (A. Mayer & Marks, 2019). It had large effects on reading comprehension in other populations (Yapp et al., 2021). Advance organisers such as pictures can support paragraph level reading in PWA (Nguyen et al., 2018). By inferring a maximum of three key words about each paragraph, participants were required to reduce microstructure to the most relevant information and to inhibit less relevant information.
Strategy Macro 2: Summarisation and re-reading	
Product	News in short
Procedures	1. PWA reads paragraph aloud 2. PWA re-reads 2-3 sentences of that paragraph aloud 3. PWA re-reads the same 2-3 sentences silently 4. Text is covered, PWA summarizes these sentences from memory based on macrorules (Kintsch, 2018) and with specific restrictions (no personal opinion, no unspecific words) similar to Rogalski & Edmonds (2008) and Rogalski et al.(2013) 5. Same procedure for the next 2-3 sentences from the same paragraph, until paragraph is completed 6. From memory, PWA adds 1-3 key words about the paragraph into the mind map 7. Repeat from step 1 with the next paragraph
Rationale	We intended to facilitate the comprehension of the macrostructure and the construction of the situation model by actively applying macrorules. We combined strategies previously described for PWA (use of keywords, writing down key messages, summarisation, and re-reading text). We used a modified version of *ARCS* (Rogalski et al., 2013; Rogalski & Edmonds, 2008) in order to integrate the cognitive strategy of re-reading text aloud and silently and to target cognitive functions such as attention and maintaining information. Summarisation had large effects on reading comprehension in other populations (Souvignier & Antoniou, 2007)
Example	The young guy who wore a suit opened the door. He looked around, sat down and asked for the menu. He ate soup, lasagna and tiramisu, paid, and left. → *The guy ate a meal in a restaurant.*

Note. Intervention Macro targeted the macrostructure and the situation model; items in italics illustrate answers produced by the participants.

Table 4: Intervention Micro: strategies, procedures, rationales, and examples (Thumbeck et al., 2021).

Strategy Micro 1: Asking questions and providing answers	
Product	Quiz
Procedures	1. PWA skims a paragraph 2. PWA underlines any part of the first sentence 3. PWA asks for the underlined part of the sentence 4. PWA generates a) a synonym / paraphrase, b) a semantically related answer, c) logically possible but wrong answer according to the text 5. Repeat steps 2-4 until paragraph is completed, then repeat from step 1 for the next paragraph
Rationale	Despite evidence for large effect sizes in other populations (Souvignier & Antoniou, 2007; Yapp et al., 2021), this reading strategy has not been investigated in PWA apart from using predetermined questions (Purdy et al., 2018; Watter et al., 2016). This procedure allowed PWA to ask questions on subordinate propositions, which may facilitate the comprehension of the microstructure. We assumed that rearranging sentence structures from statements into questions would only be possible with understanding the links between the clauses. To ensure that participants would not stick to the surface structure but access the semantic content of the answers to the questions, they generated a) a synonym / paraphrase and b) a semantically related answer. To address previously described problems in cognitive flexibility and to integrate background knowledge, they generated c) a possible but incorrect answer to the question.
Example	Original sentence: The boy stole <u>candy</u>. *What did the boy steal?* a) *sweets* (synonym) b) *chocolate* (semantically related) c) *a computer* (logically possible but wrong according to text)
Strategy Micro 2: Using referential links and elaboration	
Product	Fake news
Procedures	1. PWA identifies topic of the text 2. PWA substitutes the topic by a topic that is similar to the original topic and that PWA is interested in 3. PWA substitutes word by word as many words as possible and produces a semantically coherent text based on the structure of the original one
Rationale	The participants produce a coherent text based on the surface structure of the original text by substituting as many words as possible. Similar techniques have been used in second / foreign language teaching (e.g. Frieg et al., 2012). Medium to large effect sizes for strategies focusing on the text structure were observed in other populations (Souvignier & Antoniou, 2007; Yapp et al., 2021). Valency theory (Höllein, 2020) suggests that this task requires participants to understand thematic roles of all elements in a sentence. To maintain the surface structure, participants had to apply the strategy of using referential links between the elements. Furthermore, participants continually had to switch between the situation models of the original and the new text which may address potential difficulties in cognitive flexibility.
Example	The boy ↓ waited ↓ in front of ↓ his house. e.g. 1 *The skier queued up behind the line.* e.g. 2 *A hiker marched towards a cottage.*

Note. Intervention Micro targeted the microstructure and the surface structure; items in italics illustrate answers produced by the participants.

All participating therapists received a manual including instructions, examples, structured guidance for facilitation, and worksheets (see Supplementary Figure 1 for an example of a worksheet). Worksheets and step-by-step-instructions were designed with short sentences, easy wording, sans serif font, pictograms, use of colour, and frames to facilitate comprehension in PWA (Herbert et al., 2012). We are preparing the therapy manual for publication. Stimulus material consisted of selected articles from magazines with two categories of difficulty (based on word count, number of pictures, and Lix readability index, Anderson, 1981). The articles were randomized for each participant starting with articles from the easier category followed by more difficult ones. Procedures of allocated interventions could not be modified. Whenever a participant could not solve a given task, standardised strategy-specific increasing cues were offered (e.g. references to authentic situations, semantic cues, or phonological cues; see Thumbeck et al., 2021). In steps that required participants to read out elements aloud, therapists were instructed to correct mistakes. During the intervention sessions, SLPs wrote down the answers of the participants. In addition to the procedures outlined in the protocol, the following facilitation methods for homework were added: Participants who were unable to write used speech-to-text-technologies or asked caregivers to help in writing. Participants who had difficulty with interrogative pronouns in *Strategy Micro 1* were provided with a modified worksheet with visual symbols. Participants who reported difficulty in word-finding in *Intervention Micro* were advised to look up synonyms and antonyms online or in dictionaries.

Adherence to the therapy manual was monitored by ST using a standardized step-by-step documentation form in which SLPs had to check all steps for each session, and in weekly supervision.

Outcome measures

The outcome measures were selected according to the levels *functions* and *activities* of *The International Classification of Functioning, Disability and Health* (World Health Organisation, 2005). Assessments took place at six points (T1, T2, T3, T4, T5, T6). In case of temporal deviations (e.g. illness of participants or SLPs) up to three weeks, intervention or assessment sessions were continued according to the protocol, whereas longer deviations resulted in dropout. Table 5 provides a summary of the outcome measures including time of the assessments. Details including psychometric properties are presented in Thumbeck et al. (2021). Where applicable, scores were adjusted for age and / or education, compared to normative data, and interpreted as at least mildly to moderately impaired if below test-specific cut-offs or 1.5 SD from the mean (i.e. T-scores below 35 or percentiles below 6; Brooks et al., 2011).

Table 5: Outcome measures and times of assessment.

Outcomes measurement instruments	**Times of assessment**
Text level reading comprehension German version of *Test de Compréhension de Textes* (TCT; Chesneau, 2012)	All assessments: T1, T2, T3, T4, T5, T6
Self-reported reading abilities, thoughts and feelings about reading, and reading activities German version of *Comprehensive Assessment of Reading in Aphasia* (*CARA) Reading Questionnaire* (Morris et al., in preparation; Thumbeck, Webster, et al., 2023; Webster et al., 2021)	All assessments: T1, T2, T3, T4, T5, T6
General information Information required according to the *DESCRIBE checklist* (Wallace et al., 2022) Information on inclusion and exclusion criteria *Aachener Aphasie Test* (AAT; Huber et al., 1983) *Montreal Cognitive Assessment* (MoCA; Bartusch & Zipper, 2004)	Initial assessment: T1
Written discourse comprehension *MAKRO* (subtests text reception and inferences; Büttner, 2018)	Before and after the intervention: T2, T4
Generalisation and individual effects Semi-structured interview	After the intervention: T4
Cognitive functions *Wechsler memory scale* (WMS-IV, subtest logical memory 1; Petermann & Lepach, 2012) *Wechsler memory scale* (WMS-R, subtests digit span forward and digit span backward; Härting et al., 2000) *Aphasie-Check-Liste* (ACL, subtest attention; Kalbe et al., 2002) *Stroop-Test: Farbe-Wort-Interferenz-Test* (FWIT; subtests Farbstrichebenennen FSB: naming the colour of ink of colour lines, Farbwörterlesen FWL: reading out colour words, Interferenzversuch INT: naming the colour of ink of incongruent colour words, Nomination NOM: adjusted naming speed, Selektivität SEL: individual sensitivity to interference; Bäumler, 1985)	Before and after the intervention: T2, T4

The primary outcome was text level reading comprehension measured with the outcome variable *TCT-D Total* (sum of microstructure and macrostructure scores across all subtests of *TCT-D,* maximum TCT-D Total score is 90 points). The *TCT-D* measures specific text level reading functions that can be impaired in PWA. It consists of three parallel versions with narrative texts. In each assessment session, participants read three texts that varied systematically in the number of propositions and in the need for updating the situation model. They were not explicitly encouraged to use reading strategies during post-intervention assessments. In the subtest macrostructure, participants summarized each text. For microstructure, they answered questions about detailed information from the text. Rating was based on a standardized protocol and duplicated for assessments T1, T2, and T4 by a blinded assessor based on audio recordings. The level of agreement is reported in the Results section.

As normative data is not yet available for the German version, we used normative data of the original French version to detect impairment, i.e. deviations of more than 1.5 SD from the mean (Chesneau, 2012). Supplementary Tables 4 and 5 provide demographic information and TCT-D results for test and re-test of a neurotypical German sample matched to the participants of this study by sex, age, and education. Secondary outcomes were *TCT-D* scores in microstructure, macrostructure, reading time, and the situation model (classified as successfully updated if two specific events presented in the text were integrated).

Furthermore, in all assessments participants reported on their perception of reading with an adapted German version of the *Comprehensive Assessment of Reading in Aphasia (CARA) Reading Questionnaire* (Morris et al., in preparation; Thumbeck, Webster, et al., 2023; Webster et al., 2021). Participants rated reading abilities, reading activities, and attitudes towards reading on visualized Likert scales with a range from 1 to 9: Section A refers to current reading and is introduced by the phrase “At the moment, how difficult do you find reading and understanding” followed by eight items “single words / short sentences / paragraphs / a book / reading aloud / concentrating on reading / remembering what you have read / having a conversation about what you have read”. Section B asks about thoughts and feelings about reading and section C investigates sixteen different reading activities such as reading labels, signs, letters, or newspaper articles. Sum scores for each section and for the entire questionnaire were calculated based on the ratings resulting in a maximum possible CARA Total score of 288 points (Webster et al., 2021).

We transformed scores of TCT-D and of CARA into percent of maximum possible scores (POMP) to allow an interpretation as percentages of the possible maximum score (Moeller, 2015).

At T2 and T4, we measured the ability to draw inferences and to understand macrostructure using the *MAKRO* Screening (Büttner, 2018). The *MAKRO* Screening (Büttner, 2018) provides two parallel versions. In *text reception*, the participants read a narrative text and answered ten single-choice questions. Correct answers were rated with 3 points, compared to 0 points for wrong answers. In *inferences*, ten brief written sequences of events had to be completed with one missing causal inference each. According to a modified evaluation protocol for PWA, a maximum of 2 points per inference resulted in a maximum score of 20 points.

At T2 and T4, we also measured selected cognitive functions that have been shown to be relevant for reading in PWA (see Table 5 for a list of measures used). The Stroop test was discontinued at participants’ request.

At T4, we conducted semi-structured interviews to explore individual effects on functions, activities, and participation a) across domains, b) in language-related domains, c) in text

comprehension, and d) in language activities. Generalisation of strategy use was explored by asking about behavioural changes in reading. We will report on the interview data in a separate article.

We analysed change in individual scores across the whole group and across the two subgroups between specific assessment points. Data was collected by ST and by participating SLPs based on standardized manuals and protocol booklets (see section Setting).

Statistical methods

In line with the study protocol (Thumbeck et al., 2021), primary and secondary analyses were conducted using contrast analyses within repeated measures analyses of variance (rmANOVA) models controlling for group. Firstly, we analysed changes in the primary outcome (TCT-D Total) over time. To this end, we used three contrasts to analyse short-term (contrast weights: -1_{T2}; 1_{T4}) and long-term benefits (-1_{T2}; 1_{T5} and -1_{T2}; 1_{T6}) of the intervention. Secondly, we investigated superiority of the intervention to recovery without treatment by comparing the change scores from step one (T2 – T4; T2 – T5; T2 – T6) with the change score from the waiting period (T1 – T2) using three contrasts (-1_{T2-T1}; 1_{T4-T2} and -1_{T2-T1}; 1_{T5-T2} and -1_{T2-T1}; 1_{T6-T2}).

To address our secondary objectives, we conducted the same two-step-procedure using analogous contrasts with the total score and the section scores of the German version of the CARA Reading Questionnaire.

Furthermore, we explored strategy-specific effects on macro- and microstructure as well as on the self-reported perception of reading by analysing changes in TCT-D Microstructure, TCT-D Macrostructure and CARA Total scores over time as a function of group allocation in rmANOVA models. Moreover, potential moderator effects of severity of aphasia, gender, age, education, time post-onset and cognitive functions on changes in the primary outcome over time were explored in rmANOVA models. Differences between scores at T2 and T4 in MAKRO subtests *text reception* and *inferences* as well as in cognitive functions were analysed with t-tests or the non-parametric Wilcoxon signed-rank tests for paired samples.

We used a significance level of $\alpha = 0.05$ for all models. We adjusted for multiple testing using the Bonferroni-Holm method in confirmatory analyses for short-term ($\alpha/2$) and long-term effects ($\alpha/4$) for TCT-D Total and CARA Total separately. In case of missing data points, we used listwise deletion and analysed just the metrics that had both pre- and post-treatment data points available. In addition to the prespecified per protocol analysis, we conducted an intention to treat analysis: We repeated our primary analysis with data up to T5 of all participants (including dropouts) who had started the strategy-based intervention, imputing missing data

with “endpoint analysis” (Armijo-Olivo et al., 2009). Statistical analyses were conducted with R using Jeffreys's Amazing Statistics Program (JASP; JASP Team, 2022).

RESULTS

Text comprehension and neuropsychological profiles

At T1, all participants presented with scores within the impaired range in at least one of the subtests microstructure, macrostructure, situation model, or reading time in the TCT-D. In CARA Total, participants reported a range of difficulties in reading including reduced confidence and dissatisfaction with their reading speed. Difficulties generally increased with longer and more complex material. For some participants, difficulties started already in reading and understanding single words or short sentences, whereas for others, difficulties were perceived only in complex materials such as books, e-mails, official letters, or newspaper articles.

In neuropsychological assessments at T2, all but one participant (P20) had scores below cut-off in at least one of the assessments. Four participants requested to abandon the Stroop test. In seven out of ten subtests, at least half of the sample presented with scores within the impaired range. Most frequently impaired scores were WMS-R digit span forward, WMS-IV logical memory 1, and Stroop test (FWIT, subtests FSB, FWL and INT). Individual participants' data for assessments T2 and T4 is presented in Supplementary Table 6.

Treatment fidelity

Therapists documented each treatment session in standardized step-by-step-documentation forms containing 9 to 19 steps depending on the strategy in use. The forms were checked by ST immediately after each treatment session, and therapists had the opportunity to discuss questions or unclarities in supervision at any time throughout the period of the study. Across all participants and all sessions, 98.5% (SD = 2.6%, R = 91.2% - 100%) of the prespecified steps were completed. Documentation forms confirmed that all participants included in the per-protocol analysis completed at least 75% of the assigned homework. For 19 out of 22 participants, exact minutes of homework duration were available (per session M = 64 minutes homework).

Adverse events resulting in dropout were not related to study participation (see Figure 2).

Primary Analyses

TCT-D Total: Text level reading comprehension.

Figure 3 shows the development in our primary outcome TCT-D Total across assessments.

The analyses of short-term efficacy indicate that the intervention was effective in increasing text level reading comprehension in PWA on the short-term: Preregistered contrast analyses

of short-term effects revealed that TCT-D Total scores increased significantly immediately after receiving the intervention (T2–T4; Table 6). Additional preregistered comparisons between changes during the intervention phase (T2–T4) and during the waiting period (T1–T2) confirmed the superiority of the intervention effect over random fluctuation or spontaneous remission (Table 6).

Post-intervention improvements in TCT-D Total scores remained stable over time (Figure 3), as demonstrated by significant improvements in preregistered contrast analyses of long-term effects (T2–T5; T2–T6; Table 6). Comparisons between long-term changes during and after the intervention phase (T2–T5; T2–T6) and during the waiting period (T1–T2) confirmed a long-term effectiveness of the intervention for T5 but not for T6 (Table 6). Thus, the intervention had an effect on text level reading comprehension in PWA at least for 3 months. All effect sizes show that the impact of the intervention on text level reading comprehension is rather small by convention (Table 6, Sedlmeier & Renkewitz, 2018).

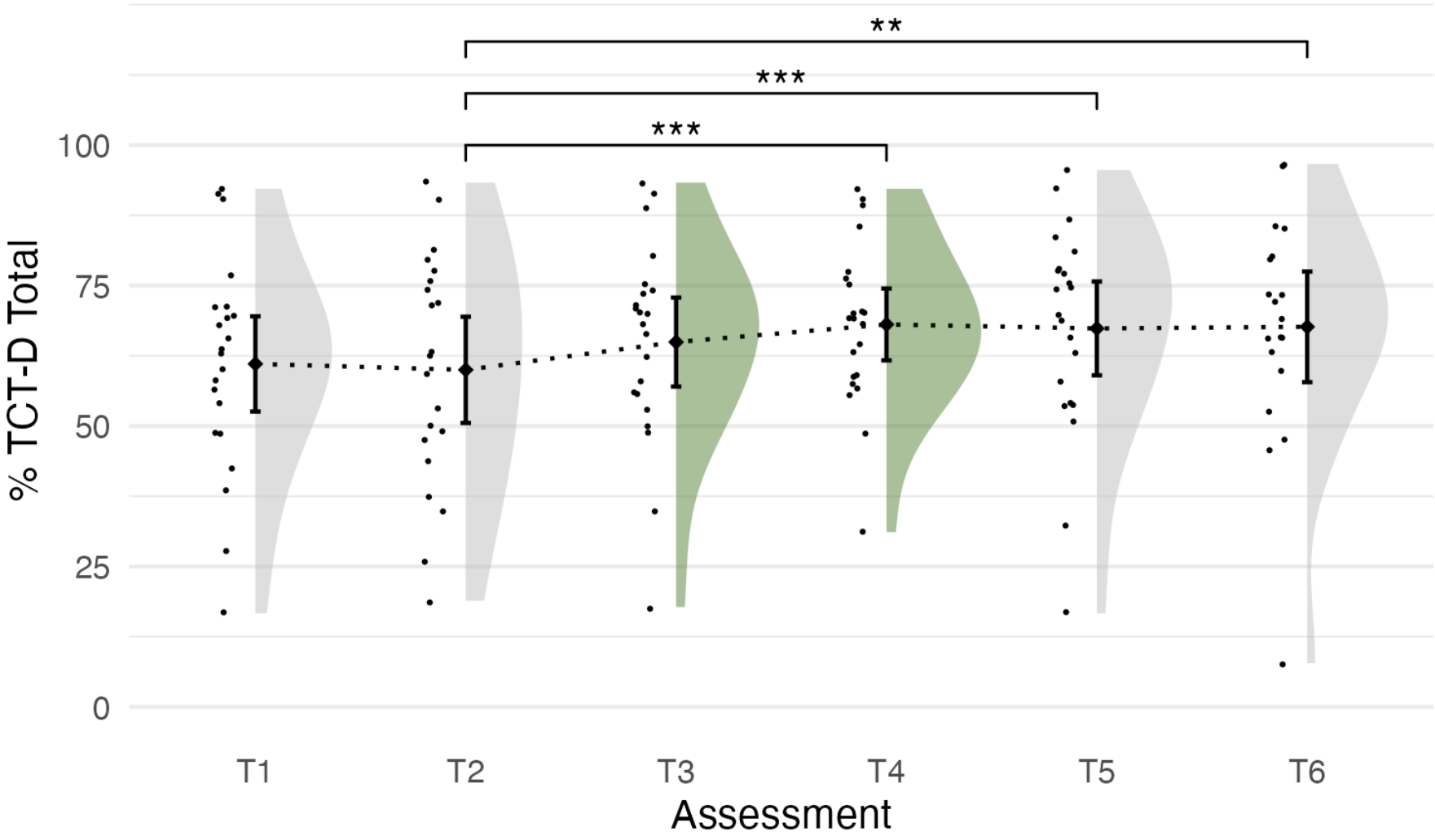

Figure 3. TCT-D Total score (in per cent); n = 22 for T1 to T5, n = 19 for T6; see Supplementary Table 7 for further details. Green color highlights the assessments during and immediately after the intervention. The brackets indicate statistically significant differences between pre-intervention scores (T2) and post-intervention scores (T4, T5, T6): *** $p < .001$; ** $p < .01$; * $p < .05$.

Table 6: TCT-D Total (in per cent); results of contrast analyses within repeated measures ANOVA models.

Contrast		*n*	*MD*	*SE*	*df*	*t*	*p*	*d (95% CI)*[b]
Efficacy of treatment								
Short-term: T4 – T2		22	8.64	2.08	80	4.16	< .001[a]	0.46 (0.19-0.74)
Long-term: T5 – T2		22	7.93	2.08	80	3.82	< .001[a]	0.43 (0.16-0.69)
Long-term: T6 – T2		19	6.93	2.24	85	3.10	.003[a]	0.35 (0.08-0.61)
Superiority of treatment compared to waiting period								
Change scores	Short-term: T2 – T1 (waiting period) – T4 – T2 (intervention)	22	10.25	4.34	20	2.36	.028[a]	0.90 (0.10-1.71)
	Long-term: T2 – T1 (waiting period) – T5 – T2 (change up to first follow-up)	22	9.55	3.42	20	2.79	.011[a]	0.96 (0.23-1.68)
	Long-term: T2 – T1 (waiting period) – T6 – T2 (change up to second follow-up)	19	7.51	3.36	51	2.24	.098	0.72 (-0.15-1.59)

Note. Full rmANOVA models are provided in Supplementary Table 8; analyses are based on percent of maximum possible (POMP) scores allowing an interpretation as percentages of the possible maximum score; *MD* = Mean Difference (in per cent of maximum possible scores); [a]remained significant when applying Bonferroni-Holm-adjusted significance level for short-term ($\alpha/2$) and long-term effects ($\alpha/4$), see Supplementary Table 9; [b]unadjusted confidence intervals.

The rating of the primary outcome for assessments T1, T2, and T4 was duplicated by a blinded SLP student based on all available 195 audio recordings (recordings were partially not available for three participants). Interrater agreement based on single measures, absolute-agreement, 2-way mixed-effects model between the ratings of the blinded and the unblinded rater was moderate to excellent, Intraclass Correlation Coefficient ICC = 0.94 ($F(64, 64) = 62.84$, $p < .001$, 95% CI [0.68, 0.98]).

Secondary Analyses

CARA Total: Self-reported perception of reading abilities, thoughts and feelings about reading, and reading activities. Figure 4 shows the development in the German version of the CARA reading questionnaire (Thumbeck, Webster, et al., 2023) across assessments (see Supplementary Table 10 for further details). Preregistered contrast analyses of short-term and long-term effects between pre-intervention scores (T2) and post-intervention scores (T4, T5, T6) showed significant improvements in CARA Total (Table 7, Supplementary Table 11) and across all CARA sections (Supplementary Table 12) with medium to large effect sizes. However, comparing post-intervention change scores in CARA Total against change during the waiting period, preregistered contrast analyses revealed only one significant effect which

did not remain significant when applying Bonferroni-Holm correction (Table 7). Thus, the results in CARA Total did not reveal evidence for the superiority of the intervention compared to the waiting period.

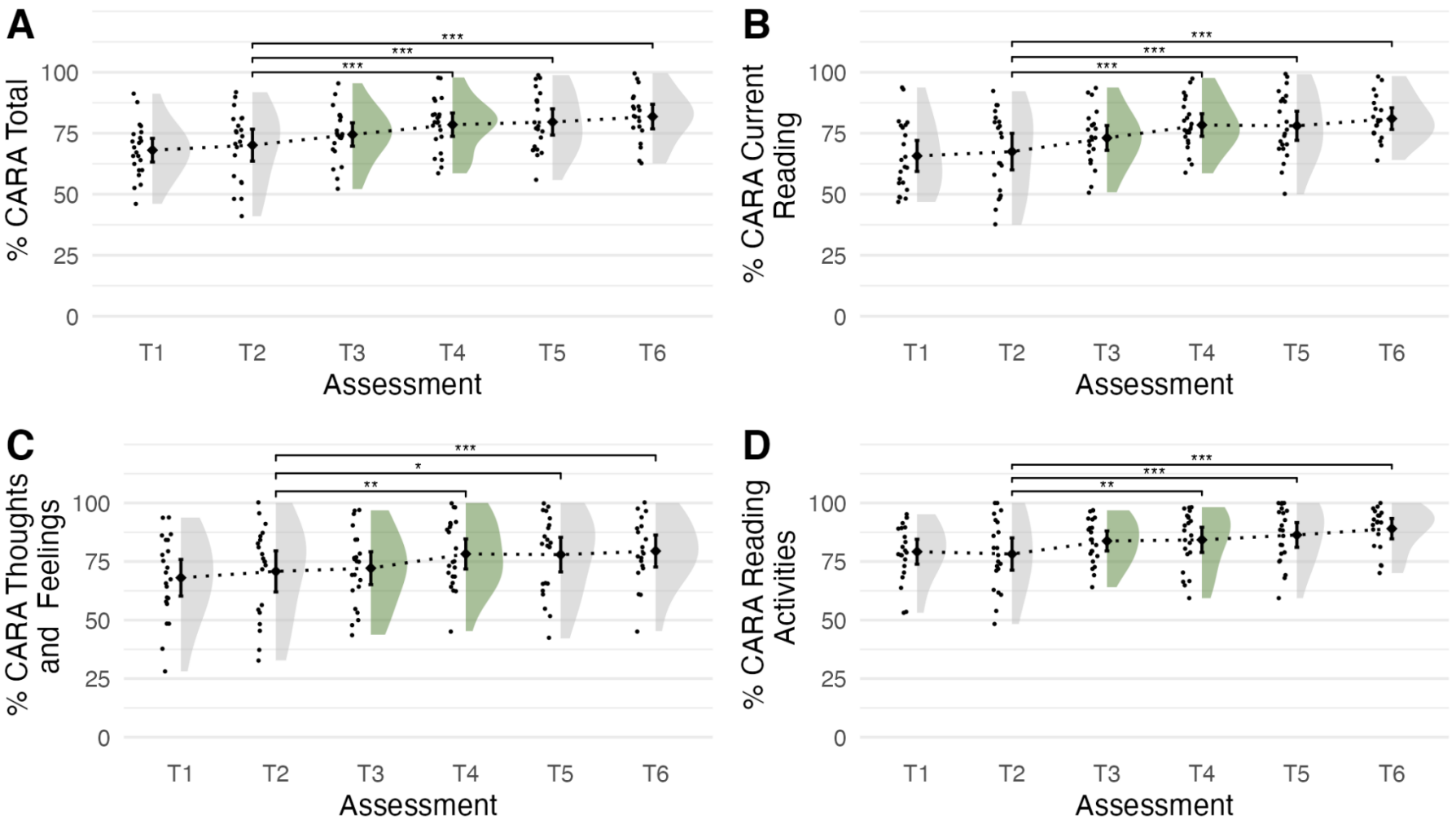

Figure 4. CARA outcomes (in per cent); n = 22 for T1, T3, T4, T5, n = 21 for T2, n = 19 for T6; Green color highlights the assessments during and immediately after the intervention. (4A) CARA Total Score, see Supplementary Table 10 for further details; (4B) CARA Section A, Current Reading; (4C) CARA Section B, Thoughts and feelings about reading; (4D) CARA Section Activities (for each individual, the total score of section C was divided by the individual number of selected relevant reading activities). The brackets indicate statistically significant differences between pre-intervention scores (T2) and post-intervention scores (T4, T5, T6): *** $p < .001$; ** $p < .01$; * $p < .05$.

Table 7: CARA Total (per cent); results of contrast analyses within repeated measures ANOVA models.

Contrast		*n*	*MD*	*SE*	*df*	*t*	*p*	*d (95% CI)*[b]
Efficacy of treatment								
Short-term: T4 – T2		21	8.21	1.95	76	4.20	< .001[a]	0.68 (0.28-1.07)
Long-term: T5 – T2		21	9.53	1.95	76	4.88	< .001[a]	0.78 (0.37-1.20)
Long-term: T6 – T2		18	12.08	2.14	80	5.64	< .001[a]	0.96 (0.47-1.45)
Superiority of treatment compared to waiting period								
Change scores	Short-term: T2 – T1 (waiting period) – T4 – T2 (intervention)	21	6.01	4.01	19	1.50	.150	0.61 (-0.25-1.46)
	Long-term: T2 – T1 (waiting period) – T5 – T2 (change up to first follow-up)	21	7.33	4.76	19	1.54	.140	0.62 (-0.24-1.48)
	Long-term: T2 – T1 (waiting period) – T6 – T2 (change up to second follow-up)	18	11.21	4.74	16	2.37	.031	1.04 (0.05-2.02)

Note. Full rmANOVA models are provided in Supplementary Table 11; analyses are based on percent of maximum possible (POMP) scores allowing an interpretation as percentages of the possible maximum score; *MD* = Mean Difference (in per cent of maximum possible scores); [a]remained significant when applying Bonferroni-Holm-adjusted significance level for short-term (α/2) and long-term effects (α/4), see Supplementary Table 9; [b]unadjusted confidence intervals.

TCT-D Total: Moderator effects. Exploration of potential moderator effects on the primary outcome TCT-D Total in rmANOVA models with data up to assessment T5 did not reveal any significant interaction between time of the assessment and severity of aphasia (age-adjusted score in the subtest Token Test of AAT, Huber et al., 1983), biological sex, age, education (university entrance qualification yes / no), time post-onset, or any of the cognitive functions (Supplementary Table 13).

Strategy-specific effects in TCT-D Microstructure, TCT-D Macrostructure, CARA Total: Exploratory between-group analysis. During the first intervention phase, Group 1 received strategy-based treatment targeting the microstructure, whereas Group 2 started with the strategy-based treatment targeting the macrostructure. Treatment components were interchanged during the second intervention phase. Change after the first intervention phase in TCT-D Macrostructure was numerically larger for Group 2 that was receiving macrostructure treatment (M = 12.99, SD = 14.84) compared to Group 1 that started with microstructure treatment (M = 1.95, SD = 13.21) (see Supplementary Figure 2). Despite numerical differences between groups in change in TCT-D Total, TCT-D Macrostructure, TCT-D Microstructure, and CARA Total scores, prespecified contrast analyses within ANOVA models, n = 11 per group, did not reveal differences between groups during the first (i.e. T2 – T3) or the entire intervention period (i.e. T2 – T4) (Supplementary Tables 14 and 15). Only an additional exploratory non-parametric analysis showed that during the first intervention phase, Group 2 improved

significantly more in TCT-D Macrostructure than Group 1, Mann–Whitney U = 32.00, p = .032 one-tailed. There were no significant differences between groups with regard to TCT-D Microstructure (Mann-Whitney U = 56.50, p = .616 one-tailed). In fact, numerical improvements in TCT-D Microstructure during the first intervention period were even larger for the group that had received macrostructure intervention than for the group that had received microstructure intervention. At T4 (after both intervention phases), there were no significant differences between groups in TCT-D Total, TCT-D Micro- and Macrostructure, or CARA Total (Supplementary Table 16).

TCT-D reading time. The reading time varied largely with some participants requiring around 2.5 minutes and others around 24 minutes to complete reading the three TCT-D texts pre-intervention at T2. Although reading time decreased from M = 541s (SD = 370s) at T2 to M = 519s (SD = 458s) at T4, the effect was not significant in a rmANOVA model with Greenhouse-Geisser correction taking into account assessments T1 to T5, $F(1.43, 28.52) = 1.53$, $p = .233$, partial $\eta^2 = 0.07$.

TCT-D Situation model. The TCT-D situation model is evaluated in two out of three texts which require the participants to integrate two events and thereby infer that the first part of the text was a dream. Descriptively, all 22 participants were able to update the situation model in both of these texts at the end of the intervention (i.e. T4), as compared to 14 participants at T1, 16 participants at T2,18 participants at T3, and 21 participants at T5.

MAKRO Screening, subtests text reception and inferences. Despite numerical improvements between assessments T2 and T4 in all measures, improvements in total scores, reading time (i.e. time required to read the text), working time (i.e. time required to answer the questions), and the number of correct inferences were not significant (Supplementary Table 17).

Cognitive functions. Between T2 and T4, the number of participants scoring within the impaired range decreased in WMS-IV logical memory 1, WMS-R digit span forward and backward, ACL percentage of mistakes, and Stroop test (FWIT subtests FWL, FSB, INT, NOM). The number of scores below cut-off did not improve in ACL (subtest number of items) and in FWIT (subtest SEL) (Supplementary Table 6). Most changes from the impaired to the normal range were observed in digit span forward with 16 (T2) as opposed to 9 (T4) scores below cut-off. Improvements at T4 compared to T2 were significant for ACL (number of processed items), Stroop Test (subtest FSB: naming of colour lines), and WMS-R digit span forward. There were no significant differences in WMS-IV logical memory 1, WMS-R digit span backward, and the other variables measured in Stroop test (Supplementary Table 18).

Exploratory analyses

TCT-D Total and CARA Total – Robustness analyses and additional analyses. We conducted several robustness analyses (Supplementary Tables 19 and 20):

At the group level, the mean TCT-D Total score decreased numerically between T1 and T2 during the waiting period. In the preregistered contrasts, we compared post-intervention scores to pre-intervention scores collected at T2 (see above). Considering potentially higher scores at T1, we repeated our contrast analyses comparing post-intervention scores (i.e. T4, T5, T6) to scores collected at T1. Post-intervention scores in TCT-D Total and in CARA Total remained significantly larger at T4, T5, and T6 also compared to T1.

As mean scores had numerically increased already after the first intervention phase at T3, we added an additional contrast comparing TCT-D Total and CARA Total scores at T3 against pre-intervention scores at T1 and T2. Improvements after the first intervention phase (without having completed the second intervention phase yet) were not significant when taking into account all contrasts.

In the CARA Total, we observed a numerical increase at T2 after the waiting period. Therefore, we added an additional contrast comparing results at T2 against results at T1. Scores did not change significantly during the waiting period without aphasia treatment.

Intention to treat analysis. We replicated the primary analysis up to T5 for the main outcome TCT-D Total based on data from all participants that had started the intervention (n = 25 as compared to n = 22 in the per protocol analysis). We imputed missing data using “endpoint analysis” with carrying forward TCT-D total scores from T2 for P4 and T3 for P12, and we included data from P5 (Armijo-Olivo et al., 2009). All effects including long-term superiority compared to the waiting period up to three months post-intervention remained significant. In the case of short-term superiority immediately after the intervention the p value was .058 (Supplementary Tables 21 and 22).

Individual improvements. We conducted additional item-based analyses for each participant with one-tailed non-parametric tests to explore improvements in the total scores of TCT-D and CARA on an individual level (Supplementary Table 23). We found significant improvements for ten participants in the CARA, for three participants in the TCT-D, and for one participant in both CARA and the TCT-D. Significant effect sizes were small in TCT-D, and small (n = 1), medium (n = 6) and large (n = 4) in CARA. Eight participants demonstrated no significant improvements in either of these outcome measures.

Interviews. Preliminary analysis underlines that the participants were able to employ the StraTexT materials and to incorporate protocol features such as frequency, duration, and commitment to homework into their weekly schedules. 20 out of 22 participants reported that they benefitted from the intervention. The interview data suggests a wide spectrum of individual experiences with StraTexT as well as interindividual differences in treatment response with regard to text comprehension, other language functions, activities, and the generalisation of the strategies to everyday reading materials. A detailed analysis will be presented in a separate article.

DISCUSSION

Effects of reading strategies on text level reading comprehension

We found significant small improvements in text level reading comprehension (i.e. primary outcome TCT-D Total) up to six months post-intervention compared to pre-intervention. The effects of the intervention phase were superior compared to the control condition, i.e. waiting period without treatment, up to three months in follow-up, which supports the assumption that the improvements were induced by the treatment. The intention to treat analysis confirmed the major pattern of the primary analysis with regard to efficacy and long-term superiority. As TCT-D Total combines the subtests TCT-D Macrostructure and TCT-D Microstructure, the intervention helped participants to better understand, retain, and reproduce main information as well as details in a text. All participants were able to update the situation model in TCT-D after the intervention, which indicates that reading strategies also seem to facilitate the integration of text contents with the reader's previous knowledge including preceding text contents. The additional analysis on an individual level suggests that not all PWA respond equally to StraTexT. However, at least in this sample, the treatment effect was not moderated by any of the sociodemographic variables or cognitive functions tested.

Effects of reading strategies on the subjective perception of reading abilities, thoughts and feelings about reading, and reading activities

We found significant medium to large improvements in self-reported reading abilities, thoughts and feelings about reading, and reading activities (i.e. CARA Total) up to six months post-intervention compared to pre-intervention. This may indicate that reading strategies improve a person's perceived ability to read and to engage in reading activities as well as individual attitudes towards reading. The CARA Total data suggest that after the intervention, scores might continue to increase and reading strategies might have a sustainable impact on the perception of reading in aphasia. However, despite a numerical trend, the significant improvements in CARA Total were not significantly larger than change during the waiting period. Therefore, we cannot be certain that the observed improvements during and after treatment were specific to the intervention. Possible explanations include heterogeneity in treatment response or effects that may have been present also during the waiting period (e.g. influences of social desirability, motivation, or increased awareness of one's own abilities and difficulties). However, while random fluctuations usually go up and down, the CARA Total score increased throughout the entire period of the study with significant improvements only after the intervention.

The results of our group study in TCT-D and in CARA strengthen the promising outcomes of previously conducted case studies that explored strategy-based interventions in aphasia (Purdy et al., 2018). TCT-D Total and CARA Total measure two different constructs. It is remarkable that the effect sizes in the CARA Total were larger than in the TCT-D Total. The items included in the CARA questionnaire relate not only to self-reported text level reading abilities, but also to smaller units (e.g. words or sentences), to cognitive functions (e.g. remembering read content or concentrating while reading), to feelings and emotions (e.g. motivation, enjoyment, confidence, or satisfaction with reading speed) as well as to specific reading activities (e.g. reading labels, books, or newspaper). Thus, the CARA questionnaire encompasses a broader scope compared to the TCT-D. The small improvements observed in the TCT-D Total may only capture text level reading comprehension functions, while the larger effects in the CARA Total might indicate effects beyond this level such as improvements in functions, feelings, activities, or resources like strategy use which were not captured by the TCT-D Total. In fact, Webster et al. (2022) demonstrated that the personal perception of reading abilities, feelings, and activities as measured with the CARA questionnaire does not correlate with performance-based reading scores. The improvements in the CARA questionnaire show that the effects reached a magnitude which was perceivable by the participants and therefore suggest clinical rather than solely statistical significant effects of StraTexT.

Strategy-specific effects and order effects

Within the whole group, improvements in TCT-D Total were not yet significant after the first intervention phase (i.e. T3), suggesting that the significant improvements at T4, T5, and T6 resulted only from the combination of both intervention phases (i.e. Intervention Micro and Intervention Macro). As there were no between-group differences at T4 after the intervention, the current data suggest that the order of interventions Micro and Macro does not affect the results.

We anticipated improvements in TCT-D Macrostructure specifically after the macrostructure intervention, and improvements in TCT-D Microstructure specifically after the microstructure intervention. The between-group analysis should be interpreted with caution because our sample size was calculated for the within-group analyses and the preregistered contrast analyses did not reveal significant differences between the two groups. According to the descriptive results, each of the components, i.e. Intervention Micro and Intervention Macro, affected both micro- and macrostructure. The group differences at T3 in TCT-D Macrostructure in the additional exploratory analyses suggest that the reading strategies included in Intervention Macro might indeed be linked to specific improvements in the macrostructure (irrespective of whether treated before or after the microstructure intervention) and also

generalize to the microstructure. However, TCT-D Microstructure improved irrespective of the intervention in use without more pronounced effects after Intervention Micro. Thus, Intervention Micro does not seem to specifically target the microstructure, but to contribute essentially and indispensably to the overall improvements. Considering that the total number of sessions in previous case studies on strategy-based interventions in aphasia ranged between 8 and 58 sessions (Purdy et al., 2018), it is possible that seven sessions in each of the two intervention phases were just not enough to promote more pronounced strategy-specific effects. This could account for the lack of significant differences between the two groups in the preregistered contrast analyses.

Text comprehension, reading strategies, and cognitive functions in people with aphasia

As outlined in the introduction, text level reading comprehension involves many cognitive resources. Interpreting the results with regard to interactions between reading strategies and cognitive functions in PWA, two main subjects emerge: a potential impact on treatment response as well as co-occurring treatment effects in language and cognitive functions.

According to a recent scoping review (Diedrichs et al., 2022), studies on the relationship between nonlinguistic cognitive abilities (executive functioning, memory, visuospatial skills and attention) and language treatment efficacy in PWA yielded inconsistent results. While an impact cannot be ruled out, the results of our moderator analysis suggest that the treatment efficacy of StraTexT was not influenced by the cognitive functions considered in the present study.

In most of the neuropsychological assessments evaluated in the current study, the number of participants scoring within the impaired range decreased post-intervention. In line with Watter et al. (2016), and even though StraTexT did not primarily address cognitive functions, the results suggest that reading strategies might indeed affect not only linguistic, but also cognitive functions in PWA. Our results indicate significant improvements post-intervention in a) selective attention (ACL, number of processed items; Kalbe et al., 2002), b) information processing speed and conceptual structuring (Stroop Test FWIT, naming of colour lines; Bäumler, 1985), and c) maintenance of verbal information (WMS-R, digit span forward; Härting et al., 2000). There were no improvements in verbal episodic memory (WMS IV logical memory 1; Schellig et al., 2009) and in processing maintained information (WMS-R digit span backward; Schellig et al., 2009).

While the primary outcome in the present study was text level reading comprehension, the implementation of the reading strategies in StraTexT clearly took into account potential impairments in aphasia not only in linguistic but also in cognitive functions: The reading strategies required the participants to retrieve background information and to integrate it with

text information (as required in inference making), to maintain and process information, to shift attention to relevant information, and to inhibit irrelevant information. Unfortunately, cognitive functions were not included as pre- and post-intervention outcome measures in any case study on strategy-based treatments in PWA included in the systematic review by Purdy et al. (2018; i.e. Cocks et al., 2013; Gold & Freeman, 1984; Lynch et al., 2009; Webster et al., 2013). Therefore, the impact of other types of strategy-based treatments on cognitive functions in PWA remains unclear. Nevertheless, evidence for co-occurring treatment effects in cognitive functions and reading comprehension was found in case studies on cognitive treatments which addressed underlying cognitive functions such as attention or working memory to enhance reading comprehension in PWA (e.g. Coelho, 2005; Lee & Sohlberg, 2013; J. F. Mayer & Murray, 2002; Sinotte & Coelho, 2007). Our results suggest that improvements in both cognitive functions and text level reading comprehension may result not only from cognitive treatments, but also from the reading strategies implemented in StraTexT. The relationship between specific reading strategies and their potential effects on particular cognitive functions remains to be evaluated in more detail.

The results should be interpreted carefully because most of the assessments contained linguistic stimuli. As cognitive functions were evaluated pre- and post-intervention only, it was not possible to compare change after the intervention to change without treatment, and information on critical change scores exceeding re-test effects or practice effects in PWA during the specific time interval was not available. The results of this study thus call for more detailed research with regard to the potential effects of reading strategies on cognitive functions in aphasia.

Clinical implications

The results suggest that systematic strategy-based interventions could be incorporated into clinical practice to treat text level reading comprehension in people with post-stroke chronic aphasia.

Protocol features. The treatment fidelity analysis shows that one-hour treatment sessions allow the implementation of all steps and procedures outlined in the study protocol. StraTexT requires a lower intensity than other evidence-based treatment approaches in the chronic phase of aphasia. We suggest replicating the protocol features (i.e. intensity and duration) in real life clinical settings.

Selection of reading strategies. To achieve significant treatment effects, both Intervention Micro and Intervention Macro seem to be essential components. Since there was no evidence indicating that the order of implementation affects the results, we cannot recommend any

specific order and suggest implementing Intervention Micro and Intervention Macro sequentially without preference for either order. If the intervention time is limited, it may be more helpful to focus on the intervention targeting the macrostructure, but the evidence for this is weak. Studies with larger sample sizes are necessary to investigate strategy-specific effects as well as individual preconditions that may contribute to a successful use of specific reading strategies. Other reading strategies (e.g. highlighting, covering information) or text-to-speech-technologies as explored in Hux et al. (2021) could be used additionally.

Additional impairments in metacognitive functioning in PWA might affect monitoring and selecting reading strategies flexibly according to individual reading goals in everyday life reading activities (Rosebrock & Nix, 2020). To facilitate transfer after the 14-session treatment, it might be possible to start with only one or two specific reading strategies according to individual reading goals to be applied in very specific reading activities in everyday life. Metacognitive strategy training might guide transfer and help PWA to monitor and evaluate the use of the selected reading strategies during the selected reading activities. A protocol for an adapted metacognitive strategy training intervention is suggested by Kersey et al. (2021).

Target population. Reading comprehension in aphasia cannot only be treated with strategy-based interventions, but also with oral, cognitive, or hierarchical reading interventions (Purdy et al., 2018). We still lack sufficient knowledge about predictors that motivate the choice of one method over another in an individual PWA. According to Purdy et al. (2018), the oral intervention *Oral Language for Reading in Aphasia* (e.g. Cherney, 2010) might be particularly beneficial in more severe aphasia. Despite the aphasia-friendly design of StraTexT worksheets and materials, the complex nature of reading strategies along with requirements in metacognitive abilities suggest that StraTexT might be more suitable for people with mild to moderate aphasia. However, the only participant with severe aphasia included in this study (P28) improved significantly in TCT-D Total. This result implies that, although challenging, StraTexT may also be practicable and beneficial for people with severe aphasia. For this target group, modifications such as additional facilitation techniques, a reduced number of strategies, an abbreviated number of steps within each strategy, or shorter or easier text material could be explored.

Text material. The use of individually relevant and authentic text material might contribute to motivation, engagement, and improvements (Purdy et al., 2018). Text length and reading complexity might progress from basic factual reading materials to longer factual information, and finally to inferential reading of complex, lengthy text as suggested by Watter et al. (2021).

Future research

It is important to acknowledge that *statistical* significance on a group or individual level does not allow conclusions about *clinical* significance (Breitenstein et al., 2022). The improvements in the CARA questionnaire indicate that the improvements in text comprehension as measured with the TCT-D were indeed perceived in everyday life reading by the participants. To gain a deeper insight, we will analyse the interview data with regard to subjectively perceived effects, potential responder characteristics, modifications proposed by the participants, self-reported generalisation, as well as transfer to other linguistic levels. We suggest investigating whether effects on the more complex level of text comprehension generalize to less complex structures such as written word or sentence comprehension as has been shown for other language structures in the Complexity Account of Treatment Efficacy (Thompson, 2007) and in Ablinger and Domahs (2009). The results of our study may encourage randomised controlled trials including a control group and – in view of the relatively low dosage in this approach – cost effectiveness as a measure. It could also be investigated whether the sole use of the Intervention Macro causes the same (or even larger) treatment effects as the combination of Micro and Macro. A key research endeavour remains to identify individual features that contribute to treatment success in this specific intervention approach. Purdy et al. (2018) suggest considering several aspects, e.g. neurological factors, stamina, motivation, treatment protocol factors such as dosage and materials, level of reading difficulties at the beginning of the intervention, or accompanying motor speech deficits.

Limitations

Our study was powered for the primary within-group analyses. The a priori determined sample size was maintained up to the first follow-up T5, whereas at T6, we could only include 19 instead of the required 21 participants. We therefore presented results both including and excluding data from T6. Equally, our between-group analyses should be interpreted with caution, given the limited statistical power.

Participants and SLPs providing treatment and collecting data could not be blinded, which involves a potential risk of bias. As a measure to reduce this risk of subjectivity in data analysis, we had the primary outcome duplicated by a blinded second rater and reported a high interrater agreement.

The study design did not allow any aphasia treatment during the waiting period (T1 to T2) or in addition to the controlled intervention period (T2 to T4). However, due to aspects of practicability and ethical concerns about participants not being able to access their routine treatment for the full duration of the project, it was not possible to control treatment during the 6 months follow-up period (T4 to T6). In fact, 16 out of 22 participants received uncontrolled standard speech and language therapy (i.e. 45 minutes once or twice per week) between T4

and T5. While interpreting the follow-up period is challenging in light of this aspect, it reflects standard speech and language therapy practice in Germany.

Due to the lack of appropriate diagnostic outcome measures in German language to assess text comprehension in PWA, we translated and adapted the TCT (Chesneau, 2012) and the CARA questionnaire (Morris et al., in preparation; Thumbeck, Webster, et al., 2023; Webster et al., 2021). Despite extensive translation and adaptation procedures including forward and back translations as well as pilot testing and data collection with the TCT-D in a neurotypical German sample matched to the PWA of this study, information on psychometric properties of the German versions of these outcome measures is still limited.

Although eligibility criteria did not specify an upper age limit, the mean age of the participants who enrolled in this study was 59 years, suggesting a somewhat younger sample compared to the typical stroke population.

CONCLUSION

This is the first group study that evaluated the efficacy of StraTexT, a strategy-based intervention to treat text level reading comprehension in aphasia. This novel multiple-strategy intervention is theory- and evidence-driven and takes into account aphasia-specific impairments in linguistic resources and cognitive functions relevant for text comprehension. The approach consists of two treatment components (Intervention Micro and Intervention Macro) with a total of four reading strategies that are used to treat surface structure, microstructure, macrostructure, and the situation model. The strategies are embedded in a product-oriented approach to facilitate their application in aphasia.

The intervention proved to be effective in both performance-based measures of text level reading comprehension (small effect sizes) and in self-reported measures of the personal perception of reading abilities, feelings, and reading activities (medium to large effect sizes) up to six months post-intervention. The improvements in text level reading comprehension were superior to a waiting period without treatment for at least three months after the intervention.

The results with regard to strategy-specific effects of Intervention Micro on the microstructure and Intervention Macro on the macrostructure are inconclusive and call for further research. Strategy-specific effects of Intervention Macro are suggested only by the additional exploratory analyses. Thus, to the current state of knowledge, both components can be considered indispensable contributors to treatment success.

Overall, the results build on findings from previously conducted case studies. As the protocol features such as duration and frequency of treatment sessions were designed to be compatible with regular rehabilitation contexts, we suggest integrating StraTexT in regular clinical settings.

Author contributions: ST conceived the study and led the manuscript development. ST, PS, SC and FD developed the study design. FD helped with implementation. SC supported the translation and adaptation process of the TCT. ST was responsible for data acquisition and data management. PS provided statistical expertise in clinical trial design. All authors contributed to the refinement of this article and approved the final manuscript. No other groups or individuals were involved in overseeing the trial.

Geolocation information: Germany

Declaration of interest: The authors declared no conflict of interest.

Funding: This work was supported by a Christoph-Martin-Wieland scholarship of the University of Erfurt granted to ST. This source of funding did not and will not influence any aspects in study design, conduct, data analysis, interpretation, manuscript writing, and dissemination of results.

Data availability statement: The data that support the findings of this study are openly available in Open Science Framework at https://doi.org/10.17605/OSF.IO/F6T5B.

Ethics approval statement: This study was approved by the ethics committee of Deutscher Bundesverband für akademische Sprachtherapie und Logopädie (dbs) (20-10074-KA-MunmErw+Ko).

Protocol: The study protocol is available in Thumbeck et al. (2021).

Trial registration: Deutsches Register Klinischer Studien (DRKS): DRKS00021411.

Patient consent statement: Participants had to provide written informed consent prior to inclusion as approved by the ethics committee. Patient consent for publication is not applicable as no details relating to individual persons have been included.

Permission to reproduce material from other sources: Not applicable.

Acknowledgments: We would like to thank all the participants for contributing to this study. Thank you to all the speech and language therapists who delivered intervention and / or assessment sessions. We express our gratitude to Dr Thomas Lauer, scientific managing director of ErfurtLab, who provided his expertise on randomisation processes and who performed the randomisation and allocation procedures. Thanks to Bethan Tichborne for helpful comments on the draft of this manuscript. We also thank the peer reviewers for their helpful and constructive comments.

REFERENCES

Ablinger, I., & Domahs, F. (2009). Improved single-letter identification after whole-word training in pure alexia. *Neuropsychological Rehabilitation*, *19*(3), 340–363. https://doi.org/10.1080/09602010802204000

Anderson, J. (1981). *Analysing the readability of English and non-English texts in the classroom with Lix*. Seventh Australian Reading Association Conference, Darwin. https://files.eric.ed.gov/fulltext/ED207022.pdf

Armijo-Olivo, S., Warren, S., & Magee, D. (2009). Intention to treat analysis, compliance, drop-outs and how to deal with missing data in clinical research: A review. *Physical Therapy Reviews*, *14*(1), 36–49. https://doi.org/10.1179/174328809X405928

Artelt, C., McElvany, N., Christmann, U., Richter, T., Groeben, N., Köster, J., Schneider, W., Stanat, P., Ostermeier, C., Schiefele, U., Valtin, R., & Ring, K. (2005). Expertise. Förderung von Lesekompetenz. *Bildungsreform*, *17*.

Bartusch, S., & Zipper, S. (2004). *Montreal Cognitive Assessment (MoCA). Deutsche Übersetzung*. www.mocatest.org

Bäumler, G. (1985). *FWIT Farbe-Wort-Interferenz-Test nach J. R. Stroop*. Hogrefe.

Breitenstein, C., Hilari, K., Menahemi-Falkov, M., L. Rose, M., Wallace, S. J., Brady, M. C., Hillis, A. E., Kiran, S., Szaflarski, J. P., Tippett, D. C., Visch-Brink, E., & Willmes, K. (2022). Operationalising treatment success in aphasia rehabilitation. *Aphasiology*, 1–40. https://doi.org/10.1080/02687038.2021.2016594

Brooks, B. L., Sherman, E. M. S., Iverson, G. L., Slick, D. J., & Strauss, E. (2011). Psychometric Foundations for the Interpretation of Neuropsychological Test Results. In M. R. Schoenberg & J. G. Scott (Eds.), *The Little Black Book of Neuropsychology* (pp. 893–922). Springer US. https://doi.org/10.1007/978-0-387-76978-3_31

Büttner, J. (2018). *MAKRO: Screening zur Verarbeitung der Makrostruktur von Texten bei neurologischen Patienten*. NAT-Verlag.

Cherney, L. (2010). Oral Reading for Language in Aphasia: Impact of Aphasia Severity on Cross-Modal Outcomes in Chronic Nonfluent Aphasia. *Seminars in Speech and Language*, *31*(01), Article 01. https://doi.org/10.1055/s-0029-1244952

Chesneau, S. (2012). *TCT, test de compréhension de textes: 16-80 ans*. Mot à Mot.

Chesneau, S., & Ska, B. (2015). Text comprehension in residual aphasia after basic-level linguistic recovery: A multiple case study. *Aphasiology*, *29*(2), 237–256. https://doi.org/10.1080/02687038.2014.971098

Cocks, N., Pritchard, M., Cornish, H., Johnson, N., & Cruice, M. (2013). A "novel" reading therapy programme for reading difficulties after a subarachnoid haemorrhage. *Aphasiology*, *27*(5), Article 5. https://doi.org/10.1080/02687038.2013.780283

Coelho, C. (2005). Direct attention training as a treatment for reading impairment in mild aphasia. *Aphasiology*, *19*(3–5), Article 3–5. https://doi.org/10.1080/02687030444000741

Council of Europe (Ed.). (2020). *Common European framework of reference for languages: Learning, teaching, assessment ; companion volume*. Council of Europe Publishing.

Diedrichs, V. A., Jewell, C. C., & Harnish, S. M. (2022). A Scoping Review of the Relationship Between Nonlinguistic Cognitive Factors and Aphasia Treatment Response. *Topics in Language Disorders*, *42*(3), 212–235. https://doi.org/10.1097/TLD.0000000000000290

Frieg, H., Hilbert, C., Belke, E., & Belke, G. (2012). Sprachförderung in ein- und mehrsprachigen Gruppen: Die generative Textproduktion. *Sprachheilarbeit*, *57*, 155–161.

Gold, P. C., & Freeman, E. A. (1984). Remediation of Alexia: A Case Study. *Reading Psychology*, *5*(1–2), Article 1–2. https://doi.org/10.1080/0270271840050107

Gudjons, H. (2014). *Handlungsorientiert lehren und lernen: Schüleraktivierung - Selbsttätigkeit - Projektarbeit* (8th ed.). Klinkhardt.

Härting, C., Markowitsch, H. J., Neufeld, H., Calabrese, P., & Deisinger, K. (2000). *Wechsler-Gedächtnistest - revidierte Fassung: WMS-R; Manual; deutsche Adaptation der revidierten Fassung der Wechsler Memory scale* (J. Kessler, Ed.; 1st ed.). Huber.

Herbert, R., Haw, C., Brown, C., Gregory, E., & Brumfitt, S. (2012). *Accessible information guidelines: Making information accessible for people with aphasia.* Stroke Association.

Hoffmann, T. C., Glasziou, P. P., Boutron, I., Milne, R., Perera, R., Moher, D., Altman, D. G., Barbour, V., Macdonald, H., Johnston, M., Lamb, S. E., Dixon-Woods, M., McCulloch, P., Wyatt, J. C., Chan, A.-W., & Michie, S. (2014). Better reporting of interventions: Template for intervention description and replication (TIDieR) checklist and guide. *BMJ*, *348*(mar07 3), g1687–g1687. https://doi.org/10.1136/bmj.g1687

Höllein, D. (2020). Valency Theory. In D. Höllein, *Linguistics*. Oxford University Press. https://doi.org/10.1093/obo/9780199772810-0260

Huber, W., Poeck, K., Weniger, D., & Willmes, K. (1983). *Aachener Aphasie Test (AAT)*. Hogrefe.

Hux, K., Wallace, S. E., Brown, J. A., & Knollman-Porter, K. (2021). Perceptions of people with aphasia about supporting reading with text-to-speech technology: A convergent mixed methods study. *Journal of Communication Disorders*, *91*, 106098. https://doi.org/10.1016/j.jcomdis.2021.106098

JASP Team. (2022). *JASP* (0.16.3) [Computer software]. https://jasp-stats.org/

Jesch, T. (2010). Textverstehen. In C. Garbe, K. Holle, & T. Jesch (Eds.), *Texte lesen: Textverstehen—Lesedidaktik—Lesesozialisation* (2nd ed., pp. 39–102). Ferdinand Schöningh.

Kalbe, E., Reinhold, N., Ender, U., & Kessler, J. (2002). *Aphasie-Check-Liste (ACL)*. ProLog.

Kendeou, P., van den Broek, P., Helder, A., & Karlsson, J. (2014). A Cognitive View of Reading Comprehension: Implications for Reading Difficulties. *Learning Disabilities Research & Practice*, *29*(1), 10–16. https://doi.org/10.1111/ldrp.12025

Kersey, J., Evans, W. S., Mullen, K., Askren, A., Cavanaugh, R., Wallace, S. E., Hula, W. D., Walsh Dickey, M., Terhorst, L., & Skidmore, E. (2021). Metacognitive Strategy Training Is Feasible for People With Aphasia. *OTJR: Occupation, Participation and Health*, *41*(4), 309–318. https://doi.org/10.1177/15394492211023196

Kintsch, W. (2018). Revisiting the Construction—Integration Model of Text Comprehension and its Implications for Instruction. In D. E. Alvermann, N. J. Unrau, M. Sailors, & R. B. Ruddell (Eds.), *Theoretical Models and Processes of Literacy* (7th ed., pp. 178–203). Routledge. https://doi.org/10.4324/9781315110592-12

Lee, J. B., & Sohlberg, M. M. (2013). Evaluation of Attention Training and Metacognitive Facilitation to Improve Reading Comprehension in Aphasia. *American Journal of Speech-Language Pathology*, *22*(2), Article 2. https://doi.org/10.1044/1058-0360(2013/12-0099)

Lenhard, W., Baier, H., Endlich, D., Schneider, W., & Hoffmann, J. (2013). Rethinking strategy instruction: Direct reading strategy instruction versus computer-based guided practice. *Journal of Research in Reading*, *36*(2), 223–240. https://doi.org/10.1111/j.1467-9817.2011.01505.x

Lynch, K. E., Damico, J. S., Abendroth, K. J., & Nelson, R. L. (2013). Reading performance subsequent to aphasia: Strategies applied during authentic reading. *Aphasiology*, *27*(6), Article 6. https://doi.org/10.1080/02687038.2012.748182

Lynch, K. E., Damico, J. S., Damico, H. L., Tetnowski, J., & Tetnowski, J. (2009). Reading Skills in an Individual with Aphasia: The Usefulness of Meaning-Based Clinical Applications. *Asia Pacific Journal of Speech, Language and Hearing*, *12*(3), Article 3. https://doi.org/10.1179/136132809805335328

Mayer, A., & Marks, D.-K. (2019). Förderung des Textverständnisses durch die Vermittlung von Verstehensstrategien – Eine Metaanalyse zur Effektivität. Improving reading comprehension skills by mediating comprehension strategies. A meta-analysis of the effectiveness. *Forschung Sprache*, *7*, 4–36.

Mayer, J. F., & Murray, L. L. (2002). Approaches to the treatment of alexia in chronic aphasia. *Aphasiology*, *16*(7), Article 7. https://doi.org/10.1080/02687030143000870

McKevitt, C., Fudge, N., Redfern, J., Sheldenkar, A., Crichton, S., Rudd, A. R., Forster, A., Young, J., Nazareth, I., Silver, L. E., Rothwell, P. M., & Wolfe, C. D. A. (2011). Self-Reported Long-Term Needs After Stroke. *Stroke*, *42*(5), Article 5. https://doi.org/10.1161/STROKEAHA.110.598839

Meteyard, L., Bruce, C., Edmundson, A., & Oakhill, J. (2015). Profiling text comprehension impairments in aphasia. *Aphasiology*, *29*(1), 1–28. https://doi.org/10.1080/02687038.2014.955388

Moeller, J. (2015). A word on standardization in longitudinal studies: Don't. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/fpsyg.2015.01389

Morris, J., Webster, J., Howard, D., & Garraffa, M. (in preparation). *Comprehensive Assessment of Reading in Aphasia (CARA)*. Newcastle University.

Nguyen, H., Morris, J., Webster, J., & Nickels, L. (2018). Reading of everyday texts by people with aphasia: Do advance organisers help? *Aphasiology*, *32*(sup1), 153–155. https://doi.org/10.1080/02687038.2018.1486376

OECD. (2006). *Assessing Scientific, Reading and Mathematical Literacy: A Framework for PISA 2006*. OECD. https://doi.org/10.1787/9789264026407-en

Parr, S. (1995). Everyday reading and writing in aphasia: Role change and the influence of pre-morbid literacy practice. *Aphasiology*, *9*(3), Article 3. https://doi.org/10.1080/02687039508248197

Perfetti, C. (1999). Comprehending written language: A blueprint of the reader. In C. M. Brown & P. Hagoort (Eds.), *The neurocognition of language* (pp. 167–208). Oxford University Press.

Petermann, F., & Lepach, A. C. (2012). *Wechsler memory scale (WMS-IV): Manual zur Durchführung und Auswertung; dt. Übers. und Adaptation der WMS-IV von David Wechsler* (4. ed). Pearson.

Piccardo, E. (2014). *From Communicative to Action-Oriented: A Research Pathway*. https://www.researchgate.net/profile/Enrica-Piccardo/publication/338177979_Piccardo_E2014From_Communicative_to_Action-oriented_a_Research_Pathways/links/5e050f6b299bf10bc37bef39/Piccardo-E2014From-Communicative-to-Action-oriented-a-Research-Pathways.pdf

Purdy, M., Coppens, P., Madden, E. B., Mozeiko, J., Patterson, J., Wallace, S. E., & Freed, D. (2018). Reading comprehension treatment in aphasia: A systematic review. *Aphasiology*, *33*(6), Article 6. https://doi.org/10.1080/02687038.2018.1482405

Riedel, B. (2014). *Texte für die neurologische Rehabilitation*. NAT.

Rogalski, Y., & Edmonds, L. A. (2008). Attentive Reading and Constrained Summarisation (ARCS) treatment in primary progressive aphasia: A case study. *Aphasiology*, *22*(7–8), 763–775. https://doi.org/10.1080/02687030701803796

Rogalski, Y., Edmonds, L. A., Daly, V. R., & Gardner, M. J. (2013). Attentive Reading and Constrained Summarisation (ARCS) discourse treatment for chronic Wernicke's aphasia. *Aphasiology*, *27*(10), 1232–1251. https://doi.org/10.1080/02687038.2013.810327

Rosebrock, C., & Nix, D. (2020). *Grundlagen der Lesedidaktik und der systematischen schulischen Leseförderung* (9., aktualisierte Neuauflage). Schneider Verlag Hohengehren GmbH.

Schellig, P., Drechsler, R., Heinemann, D., & Sturm, W. (Eds.). (2009). *Aufmerksamkeit, Gedächtnis, exekutive Funktionen* (1st ed., Vol. 1). Hogrefe.

Schmidt, C. (2007). Lesestrategien. *Französisch Heute*, *38*(2), 121–129.

Schulz, K. F., Altman, D. G., Moher, D., & for the CONSORT Group. (2010). CONSORT 2010 Statement: Updated guidelines for reporting parallel group randomised trials. *BMJ*, *340*(mar23 1), c332–c332. https://doi.org/10.1136/bmj.c332

Schumacher, R., Halai, A. D., & Lambon Ralph, M. A. (2019). Assessing and mapping language, attention and executive multidimensional deficits in stroke aphasia. *Brain*, *142*(10), 3202–3216. https://doi.org/10.1093/brain/awz258

Sedlmeier, P., & Renkewitz, F. (2018). *Forschungsmethoden und Statistik Für Psychologen und Sozialwissenschaftler*. Pearson Education Deutschland GmbH. http://ebookcentral.proquest.com/lib/ufb/detail.action?docID=5583851

Sinotte, M. P., & Coelho, C. A. (2007). Attention training for reading impairment in mild aphasia: A follow-up study. *NeuroRehabilitation*, *22*(4), Article 4. https://doi.org/10.3233/NRE-2007-22408

Snow, C. E. (2002). *Reading for understanding: Toward an R&D program in reading comprehension* (Science and Technology Policy Institute (Rand Corporation), Ed.). Rand.

Souvignier, E., & Antoniou, F. (2007). Förderung des Leseverständnisses bei Schülerinnen und Schülern mit Lernschwierigkeiten—Eine Metaanalyse. *Vierteljahreszeitschrift Für Heilpädagogik Und Ihre Nachbargebiete*, *76*, 46–62.

Thompson, C. K. (2007). Complexity in Language Learning and Treatment. *American Journal of Speech-Language Pathology*, *16*(1), Article 1. https://doi.org/10.1044/1058-0360(2007/002)

Thumbeck, S.-M., Schmid, P., Chesneau, S., & Domahs, F. (2021). Efficacy of a strategy-based intervention on text-level reading comprehension in persons with aphasia: A study protocol for a repeated measures study. *BMJ Open*, *11*(7), e048126. https://doi.org/10.1136/bmjopen-2020-048126

Thumbeck, S.-M., Webster, J., & Domahs, F. (2023). Comprehensive Assessment of Reading in Aphasia (CARA) reading questionnaire—German version. *International Journal of Language & Communication Disorders*, 1460-6984.12884. https://doi.org/10.1111/1460-6984.12884

Verhoeven, L., & Perfetti, C. (2008). Advances in text comprehension: Model, process and development. *Applied Cognitive Psychology*, *22*(3), 293–301. https://doi.org/10.1002/acp.1417

Wallace, S. J., Isaacs, M., Ali, M., & Brady, M. (2022). *Establishing Reporting Standards for Participant Characteristics in Post Stroke Aphasia Research: An International e-Delphi Exercise and Consensus Meeting.*

Watter, K., Copley, A., & Finch, E. (2016). Discourse level reading comprehension interventions following acquired brain injury: A systematic review. *Disability and Rehabilitation*, *39*(4), Article 4. https://doi.org/10.3109/09638288.2016.1141241

Watter, K., Copley, A., & Finch, E. (2021). Developing an evidence-based reading intervention for early brain injury rehabilitation. *Brain Impairment*, *22*(2), 165–188. https://doi.org/10.1017/BrImp.2020.8

Webster, J., Morris, J., Connor, C., Horner, R., McCormac, C., & Potts, A. (2013). Text level reading comprehension in aphasia: What do we know about therapy and what do we need to know? *Aphasiology*, *27*(11), Article 11. https://doi.org/10.1080/02687038.2013.825760

Webster, J., Morris, J., & Howard, D. (2022). Reading comprehension in aphasia: The relationship between linguistic performance, personal perspective, and preferences. *Aphasiology*, 1–17. https://doi.org/10.1080/02687038.2022.2039999

Webster, J., Morris, J., Malone, J., & Howard, D. (2021). Reading comprehension difficulties in people with aphasia: Investigating personal perception of reading ability, practice, and difficulties. *Aphasiology*, *35*(6), 805–823. https://doi.org/10.1080/02687038.2020.1737316

World Health Organisation. (2005). *ICF. Internationale Klassifikation der Funktionsfähigkeit, Behinderung und Gesundheit, Stand Oktober 2005*. Deutsches Institut Für Medizinische Dokumentation Und Information. https://www.dimdi.de/dynamic/.downloads/klassifikationen/icf/icfbp2005.zip

Yapp, D. J., De Graaff, R., & Van Den Bergh, H. (2021). Improving second language reading comprehension through reading strategies: A meta-analysis of L2 reading strategy interventions. *Journal of Second Language Studies*, *4*(1), 154–192. https://doi.org/10.1075/jsls.19013.yap

[dataset] Thumbeck, S.-M., Schmid, P., Chesneau, S., & Domahs, F.; 2023; Open Science Framework; *Efficacy of reading strategies in aphasia;* https://doi.org/10.17605/OSF.IO/F6T5B