University of Reading

Situated language use in post-stroke aphasia:

a systematic exploration of functional communication

Thesis presented for the degree of Doctor of Philosophy

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September 2020

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For oma

Declarations

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

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Contributions by chapter

Chapter 2

Doedens, W.J. & Meteyard, L. (under review). What is functional communication? A theoretical framework for real-world communication applied to aphasia rehabilitation. *Neuropsychology Review*.

Contributor	Statement of contribution
Author: Willemijn Doedens (Candidate)	Literature search & synthesis: 100% Writing: 100%
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Chapter 3

Doedens, W.J. & Meteyard, L. (2020) Measures of functional, real-world communication for aphasia: a critical review, *Aphasiology*, 34:4, 492-514, doi: 10.1080/02687038.2019.1702848

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Chapter 4

Doedens, W.J., Bose, A. & Meteyard, L. (to be submitted). Using a face-to-face collaborative communication task to understand functional communication in aphasia.

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	Data analysis: 80%
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	Editing: 50%
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Chapter 5

Doedens, W.J., Bose, A., Lambert, L. & Meteyard, L. (under review). Real-world communication in aphasia: the influence of speaker familiarity on a collaborative communication task. *Frontiers in Communication.*

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Chapter 6

Doedens, W.J., Bose, A. & Meteyard, L. (to be submitted). Measuring task-based functional communication in post-stroke aphasia: an evaluation of construct validity.

Contributor	**Statement of contribution**
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	Data collection: 100%
	Data analysis: 80%
	Writing: 100%
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Author: Arpita Bose	Study design: 0%
	Data analysis: 0%
	Editing: 50%
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Abstract

Aphasia is an acquired language impairment most often caused by stroke. One of the main goals of speech and language therapy is to improve a person's ability to communicate in everyday life. Research on this level of functioning, often referred to as *functional communication*, has grown since the 1980s. The lack of a clear conceptualisation of the term functional communication has, however, negatively affected the evidence base for the assessment and treatment of everyday communication in aphasia.

This thesis explores the theoretical, practical and empirical operationalisation of functional communication in aphasiology by addressing the following questions: How can we: (1) define real-world communication? (2) measure functional communication in an ecologically valid manner? and (3) investigate communication experimentally?

A scoping review was conducted to identify a theoretical framework of real-world communication, followed by a review of existing research on each component of the framework in the aphasia and control literature, to get an overview of the existing evidence base. The framework was used to evaluate the content validity of existing clinical measures of functional communication. Finally, sixteen PWA and sixteen matched NHC participated in an experimental investigation of communication to identify which communication measures uniquely characterised communication for the aphasia group. The construct validity of one measure was established, and the influence of conversation partner familiarity on communication for PWA was explored.

Results showed that real-world communication is interactive, multimodal and embedded in context. The Scenario Test (van der Meulen et al., 2010) was selected as the instrument with the highest content validity. The experimental work provided support for the use of a lab-based task to explore communication in aphasia and identified two important characteristics of aphasic communication (the amount of information exchanged and modalities used). PWA

were shown to respond differently to an unfamiliar conversation partner compared to controls. Finally, the results suggest some PWA show evidence of learning on the experimental, communicative task.

Together, these results provide important insights into functional communication in aphasia. Theoretical and clinical implications of these findings are discussed.

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Chapter 1 | Introduction

Post-stroke aphasia

More than 100,000 people in the UK experience a stroke each year (Stroke Association, 2018). About thirty to forty percent of these people will have a language impairment called aphasia, which affects a person's ability to produce and/or understand language in spoken and written format to varying degrees. Most often, aphasia is the result of acquired brain damage in the left hemisphere, which is dominant for language (Ingram, 2007). Different levels of language processing can be affected by aphasia, ranging from difficulty in processing speech sounds to deficits in the processing of words, sentences and/or connected speech. The severity of the impairment depends on the number of language modalities affected and the degree to which each of these are impaired. A mild aphasia might include difficulty retrieving infrequent and complex words with minimal problems of comprehension, while a severe aphasia might include an inability to produce any words, and significant difficulty understanding most spoken and written sentences (Goodglass, 1993). Regardless of the severity, the language impairment has a detrimental effect on a person's ability to communicate effectively.

The presence of post-stroke aphasia has significant, negative consequences on many aspects of life. Compared to stroke survivors without language and communication difficulties, People With Aphasia (PWA) are at higher risk of depression (Lam & Wodchis, 2010), a loss of social connections (Cruice et al., 2006; Hilari & Northcott, 2016; Northcott & Hilari, 2011), decreased levels of independence (Worrall et al., 2011), and a decrease in overall well-being and quality of life (El Hachioui et al., 2014; Hilari, 2011; Kauhanen et al., 2000). An optimal rehabilitation trajectory aimed at improving language and communication abilities specifically and functioning more generally is therefore imperative.

Assessment and treatment of aphasia

Historically, aphasia has predominantly been studied from a linguistic perspective. Fundamental research on the processing of linguistic elements at the sound, word and sentence level in Neurologically Healthy Controls (NHC) led to the development of cognitive neuropsychological models of phonemic, lexical and syntactic processing in the 1950s and 1970s (Balota et al., 2007; Hagoort et al., 1999; Levelt et al., 1999). These highly influential models were applied to research on aphasia, leading to detailed insights into the impairments of language processing in aphasia (Caramazza & Berndt, 1978; Geschwind, 1972; Goodglass & Kaplan, 1972; Luria, 1970). Based on the growing evidence base, researchers were able to develop standardised diagnostic tests that reliably report the presence of specific impairments at the level of sound, word and sentence processing in people with aphasia (e.g. Western Aphasia Battery, Kertesz, 2009; Comprehensive Aphasia Test, Howard et al., 2010). These tests provide an overall profile of the impairment of language (Geschwind, 1972). Classic examples are a Broca-type of aphasia, where PWA predominantly present with difficulties in language production (non-fluent, effortful, agrammatic speech), while auditory comprehension is relatively preserved, or a Wernicke-type of aphasia, where difficulties are experienced in auditory language comprehension, while language production is fluent but often empty of meaning (Goodglass, 1993). The categorisation of aphasia into types has been questioned, as it is often difficult to fit a given individual's profile of impairment into one specific category or aphasia type (Caramazza, 1984; Ferro & Kertesz, 1987; Poeppel & Hickok, 2004; Schwartz, 1984). However, the profile of impairment that comes out of these standardised diagnostic tests do provide a clear starting point for clinical language intervention and they are commonly used to test for improvements in functioning as a result of therapy (Katz et al., 2000; Verna et al., 2009; Wallace et al., 2014). These linguistically-based approaches have formed the foundation for aphasia rehabilitation programmes that address the impairment present in aphasia (Thompson et al., 2008).

Real-world communication

As the evidence base for the impairment-based approach expanded, the realisation grew that a description of the linguistic level of functioning did not fully capture the scope of the deficit present in aphasia. For many PWA, a discrepancy was observed between the linguistic impairments as measured on standardised 'impairment-based' tests, and the way they were able to communicate in the real world. Some PWA were better able to communicate than expected based on their standardised linguistic scores: "the essentially mute patient, labelled mixed or Broca's type, may communicate a great deal in his or her animated, head nodding, non-linguistic way" (Aten, 1986 as quoted by Frattali, 1992, p. 266). This ability to communicate in the real world, outside of the clinical setting, has most often been referred to as *functional communication* in the aphasia literature, a term first coined by Audrey Holland (1982).

The growing interest in communication in aphasia led to a surge in research on language as it is used beyond the level of a single sentence, i.e. for conversation, interaction and expressing one's ideas, feelings and wishes (El Hachioui et al., 2014). Because of its complex and multi-faceted nature, communication in aphasia has since been interpreted and studied using different methodological frameworks with roots in formal linguistics, psycholinguistics, pragmatics, cognitive psychology, and sociology (as shown in Figure 1). The approach to studying communication and *how communication is achieved* is different for each of these underlying frameworks. Researchers with a background in formal linguistics are often mainly interested in analysing how meaning is expressed through the linguistic elements produced (i.e. correct sound, word and sentence retrieval and formulation; Caramazza and Berndt, 1978; Goodglass and Kaplan, 1972). Researchers in pragmatics are interested in understanding *how meaning is created* beyond the formal linguistic elements that are expressed (i.e. the use of speech acts, measures of coherence, cohesion and story grammar; Halliday, 2004; Pritchard et al., 2018; Sherratt, 2007). Conversation analysis researchers, with a theoretical background stemmed in sociology, focus on *how communication is organised* by analysing the organisation of the communication process (e.g. the sequential pattern of turn-taking, repairs, etc.; Beeke et al., 2007; Perkins, 1995; Sacks et al., 1974). Finally, a mixed group of researchers has investigated on *how much information is transferred* during communication (e.g., by analysing content or information units that are expressed by PWA compared to controls; Nicholas and Brookshire, 1993), or *how successful communication is* (sometimes described as 'getting the message across'; Ramsberger and Rende, 2002; van der Meulen et al., 2010). Finally, with the introduction of the International Classification of Functioning model of patient-centred care, the concept of functional communication has been expanded to include the functional consequences of the impairment, i.e. *how communication affects daily life activities and participation* (ICF, World Health Organization, 1980, 2001). Since then, the concept has sometimes even included measures of the impact of impaired communication on well-being and quality of life (Elman & Bernstein-Ellis, 1995). Over time, the focus on functional recovery beyond the linguistic impairment has become part of the wider 'consequences' or 'functional approach' within aphasiology, which has often been contrasted to the 'impairment-based' approach (Thompson et al., 2008).

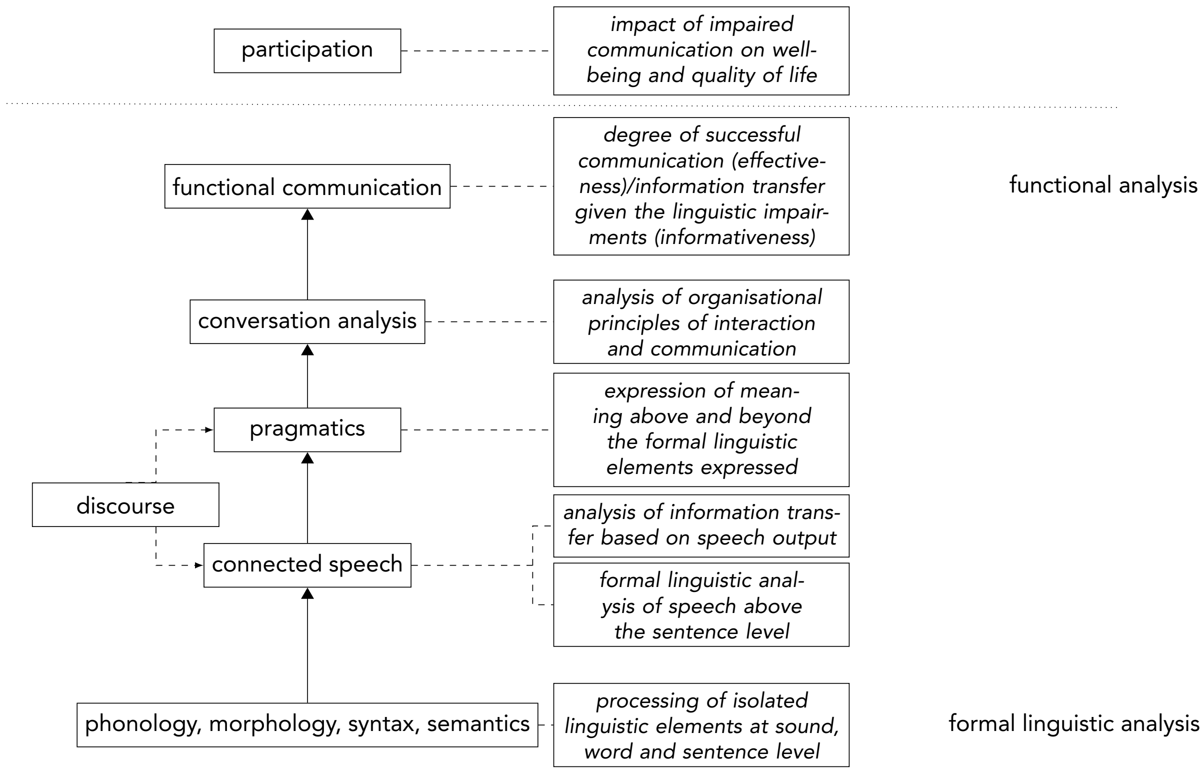

Figure 1. Schematic overview of the different theoretical/methodological frameworks used to research functional communication in aphasia.

Across theoretical frameworks, the definition of real-world communication and the terminology that is used to refer to this level of functioning has varied. Communication has, for example, interchangeably been referred to with terms such as connected speech, functional communication, and discourse. Across the different theoretical frameworks, a wide range of techniques have been used to elicit language samples that are referred to with the same terms, all with the aim to examine communication in aphasia rehabilitation. The term functional communication has, for example, been used to refer to performance on a complex picture description, as well as performance during interactive role play. The term discourse, in turn, has been used to refer to performance on a procedural narrative (i.e. a description of how to make a cup of coffee), as well as communicative performance during spontaneous conversation. The continuum of different levels of linguistic processing as presented by Webster et al. (2015; slightly adapted for the current discussion in Table 1) is based on different elicitation methods that are used to obtain samples of language use. The continuum clearly reflects the variety in terminologies that, in the literature, are all used to refer to functional communication (i.e. connected speech, discourse, functional communication and everyday communication).

level of language use	word	sentence	connected speech			everyday communication
			picture description	discourse		
				monologue	dialogue	
Elicitation methods	* Picture naming	* Constrained phrase or sentence production tests	* Complex picture description * Sentence production tests	* Narrative, e.g. story retell * Personal narrative, e.g. recount * Procedural narrative * Expositions, e.g. opinions	* Conversation (more or less naturalistic sampling) * Role-playing	* Elicited production of everyday scenarios * Rating scales

Table 1. Continuum of levels of language use, illustrating the terminologies that have been used to refer to functional communication in the aphasia literature, based on the continuum by Webster et al (2015).

The growing evidence base on functional communication has led to the development of numerous instruments that aim to capture communicative ability in PWA (e.g. Bastiaanse and Prins, 1994; Manochiopinig et al., 1992; Spreen and Risser, 2003), as well as a number of therapeutic interventions designed to, directly or indirectly, improve communication for PWA (Simmons-Mackie et al., 2014).

Relationship between linguistic and functional levels of functioning

Since the term functional communication was first introduced, research has shown that the relationship between isolated, linguistic impairments and a person's ability to communicate in the real world is not straightforward. The field is generally in agreement that scores based on impairment-level tests are not sufficient to reliably describe or predict a person's ability to communicate in everyday life (Beeke et al., 2011; Holland, 1980). Numerous studies have found correlations between impairment-based and functional measures, suggesting the two constructs are related (Frattali et al., 1995; Fridriksson et al., 2006; Holland, 1982; Hula et al., 2015; Irwin et al., 2002; Lomas et al., 1989; Mazaux et al., 2013). Globally, this relationship is found to be positive, indicating that as the linguistic impairment becomes more severe, the communicative ability is also affected more negatively. However, this pattern is often found to be slightly different for people with milder aphasias compared to people with more severe aphasias (Schumacher et al., 2020). Furthermore, changes that are found in both of these measures as a result of therapeutic intervention do not tend to correlate (Aftonomos et al., 2001; Meier et al., 2017; Persad et al., 2013), though some exceptions have been found (Doesborgh et al., 2004). These findings suggest that linguistic processing skills and functional communication represent distinct, but interconnected constructs (Irwin et al., 2002; Kagan et al., 2008; Meier et al., 2017).

Indeed, research has shown that improvements as a result of intervention measured at one level of language functioning (e.g. on a standardised linguistic test) are not necessarily reflected in improvements in the amount of information that can be transferred, and vice versa. Multi-level approaches aim to combine structural (i.e. linguistic) and functional analyses of language use to gain insight into the relationship between different levels of language use (Marini et al., 2011; Wright & Capilouto, 2012). A better understanding of the intricate interconnectedness of different levels of functioning could lead to a better understanding of potential ways in which generalisation of therapeutic effects might occur. However, the way the different levels of functioning are interrelated remains a topic of scientific investigation.

Current issues in real-world communication

Functional, or real-world communication is central to aphasia rehabilitation. PWA, those closest to them, speech and language therapists and other important stakeholders all view the improvement of a person's ability to communicate in their own environment as one of the most important goals in the rehabilitation process (Wallace et al., 2016; Worrall et al., 2017). Regardless of the chosen therapeutic approach, improvement of functioning at the level of communication is often viewed as the standard for measuring the success of an intervention. The central importance of real-world communication warrants the many investigations that seek to better understand this level of behaviour, and its relationship to other levels of language use in post-stroke aphasia.

While the evidence base for real-world communication in aphasia has grown since Holland first coined the term *functional communication* in the 1980s, as described above, it has not led to a strong foundation of knowledge such as that which exists for the impairment-based level of functioning (Brady et al., 2016). Rather, the use of distinct theoretical frameworks, terminologies and elicitation techniques, as well as overlapping yet distinct definitions, has left the evidence base for real-world communication fragmented with research findings that are often irreconcilable (Armstrong, 2000; Brady et al., 2016; Irwin et al., 2002; Linnik et al., 2016). This has made it difficult to answer essential questions about the way in which communication is affected in aphasia, and the effectiveness of speech and language therapy at the level of everyday communication.

Critically, aphasiology has lacked a comprehensive theoretical definition and framework of real-world communication. Impairment-based studies have benefitted from the existing theoretical frameworks such as Levelt's model of word production (Levelt et al., 1999) as anchor points to generate hypotheses and to feed empirical findings back into such models (e.g. how phonological and semantic information are activated and retrieved, Dell, 1986). While studies on language processing in aphasia have differed in their methodological approaches, the presence of a centralised theoretical framework provided researchers with a common language with which to discuss their findings, enabling them to translate results across studies and synthesize results to form a unified evidence base. Such an overarching theoretical model or framework for real-world communication is currently missing in aphasia rehabilitation. Consequently, everyday communication has been repeatedly interpreted in different ways, which has made it particularly difficult to piece divergent lines of research together into a coherent story. While efforts are being made to better understand real-world communication in aphasia, a common language is needed to bring the different lines of research together.

Without knowing or agreeing on *what* functional communication is exactly, it is almost impossible to reliably say *how* it should be measured, *how* it can be reliably targeted through therapeutic intervention, *how* it might relate to impairment-based measures and *how* the generalisation of therapeutic effects might take place. Put differently, the reliability of claims made about the effectiveness of speech and language therapy on real-world communication depends on the existence of a thorough understanding of this concept and an ability to compare across studies on functional communication (Brady et al., 2016).

Some key, interrelated, issues are: the distinct ways in which the term *functional communication* has been interpreted in the literature (Elman & Bernstein-Ellis, 1995), the heterogeneity of assessment instruments that claim to measures functional communication (Armstrong, 2000; Manochiopinig et al., 1992; Wallace et al., 2018), the struggle in disentangling the intricate relationship between linguistic functioning and functional communication (Irwin et al., 2002) and the difficulty in finding consistent, reliable, long term generalization effects from SLT therapy to measures of communication in everyday life (Brady et al., 2016). Despite the fact that clinicians often view real-world communication as a long-term goal of therapy, linguistic standardised tests are still predominantly used to assess therapeutic effectiveness (Verna et al., 2009; Wallace et al., 2014). This might very well be a consequence of the above-mentioned issues. In short, the issues surrounding the study of functional communication touch on all aspects of empirical research and clinical assessment and treatment of communication in aphasia.

Given the central importance of real-world communication to aphasia rehabilitation, it is crucial that work is done to establish a fundamental, theoretically founded understanding of real-world communication, on which systematic investigations into functional communication in post-stroke aphasia can be built. Therefore, **the main objective of this thesis is to propose a systematic, empirical, and cognitive-behavioural approach to the study of real-world communication in post-stroke aphasia, based on an empirically founded theoretical framework**.

Research questions

This thesis contains five chapters that each represent individual papers that have been published (chapter 3), submitted (chapters 2 and 5) or will soon be submitted (chapters 4 and 6) for publication in international peer-reviewed journals. Each paper is included as as it was published or submitted, with its own abstract, introduction, discussion, and references. Together, these chapters aim to answer the following research questions:

Theoretical definition of communication (Chapter 2):

1. How can we define real-world communication in aphasiology?

Assessment of communication (Chapter 3):

2. Which existing measure of communication in aphasiology is most ecologically valid given the theoretical framework?

Methodological considerations in an experimental investigation of communication (Chapter 4 & 6):

3. How can we investigate communication experimentally in post-stroke aphasia, given the theoretical framework?

Empirical exploration of communication in post-stroke aphasia (Chapter 5):

4. How does conversation partner familiarity influence communication for PWA?

Methodological considerations

Variations in the methodological approaches used to study functional communication have led to difficulties in integrating research findings and in creating a coherent theory of real-world communication. The purpose of the current thesis is twofold. Firstly, we want to comprehensively define real-world communication in a way that will allow researchers from different methodological backgrounds to discuss their findings within a common framework and language. The hope is that such a framework will make it easier to merge findings from different studies on communication in the future, and to define what specific level of language use is investigated in a particular study. Secondly, the current thesis aims to explore real-world communication from an objective, cognitive-behavioural perspective, meaning that we want to explore the degree to which people with aphasia can successfully communicate in the real world, and how this level of performance relates to the underlying cognitive abilities (linguistic and non-linguistic). Differently put, we are interested in the skills the brain needs in order to achieve successful communication. This particular focus will allow us to investigate communication as a whole and, in a top-down manner, by identifying behaviours required for communication that can be targeted through clinical assessment and intervention.

There is an ongoing discussion regarding the *function of communication* in the literature, which is relevant to note here. A distinction is often made between the *transactional function*, i.e. 'getting the message across', and the *interactional* function of communication, which refers to the expression of social relations, personal attitudes and social affiliation through language, such as "greetings, brief comments and asides, expressions of affection and concern, an affirming gesture" (Davidson et al., 2003). It rarely happens that communication solely is used for one of the two functions (Brown & Yule, 1983). Still, the importance of the latter function of communication, especially for PWA, has been emphasized in the past. Previous research and many existing instruments that measure communication have often been criticized for focusing only on the transactional function of communication, or for an inability to capture the interpersonal, interactional aspects of communication (Davidson et al., 2003; Simmons-Mackie & Damico, 2001). The approach of the current thesis is not to focus on one function of communication over the other. Rather, the current thesis is based on the assumption that to objectively quantify a person's ability to communicate, in the most general sense of the word, inherently touches on *both* the transactional and interactional functions of communication. Whether a message is purely transactional or used to express a social affiliation, the question posed here is whether PWA are able to communicate something. If they are, the question of interest is how this is achieved, i.e. by relying on which cognitive skills. If they are not able to communicate this, the question is why not, i.e. what impairs this behaviour.

Finally, it is relevant to note that patient-reported outcome measures (PROM) have become increasingly important in healthcare and aphasia rehabilitation specifically. For the discussion of functional communication, this shift in focus from a medical model to a patient-centred model has meant that the subjective experience of the PWA and their communicative abilities and difficulties has started to play an important role in therapy planning and the assessment of therapeutic effectiveness. While the importance of the subjective experience of communication impairments is acknowledged, the author believes there is value in being able to describe and measure communicative performance objectively in research and clinical practice. A clear theoretical framework of real-world communication will ultimately benefit both the subjective and objective assessment of the behaviour. The experimental section of the current thesis therefore aims to capture real-world communication objectively.

Thesis Outline

Chapter 2 expands on the current issues surrounding the study of real-world communication in aphasia. In this chapter, an existing theoretical framework of situated language use is translated to support and centralise the discussion of real-world communication in aphasia rehabilitation. A scoping review is used to explore what is known in the literature for both Non-brain damaged, Healthy Controls (NHC) and People with Aphasia (PWA) on each component of the framework, and where gaps in knowledge exist. Clinical implications for aphasia rehabilitation based on the acceptance of this theoretical framework are discussed.

Following this, existing instruments that are currently used to assess real-world communication in aphasia, both in research and the clinical setting, are reviewed systematically. This review is presented in **Chapter 3**. Each instrument is assessed on its ability to adhere to the theoretical framework of real-world communication. The instrument that best fits with the theoretical framework, and therefore has the best ecological validity is selected and discussed. Recommendations for improvement of this clinical instrument are also presented.

Chapter 4 explores methodological aspects of exploring real-world communication in a lab-based setting, by investigating the application of a well-established experimental paradigm to the study of aphasia. The suitability of a number of canonical outcome measures for the quantification of communicative ability in aphasia, in this experimental setup, is explored.

In **Chapter 5** we present the first steps of systematically exploring real-world communication in aphasia based on the proposed theoretical framework. The influence of conversation partner familiarity (i.e. personal common ground) on communication in aphasia is investigated.

The construct validity of the lab-based measure of functional communication as used in Chapters 4 and 5 is evaluated in **Chapter 6**.

Finally, we present a general discussion of our findings as well as the clinical implications of the current thesis in **Chapter 7**.

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Chapter 2 | What is functional communication? A theoretical framework for real-world communication applied to aphasia rehabilitation.

Doedens, W.J. & Meteyard, L. (under review) *Neuropsychology review*

Abstract

Aphasia is an impairment of language and communication caused by acquired brain damage such as stroke or traumatic brain injury. The aim of rehabilitation in aphasia is to improve everyday communication, improving an individual's ability to function in his/her day-to-day life. For that reason, a thorough understanding of naturalistic communication and its underlying mechanisms is imperative. The field of aphasiology currently lacks an agreed, comprehensive, theoretically founded definition of communication. Instead, multiple disparate interpretations of 'functional communication' are used. We argue that this makes it nearly impossible to accurately assess a person's communicative performance, to target this behaviour through therapy and to measure improvements post-therapy.

In this article we propose a structured, theoretical approach to defining the concept of functional communication. We argue for a view of communication as situated language use, borrowed from empirical, psycholinguistic studies with non-brain damaged adults. The framework defines language use as: (1) interactive, (2) multimodal, and (3) contextual. Existing research on each component of the framework from non-brain damaged adults and people with aphasia is reviewed. The consequences of adopting this approach to diagnosis and therapy for aphasia rehabilitation are discussed. The aim of this article is to encourage a more systematic, comprehensive approach to the study and treatment of situated language use in aphasia.

KEYWORDS: Language use, functional communication, aphasia, multimodal, interactive, common ground.

Introduction

Decades of research in aphasia have predominantly focused on the (impaired) processing of spoken and written words and sentences (Vigliocco et al., 2014). Most of this research has studied language in isolation: words and sentences are presented aurally or visually in highly controlled tasks. Cognitive neuropsychological language processing models first developed in the 1950s have led to detailed insights into the variety of linguistic variables that are of importance when processing linguistic information, such as phonological complexity, age of acquisition, concreteness (e.g. Balota et al., 2007; Levelt et al., 1999) and syntactic complexity (e.g. Hagoort et al., 1999). Language processing approaches to aphasia emerged in the 1970s (Caramazza & Berndt, 1978; Geschwind, 1972; Goodglass & Kaplan, 1972; Luria, 1970) and have since provided rich detail on the variation and complexity of language impairments seen in this condition. Notably, measures of language impairment borrowed heavily from studies in psycholinguistics, using decontextualized tasks such as picture naming, repetition, single word and single sentence comprehension to obtain a linguistically well-defined profile of impairment. Such measures provide a starting point for clinical intervention that aims to repair the parts of language processing that have been impaired (Whitworth et al., 2005). These approaches have formed the foundation for aphasia rehabilitation programs that address the 'impairment' present in aphasia (Thompson et al., 2008).

The question arises, however, to what extent findings from such highly controlled tasks translate to language as it is used in the real world (Holland, 1982). In recent decades psychology, linguistics and neuroscience have seen a shift away from the assumption that the mind and brain can be understood in isolation, through the lens of highly simplified and restrictive tasks (Dhami et al., 2004; Hamilton & Huth, 2018; Meteyard & Bose, 2018). This is part of a broader acknowledgement in the cognitive sciences that restricted lab-based tasks, prized for their high degree of experimental control, may not accurately (or actually) reflect the cognitive processes that take place in real-world situations (Clark, 1996; Hamilton & Huth, 2018; Meteyard & Vigliocco, 2018; Owen et al., 2010; Vigliocco et al., 2014; Willems, 2015), i.e. 'in situ' (Clark, 2018a). The data from such highly controlled tasks most likely reflect cognitive processes used within those tasks alone (i.e. 'in vacuo' Clark, 2018b) rather than reflecting something universal about, for example, phonology or semantics (Hamilton & Huth, 2018; Owen et al., 2010). A key indicator of this issue is the fact that performance in restricted, decontextualized tasks does not always generalise to more naturalistic versions of the same tasks (Hamilton & Huth, 2018; Owen et al., 2010).

Real world communication - typically referred to as functional communication - is the key outcome for speech and language therapy (SLT) for People With Aphasia (PWA) (Thompson et al., 2008). In line with the other cognitive sciences, there is a general agreement in the aphasia literature that communication[1] may draw upon a different, or perhaps only partially overlapping, process when compared to the decontextualized 'in vacuo' tasks that are traditionally used to measure linguistic functioning (Beeke et al., 2011). The use of decontextualized measures of language impairment implicitly ignores the complexity of the communication process (Barnes & Bloch, 2018; Doedens & Meteyard, 2020; Vigliocco et al., 2014). In support of this critique, measures of linguistic impairment do not fully predict how PWA will use language in everyday life (Armstrong et al., 2011; Beeke et al., 2007; Davidson et al., 2008; Holland, 1982; Kolk & Heeschen, 1992; Wilkinson, 1995).

In aphasiology, real world communication is often referred to as functional communication. This is a key concept in the field, as it is often the main outcome for speech and language therapy (SLT) for PWA: i.e. to see improvements in a person's communication in their everyday lives (Thompson et al., 2008). Despite its central role in aphasiology, there is not yet an agreed-upon definition of functional communication, or what behaviours this concept entails (Wallace et al., 2018). We will argue that this lack of understanding of functional communication underlies a number of current issues in the field:

Considering therapeutic efficacy and effectiveness, there is now a substantial body of research on impairment-based approaches to the rehabilitation of aphasia. Systematic reviews show SLT intervention is effective in improving functional communication when compared to no intervention, with moderate effect sizes (Brady et al., 2016). However, it has proven difficult to find consistent, reliable, long term generalization effects from SLT therapy to meaningful measures such as language use in everyday life (Brady et al., 2016; Simmons-Mackie et al., 2014; Webster et al., 2015). There is robust evidence that therapy approaches based on 'in vacuo' language processing skills (e.g. naming individual pictures) improve performance on words and sentences trained during therapy (e.g. Brady et al., 2016; Palmer et al., 2019). However, there is limited evidence that therapy gains generalise to words and sentences that have not been trained (Efstratiadou et al., 2018; Nickels, 2002; Raymer et al., 2007; Wisenburn & Mahoney,

[1] The ability to communicate in the real world or in one's own everyday life will be referred to as functional communication or simply as communication. This refers to skills, including language skills, required to communicate in various situations one might come across in one's day-to-day life.

2009), to tasks that have not been trained (Boo & Rose, 2010; Conroy et al., 2009; Croot et al., 2014; Herbert et al., 2013) or different levels of functioning such as discourse (Boyle, 2011) or functional communication (Brady et al., 2016; Carragher et al., 2015; Carragher et al., 2012). It is also largely unexplained why some individuals with aphasia show greater therapeutic gains (and sometimes more generalisation) than others (Best et al., 2013; Lorenz & Ziegler, 2009). Finally, it remains very challenging to predict who will respond to what kind of impairment based therapy (Fillingham et al., 2006; Neumann, 2017; Webster et al., 2015; Wisenburn & Mahoney, 2009). In short, despite many attempts and the theoretical underpinning of cognitive neuropsychology, it remains difficult to reliably predict which therapy approaches will generalise in what way to functional communication.

We will argue that there is a structural problem underlying these issues. Historically, aphasia rehabilitation has relied heavily on 'in vacuo' psycholinguistic research to define language impairment and language competence. This has resulted in a strong reliance on (psycho)linguistic theory to investigate and explain the impairments of language as well as functional communication in aphasia. From this stems the prevalent assumption that language processing can be (successfully) separated, measured and treated away from the rich context in which it is normally used (i.e. the real world), and that language assessment is sufficient to describe communication in the real world.

The lack of therapeutic gain at the level of functional communication could be explained by the decontextualized nature of the often used 'impairment-based tasks'. That is, these tasks may train linguistic processes that are different to those employed at the level of functional communication. The decontextualized tasks that are routinely used in assessment and rehabilitation for aphasia, in turn, may not reflect the language skills that are needed in the rich environments of real-world communication. For example, lexical retrieval during a picture naming task may not be identical (or directly translatable) to lexical retrieval during conversation (Heath et al., 2012; Nickels, 2002).

There is a movement to address the issues of assessment, intervention and generalisation to functional communication in the field of aphasia (Barnes & Bloch, 2018; Carragher et al., 2012; Harmon, 2020; Webster et al., 2015). A key problem is how to measure functional communication. In research as well as the clinic, therapy effects at the level of functional communication are often not measured (Brady et al., 2016; Rohde et al., 2012; Verna et al., 2009) or a set of highly heterogeneous measures are used (Brady et al., 2016; Doedens & Meteyard, 2020;

Wallace et al., 2014). This makes it difficult to synthesise and compare results across different studies and thus to draw stronger conclusions about therapy effectiveness in aphasia rehabilitation (Brady et al., 2016; Wallace et al., 2014). Recently, experts struggled to reach consensus on a single (existing) measure to capture functional communication in aphasia research (Wallace et al., 2018). This serves to highlight the difficulty in operationalising functional communication effectively for aphasia rehabilitation. This is problematic for the field, as effective measurement of this level of functioning is a crucial part of the success of the rehabilitation process.

The field can, and should, capitalise on the substantial body of research that has taken place across cognitive and neurosciences in the last 20 years to improve understanding of the processes that are involved in real-world communication. A clear framework for functional communication should make it possible to effectively describe and measure difficulties at this level of functioning. It will enable us to reason how therapy at the linguistic 'in vacuo' level might translate to language use 'in situ'. Furthermore, such a framework will make it possible to hypothesise what other cognitive processes - beyond linguistic skills - are required for communication, and which might influence the rehabilitation process of PWA (El Hachioui et al., 2014; Ferstl et al., 2005; Groenewold et al., 2014; Helm-Estabrooks, 2002; Murray, 2012).

The aims of this article are to propose a framework for real-world communication, and to translate and apply this framework for aphasia rehabilitation through a narrative review and synthesis of the relevant literature. The authors hope that such a framework can help in reaching consensus on what is meant by 'functional communication' in relation to assessment, intervention and therapeutic effectiveness. The framework aims to cover both internal (e.g. individual skills) and external (e.g. environmental) factors that influence a person's ability to communicate efficiently, explicitly moving away from the idea that communicative ability can be boiled down to a single number (Barnes & Bloch, 2018). The proposed framework of situated language use is based on the now extensive literature in the fields of psychology, communication sciences, linguistics, psycholinguistics and sociology with neurologically healthy adults (NHC) as well as with PWA.

By describing a theoretically founded framework of situated language use, the authors hope to encourage a more structured and systematic approach to this field of study and to move the study of communication in aphasia rehabilitation from a linguistic perspective, to a more comprehensive view of multiple behaviours and skills involved in communication. We are principally interested in the cognitive underpinnings of communication - that is, what skills do the mind and brain need to execute for communication to be successful? This focus allows us to identify skills and abilities that should be targeted for assessment and rehabilitation (n.b. just as under the impairment-based approach, phonological and semantic processes became key drivers for therapy; Meteyard and Bose, 2018). The hope is that this allows us to grasp the factors that influence language processing in its natural environment, and to use this knowledge to inform our interventions, to measure therapy effectiveness and to predict therapy outcomes. Finally, we hope that this overview of research on communication will shed light on new fruitful avenues for further research, including key internal and external factors and empirical measures.

Existing frameworks of functional, real-world, communication

Historically, numerous theoretical descriptions of the communication process have been proposed in the literature of psychology, communication science, sociology, neuroscience and engineering. These models aim to conceptualise, understand and investigate the different components and variables that are involved in communication. One of the first models that attempted to describe the process is the now classic Shannon-Weaver model (Shannon and Weaver, 1949). This model was created by electronic engineers who were concerned with describing information transfer over telephone and radio channels. The main aim of this information theory model was to describe the transmission of the message and the influence of potential distortions ('noise', also described as the level of uncertainty) on the message. The model describes a sender, the transmission of the message, a channel through which information can travel and a receiver. Although elegant in its simplicity and very successful in optimising the process of information transmission at a technical level, the model has been criticised for describing communication as a linear process (i.e. solely running from speaker to listener), rather than an interactive process (i.e. between speaker and listener). The model describes communication in an isolated fashion, omitting contextual, environmental factors, as well as ignoring the relational, social aspects of communication between two people (Kincaid, 1979). The model also does not concern itself with communication in terms of meaning: it solely focuses on the transmission of a message which can or cannot be received on the other end of the model.

Following Shannon and Weaver (1949), a great number of models were proposed and studied, often expanding on the original version: Schramm (Schramm, 1954) added a encoding and decoding element to the model, which describes the way in which meaning is transmitted and interpreted between two people. Westley and MacLean (1957) added feedback and multiple modalities for communicating to the model and highlighted the influence of the wider environment to communication. Berlo's Sender-Message-Channel-Receiver model (SMCR, 1960) attempted to integrate these additional features into one model by including contextual factors that influence communication such as communication skills, attitudes and social support. Overall, these models remained relatively linear in design, still describing communication as a speaker to listener 'left-to-right' process. Although not quite interactive, the Ruesch and Bateson model (1951) described the different levels of complexity on which human communication can take place ranging from an intrapersonal level to a cultural level. The level of interpersonal communication as described by Ruesch and Bateson (1951) is similar to the Shannon and Weaver model (1949), although it includes an "evaluation" of the message by the sender before it's sent, hinting at the complex internal processing that occurs during communication. From a more philosophical perspective, Alexander's (1988) describes similar influences of experience and attitude of the speaker and listener on the interpretation of the message. This model also describes the potential misunderstandings that can result from differences in these experiences and attitudes. In one of the first models applied to PWA, Wepman, Jones, Bock and Pelt (1960) proposed a model of communication to describe and analyse where different neurological language and speech disorders originate, based on data from PWA. Three basic processes are presented, namely the input of signals (to the ears, eye, and body to the brain), the integration into a symbolic formulation and the output of a signal (again, through the ears, eyes/hands, and body). As it stands, this model describes the process of communication at the level of an individual, excluding the interactive and environmental aspects of communication.

In the 1950s, language processing models emerged in psycholinguistics. These models focused on the processing on one aspect of the communication process, namely how linguistic information is produced and understood. Following the trend of psychological research more generally, highly controlled lab-based experiments were used to understand the components of language processing in great detail. From this research, influential models such as those by Levelt (1989), Patterson and Shewell (1987), Dell (1986) and Ellis and Young (1988) were published. By-and-large, these models focused on the intricacies involved in the processing (production and comprehension) of single words. Other influential models published around that time described sentence-level processing (Caramazza & Zurif, 1976; Schwartz et al., 1980). Taken together, the above-mentioned word- and sentence processing models gave rise to decades of fruitful language research. In addition, they have heavily influenced the face of language and communication research in general and research on aphasia more specifically. From a communication point of view, the criticism of these models is their sole focus on linguistic processing. In recent decades there is also a growing realisation that the results from the highly controlled lab-based experiments might not translate to how language is processed in the dynamics of the real world (as discussed in the Introduction). Alongside the emergence of single-word processing models, researchers such as Kendon (1980), McNeill (1992) and Goodwin (1995) emphasised the crucial role of non-verbal information exchange in communication (i.e. gesture, facial expression and body movement), in addition to linguistic exchanges. Whether linguistic or non-verbal, these models and bodies of research attempted to describe the exchange of information that occurs during communication, rather than describe the communication process as a whole. To demarcate the behaviours and factors that are relevant to the study and discussion of functional, real-world communication in aphasia rehabilitation a more comprehensive definition of communication is required.

A definition of situated language use

Given its complexity, it is unsurprising that there are many different ways in which to approach and describe the process of communication. It is precisely because 'functional communication' has this complexity and is so multi-faceted, spanning levels of the ICF (World Health Organization, 2001) and incorporating more than just an individual's abilities, that its definition and measurement has been so problematic (Doedens & Meteyard, 2020). To be useful for practical and clinical application in aphasia rehabilitation, a framework should help us delineate both the individual (cognitive skills) and the situational (contextual) factors that are important for communication. The framework needs to be as comprehensive as possible. Fortunately, there is research that has attempted to bring together all the different components discussed above in a single framework of communication, fit for the purpose of the current paper. In the mid-nineties (Clark, 1996) described how language is used 'in situ', during real-world, face-to-face communication. Based on this work, it is possible to identify three core components of real-world communication or situated language use. These are: (1) interactive, (2) multimodal and (3) reliant on common ground (Clark, 1996). This framework is useful for our current purpose: it defines communication in a way that allows us to differentiate language from communication theoretically (Doedens & Meteyard, 2020). Furthermore, this definition of communication is sufficiently general to encapsulate individual (internal) and situational (external) factors that impact on the communication process. Practically, it specifies the setting in which real-world communication, according to this framework, should be studied.

In this section of the paper, we will describe the basic setting in which to study communication, according to Clark (1996). After that, the three components of communication will be discussed.

The basic setting of situated language use

Communication in everyday life varies across settings, modalities and ways of communicating (speaking with a sibling at home, listening to an audio book in the car, performing for an audience in the theatre, writing a letter to a friend, ordering a meal in a restaurant, etc.). The purpose for which communication is used also varies, such as to transmit a message (transactional) or to connect to and maintain relationships with the people around us (interactional or social, Brown and Yule, 1983; Simmons-Mackie and Damico, 1995). The ability and manner in which one communicates across these different settings will vary depending on the circumstances, personal motivation, etc. (Harmon, 2020; Ramsberger & Menn, 2003). To evaluate the principles that govern situated language use, researchers have started by studying this phenomenon in its most basic setting: face-to-face communication (Barnes & Bloch, 2018; Bavelas & Chovil, 2000; Clark, 1996; McDermott & Tylbor, 1983; Pickering & Garrod, 2004). These researchers argue that face-to-face communication is the most commonly used and pervasive form of communication, it is universal to all human societies, it is the basis for typical language acquisition in children and it does not require education or special skills (Bavelas & Chovil, 2000; Clark, 1996). Indeed, Davidson, Worrall, & Hickson, (2008) showed that face-to-face conversation is the most frequently occurring communicative activity in daily life for PWA. It therefore makes sense to start by studying communicative skills in this setting (Kagan & Simmons-Mackie, 2007; Ramsberger & Menn, 2003). The reasoning is that once the principles that govern face-to-face communication are teased out, and a person's communicative skills in this basic setting are assessed, language use in other communicative situations can be derived from the basic face-to-face exchange (Clark, 1996).

Face-to-face communication brings with it a number of parameters. These parameters change, depending on the setting in which language is used (see Clark, 1996 for the full discussion on parameters). For example, one parameter of the face-to-face setting is one of immediacy in time and presence: communicating in a face-to-face setting happens in real time, without delays such as during a video chat (Barnes & Bloch, 2018; Carragher et al., 2012; Clark, 1996). Real-time communication brings with it restraints and pressures for each individual to respond within what is considered a 'reasonable' time frame, leaving little time for extensive planning of a response (Clark, 1996; Conroy et al., 2018; Sacks et al., 1974). These time pressures make face-to-face communication more complex and dynamic compared to language processing on isolated, decontextualized tasks (i.e. word-reading, picture-naming: Carragher et al., 2012), and potentially is a driver for the difference in performance on decontextualized tasks compared to real-world tasks. Face-to-face communication also occurs in the immediacy of physical presence: people can usually see each other without obstruction. This is in contract to the setting of speaking on the phone, where the visual information is not present. Finally, in the face-to-face setting, the speakers and listeners are in control of their own actions. This is in contrast to other settings, where a person's actions might be restricted by, for example, their role (in the theatre or at church).

Language use is interactive

Many researchers agree that communication is a joint activity (Barnes & Bloch, 2018; Clark, 1996; Schegloff, 1982), meaning that language is achieved by two or more people who coordinate their actions to achieve a common goal. Every decision made during a conversation will depend on the actions of the other. Language use is therefore an inherently interactive process, in which two or more participants work together and coordinate their actions to create meaning. The whole, as well as the actions of each individual can be studied within that process. When language production and comprehension are studied outside of the interactive process (i.e. in isolation or based on the behaviour of a single person), they will be tapping into inherently different processes as compared to language when it is used for communication.

Language use is multimodal

Communication is a fundamentally multimodal phenomenon (Bavelas & Chovil, 2000; Clark, 1996; Kendon, 1980; McNeill, 1992; Vigliocco et al., 2014). A number of different modalities or channels of expression are used during communication such as facial expressions, gesture, prosody, speech and body movements. These channels interact and are interdependent: they integrate into a single composite message. Channels are combined to replace, supplement, complement and emphasize speech, as well as to express emotion (Bavelas & Chovil, 2000; Kendon, 1980, 2004; McNeill, 1992). Language as a linguistic entity represents just one of the channels that can be used for communication. The study of language, within and outside of aphasiology, has largely focused on language as a decontextualized linguistic phenomenon. By studying language in isolation, the complexity and interdependence of the different channels is ignored (Vigliocco et al., 2014), and a wealth of information that is relevant for communication is missed. When people communicate with each other in the real world, they use all channels to express meaning, as well as to monitor and understand what the other participant is communicating (Clark & Krych, 2004). Communicative success or ability cannot, therefore, be determined by the evaluation of a single channel, such as the language channel, as essential information might have been communicated through gesture, prosody, a change in facial expression or any other communicative modality.

Language use is based on common ground

Finally, communication in a real-world setting allows interlocutors to rely on context (Clark, 1996). Defining context is a difficult task, because the concept is broad and all-encompassing (Meteyard & Vigliocco, 2018). Clark (1996) refers to context for situated language use as common ground: the set of shared knowledge, beliefs and assumptions that exists between two speakers. Common ground is based on the idea that for people to be able to communicate, they have to understand each other: only when both speakers implicitly or explicitly agree that they understand each other, this knowledge becomes part of their shared common ground and conversation can continue. When two interlocutors do not understand each other, conversation breaks down, or is shifted to a different topic. For example, if one speaker says "my dogs", both interlocutors have to make sure they share the belief that this refers to the speaker's feet, rather than his pets, for conversation to be successful (Clark & Brennan, 1991). If the listener has not understood, both parties have to work together to make sure sufficient mutual understanding is achieved to continue the conversation, i.e. more *grounding* is required. According to Clark (1996), everything that is understood by two interlocutors engaged in conversation is part of their common ground. Common ground can be established on the basis of (a combination of) either of these options:

Pre-existing

1. Communal common ground: Communal common ground refers to shared beliefs and knowledge based on a shared nationality or religion. Customs that are specific to a certain country or culture, will be shared and readily understood between people from that culture.
2. Personal common ground: Personal common ground reflects the number of shared experiences two participants have had together, also referred to as the level of acquaintedness or familiarity.

Discourse representation

1. Situational context: The situational context includes what is physically present in the perceptual environment.
2. Communicative context: The communicative context is an accumulation of what has been referred to earlier in conversation (through any modality).

As described by Kronmüller and Barr (2015), the reference *small candle* can be understood as referring to a particular candle because of (1) the candles physically present, one is smaller than the others (situational context), (2) a candle was previously spoken about during the same conversation (communicative context) or (3) the interlocutors have a shared personal experience or are members of a community in which the particular small candle is well-known (personal or communal common ground). There can be a degree of shared knowledge that exists even before two interlocutors start their conversation, i.e. a degree of pre-existing common ground. As two interlocutors start a conversation, common ground will accumulate from the discourse itself. Interlocutors keep track of the situation that they are speaking about, including the "participants, time, place, and pertinent surroundings" (Clark, 1996, pg. 53; Zwaan, 2014, 2016; Zwaan and Kaschak, 2008).

A key premise is that whatever is part of common ground will require less effort (time and/or energy) to refer to during communication (Boyle et al., 1994; Clark, 1996; Horton & Gerrig, 2005; Smith et al., 2005; Zwaan, 2016). This means that the more common ground two interlocutors share, the easier it becomes to communicate. In some cases, the existence of more common ground can allow the interlocutors to rely less on (complex) linguistic processing for the exchange of information and arguably, more common ground should result in less cognitive effort during communication (i.e. refer to 'small candle' instead of 'the small candle we saw in the shop last weekend that I had wanted to buy'). With sufficient common ground, speakers can thus rely on the 'givenness' of information in dialogue and produce shorter, less informative and less 'complete' utterances (Bard et al., 2014). Listeners, in turn, can rely on context to restrict the number of possible interpretations for those utterances (in the context of a discussion about the purchase of a new pair of candles, 'small candle' does not refer to any possible candle, but to the small candle who both speakers know they considered purchasing last weekend Skipper, 2014).

A review of the literature on situated language use

Clearly, language use in everyday life is a complex, multi-faceted, dynamic phenomenon. The framework provided by Clark (1996) provides us with parameters to guide our discussion of this topic. The framework is not new, nor are many of the ideas included in the framework. The use of such a comprehensive definition of communication is, however, new to aphasia rehabilitation. Over the past decades, much research has been done on communication with healthy adults in the fields of communication science, psychology, neuroscience, psycholinguistics and sociology. This research provides important clues on how interactivity, multimodality and common ground influence a person's ability to use language in a real world setting, including internal factors (i.e. cognitive skills) and the external (environmental) factors that are likely to be important, in addition to having a particular set of linguistic skills. To get a better understanding of the complexity and variety of processes that occur during communication, we will review the literature on the effect of each component on communication. In order to get a sense of the amount of work that has been completed, as well as where the gaps in knowledge are, we will summarise what we know from research with healthy adults as well as with PWA separately.

Due to the multitude of different topics covered in this theoretical, narrative review, a more restricted systematic approach was not possible. Instead, guided by Clark (1996) the authors searched databases for highly cited papers as well as the most recent, existing review articles on each topic. Based on the database searches and reference lists of the papers found, a collection of important findings relevant for the current discussion were summarised.

Language use is interactive

Neurologically healthy controls (NHC)

Research with NHC shows that having the chance to interact with a conversation partner greatly improves communicative efficiency (Clark & Krych, 2004), compared to language performance of a single individual on a similar task. This is due to the availability of feedback and the co-ordination of actions between two interlocutors. Studies have shown that interlocutors help each other in creating meaning and dialogue by providing each other with feedback (Brunner, 1979; Clark & Brennan, 1991; Clark & Krych, 2004; Schegloff, 1982). Listeners can provide immediate feedback on the message by providing so-called 'back channels', 'minimal turns' or 'continuers', i.e. signals such as 'uh huh', 'right', 'okay', nods, smiles or frowns (through any modality, as discussed in the next section), to indicate attentiveness and involvement, comprehensibility of the message and the listener's personal response to the content (Brunner, 1979; Clark & Brennan, 1991; Clark & Krych, 2004; Schegloff, 1982). Speakers have been shown to monitor their listeners for back channels and adjust their messages depending on the type of feedback they observe, for example the need for repair or elaboration of the message (Clark & Krych, 2004; Tolins & Fox Tree, 2014). Back channels have been shown to influence the content of speaker dialogues: different types of back channels can lead to significantly different ways in which a story is told, while the absence of certain back channels can result in less climactic endings to stories, qualitatively worse story content and modulation of abstract language use (Bavelas et al., 2000; Beukeboom, 2009; Norrick, 2010; Tolins & Fox Tree, 2014). The use of feedback from a conversation partner is a form of monitoring during conversation. In addition to keeping track of what is said, it requires having the flexibility to reflect on whether or not your conversation partner understands what you are saying.

Another form of monitoring happens through monitoring one's own speech output and understanding, without external prompting (Postma, 2000), also referred to as self-monitoring. Self-monitoring occurs frequently in NHC: more than 50% of errors in spontaneous speech are corrected by the speaker (Nooteboom, 1980, 2005). Theories of speech monitoring have found support for an external model of monitoring (i.e. listening to one's own speech), as well as for an internal model of monitoring (i.e. an internal representation of speech before it is articulated, Hartsuiker and Kolk, 2001; Huettig and Hartsuiker, 2010; Levelt, 1989; Nozari et al., 2011; Postma, 2000). Often, picture-naming or picture-description tasks are used to elicit errors and to observe self-monitoring behaviour. To the knowledge of the authors, no research has been done on self-monitoring during real-world communication, or how this is influenced by the presence of a conversation partner, for example.

The presence of another person necessarily brings new dynamics and variables into the mix of the communication process compared to when an individual attempt to communicate something in isolation. The influence of knowledge, beliefs and experiences that are shared between interlocutors will be discussed in section Communal and personal common ground.

PWA

Most of the research on interactive aspects of communication in aphasia have focused on (1) the shared responsibility in communicating when conversation breaks down and (2) the influence of the communication partner on the communicative competence of the PWA.

The shared responsibility of constructing conversation between interlocutors has received a lot of attention in the aphasia literature (Goodwin, 1981, 1995; Milroy & Perkins, 1992; Simmons-Mackie et al., 2014). A large body of research has focused on conversational repair, i.e. how problems or breakdowns in conversation are dealt with by the PWA and their conversation partner (Lindsay & Wilkinson, 1999; Milroy & Perkins, 1992; Schegloff, 1982). Often, this is done by analysing turn-taking patterns during conversation which, according to Conversation Analysis (CA) principles, can reveal how people understand and respond to each other during interaction (Beeke et al., 2007; Sacks et al., 1974; Schegloff, 1982). Through this approach, research has shown that repairs in conversation are often different for PWA compared to NHC. Conversational repairs can take longer for PWA and their conversation partners, and they rely more often on collaborative repair rather than on the efforts of a single interlocutor (Beeke, 2012; Lubinski et al., 1980; Milroy & Perkins, 1992). As such, the interactive component of face-to-face communication means that PWA can rely on the conversation partner in the co-construction of dialogue and meaning in communication when the PWA experiences problems in conversation (Beeke et al., 2007; Booth & Perkins, 1999; Lindsay & Wilkinson, 1999; Oelschlaeger & Damico, 1998). For example, research has shown that conversation partners help the PWA in completing conversational turns when word finding difficulties occur (Bloch & Beeke, 2008; Oelschlaeger & Damico, 1998), and in repairing turns when the PWA experiences a communication breakdown more generally (Lindsay & Wilkinson, 1999; Perkins, 1995; Samuelsson & Hyde, 2016). More generally speaking, this means that for some PWA, the presence of their communicative difficulties mean more of the conversational burden (i.e. efforts to achieve successful communication) lies with their conversation partner, compared to NHC (Linebaugh et al., 2006). In their study, Linebaugh, Kryzer, Oden and Myers (2006) showed that the degree of shift in conversational burden to the conversation partner was negatively related to the degree of impairment of functional communicative abilities (as measured on the CADL, Holland, 1980).

A lot of research has focused on how a conversation partner can facilitate or inhibit communication for PWA. The response to breakdowns in conversation vary across conversation partners, while PWA show different patterns of conversational repair depending on who they are conversing with. This difference has been shown across types of conversation partners, such as SLTs and PWA's spouses (Laakso, 2014b; Lindsay & Wilkinson, 1999; Perkins, 1995). The difference between these two groups of conversation partners has often been explained by the 'institutional' nature of conversation with the SLT, while conversation with a spouse is more 'peer'-like in nature. Some research suggests that individual characteristics of the conversation partner, such as their executive function skills, influence their ability to provide communicative support for the PWA (Eriksson et al., 2016). In addition, differences in the amount of shared knowledge and individual discourse styles have also been proposed as possible explanatory factors (Ferguson, 1994, 1998; Green, 1982; Howe et al., 2008; Laakso & Godt, 2016; Perkins, 1995; Wirz et al., 1990). Research on the influence of speaker familiarity on communication will be discussed in section Communal and personal common ground.

A larger body of research has shown that expanding the conversation partner's knowledge of aphasia and training them to use communication strategies can improve overall communication with PWA (Cruice et al., 2018; Howe et al., 2008; Kagan et al., 2001; Lesser & Algar, 1995; Lindsay & Wilkinson, 1999; Nykanen et al., 2013; Pound et al., 2000; Rayner & Marshall, 2003; Simmons-Mackie et al., 2010; Wilkinson & Wielaert, 2012). Most of these studies are based on the idea that communication strategies employed by the non-aphasic conversation partner can create an environment that enables the PWA to communicate optimally, i.e. that changes in the conversation partner's behaviour can reveal the PWA's communicative competence (Kagan et al., 2001; Turner & Whitworth, 2006). Indeed, these studies show changes in the PWA's degree of participation in conversation (Kagan et al., 2001; Wilkinson et al., 2010). Based on these findings, a number of therapies have been developed with the intention of improving the conversation partner's skills to maximally facilitate conversation and to reveal the PWA's communicative competence (Kagan et al., 2001; Simmons-Mackie et al., 2010). A slightly different approach has emphasized the collaborative aspect of conversation and the importance of training both the conversation partner and the PWA to use communicative strategies (Beckley et al., 2017; Lock et al., 2001; Nykanen et al., 2013; Simmons-Mackie et al., 2010; Wilkinson et al., 2010; Wilkinson & Wielaert, 2012). These studies have provided support for the idea that therapy can be used to directly influence communication between the PWA and their conversation partners.

Much of the research above focuses on the role of the conversation partner during conversation. Very little research has explored the communicative skills of the PWA in an interactive setting, such as the use of feedback and back channels. If NHC have been shown to adapt their output during conversation in response to feedback from their conversation partners, how does feedback influence communication for PWA? Can PWA use this feedback to their advantage? Can they change their output to improve comprehension of their conversation partners? Do PWA provide their conversation partners with clear feedback on their own level of understanding? A few studies have looked at the types of explicit feedback provided by SLTs during intervention, such as direct or delayed comments on the effective use of communicative strategies such as drawing or writing (Beckley et al., 2017; Horton, 2008; Simmons-Mackie et al., 1999). This is often unnatural, therapeutic feedback, which is not relevant for the discussion of spontaneous communication in everyday life. In a large study on communication skills in conversation in patients with left and right hemisphere strokes (the presence of aphasia is not specified; Rousseaux et al., 2010) report a relative preservation of the ability of people with a left hemisphere stroke to attend to their interlocutor for engagement in the conversation and to manage nonverbal feedback from their conversation partner. Producing feedback was also found to be preserved, which suggests that these subjects "were still able to use it to partially encompass their difficulties in understanding the interlocutor" (Rousseaux et al., 2010, p. 1105, (Perkins, 1995)) reported on three PWA who used 'minimal turns' such as "mm hm' effectively to contribute to the conversation without taking on elaborate turns that require the use of more complex linguistic resources. Furthermore, Walker, Thomson and Watt (2016) reported on the production of back channels by PWA to display different levels of understanding in conversations with their SLT, such as the production of 'oh' at the beginning of an utterance. Subtle differences were found between back channels produced by the PWA that indicated *claims* of understanding, or the more definite *displays* of understanding. SLTs were shown to be sensitive to these differences and respond with elaborations to *claims*, while affirmations or changes of topic followed the more definite *displays* of understanding (Walker et al., 2016). The feedback provided by the PWA thus influenced the course of conversation and helped to ensure mutual understanding. These studies suggest that the use of minimal turns can be preserved in PWA and can be used by PWA to maintain a natural pattern of turn exchanges during conversation, despite the difficulty in producing linguistic content (Simmons-mackie & Damico, 1997). Larger studies on the use of feedback by PWA in conversation are, however, still lacking.

One study showed that the use of feedback such as back channels can be explicitly trained during conversation therapy for dyads. Beeke, Maxim, Best and Cooper (2011) report on a therapy in which the PWA was successfully trained to signal verbally (e.g. "um" or "erm") and non-verbally (e.g. grimacing, raising eyebrows) that he was still actively working on his turn. Normally, the PWA would frequently leave long pauses during which it was unclear whether he intended to continue his turn or not. Findings such as these underline the important role of feedback in communication and show that the use and understanding of feedback during communication can be affected (directly or indirectly) by the presence of aphasia. Furthermore, the provision of feedback can, to some degree, be trained through therapy. More research is needed, however, to explore whether PWA use and can benefit from these interactive components of communication, in both production and comprehension.

Research suggests that generally speaking, self-monitoring is difficult for PWA (Oomen et al., 2001; Schlenck et al., 1987), though there are differences across aphasia types. Most studies have reported on a lack of self-monitoring and lack of error awareness in participants with jargon aphasia (Marshall, 2006; Marshall et al., 1998; Sampson & Faroqi-Shah, 2011). Less research has been done on self-monitoring in participants with non-fluent aphasia (Oomen et al., 2001). For both types of aphasia, the underlying process and impairment of self-monitoring remains unclear, though different hypotheses have been discussed relating to self-monitoring in the comprehension and/or production processes (Hartsuiker & Kolk, 2001; Huettig & Hartsuiker, 2010; Levelt, 1989; Nozari et al., 2011; Postma, 2000). Often, picture-naming or picture-description tasks are used to elicit errors and to observe self-monitoring behaviour. To the knowledge of the authors, no research has been done on self-monitoring during face-to-face communication. Self-correcting one's errors during conversation, i.e. self-repairs, can be seen as a form of self-monitoring. Repairs in conversation have been studied as a way of understanding where 'troubles' in conversation for PWA come from and how these are resolved by the interlocutors, as discussed above (Beeke, 2012). Often, these studies are conducted with smaller numbers of PWA (partly due to the time-consuming nature of the CA methodology). Larger studies that assess the initiation of repairs by PWA as a form of self-monitoring in aphasia are still lacking.

Language use is multimodal

In the clinical and academic setting it is generally accepted that PWA can use other modalities such as gesture, facial expressions, body posture, body movement and prosody in addition to the impaired verbal modality to achieve successful communication (Geigenberger & Ziegler, 2001; Goodwin, 1995; Laakso, 2014a; Rose, Raymer, et al., 2013; van Nispen et al., 2017). Interestingly, however, a large number of studies that attempt to capture functional communication do not systematically consider *all* these modalities. Very few studies have actually considered the interplay of all modalities that are said to be involved in communication. Instead, separate fields of research have evolved, each focusing on the use of a specific channel such as gesture or facial expressions. A brief overview of the relevant research on each modality and its function in communication in NHC and PWA will be discussed here.

Gesture

NHC

The field of gesture in NHC is abundant, and a thorough review of the literature is beyond the scope of this article (for a review, see Hostetter, 2011; Kendon, 1994). Of interest for the current discussion is the role of gesture in multimodal communication, i.e. how much information is transmitted through the gesture modality in communication. Generally speaking, research has shown that gesture, in the presence of speech, has a communicative function (Hostetter, 2011; Kendon, 2004). Indeed, in some contexts, the manual modality has been shown to carry 50-70% of the information of the overall message (Chovil, 1991-1992). Comprehension of a message is facilitated and improved when gesture and speech are presented together (Holler et al., 2017; Holler & Wilkin, 2009; Kelly et al., 2015; Kelly et al., 2010). This has even been shown in a more naturalistic face-to-face communicative setting (Holler et al., 2009). According to the integrated systems hypothesis, the integration of information from both modalities happens automatically (Kelly et al., 2015; Kelly et al., 2010). How much interlocutors rely on gesture to produce or comprehend a message, however, depends on a number of factors such as the type and complexity of information that is communicated (concrete or abstract, i.e. how easy or difficult it is to convey information in gesture) and whether the information is already present in speech or not (Hostetter, 2011). In addition, the assumption is often made that language proficiency, i.e. the degree to which a person can express or comprehend the entire message by relying solely on the verbal channel, also influences how much gesture is relied on in communication. When language skills are non-optimal, such as in non-native speakers, in children and in populations with language problems due to neurological or developmental impairments, it is often assumed that gesture can (partly) compensate for the loss in verbal abilities. A number of studies suggest that children's comprehension and learning of complex concepts is better when gestures are combined with speech compared to presenting them with just verbal information (Ping & Goldin-Meadow, 2008; Singer & Goldin-Meadow, 2005; Wakefield et al., 2018). Veinott, Olson, Olson and Fu (1999) showed that non-native speakers who could not use their language channel optimally due to a lack of proficiency, benefited from the use of other communicative channels in communication, such as gesture, to supplement their comprehension.

PWA

There is a growing body of research on gesture in aphasia (for a review, see Rose, 2006; Rose, Raymer, et al., 2013). Most of the research on gesture has focused on non-fluent aphasia, with a smaller number of studies that have evaluated gesture in those with fluent aphasia (for example, see Carlomagno et al., 2013). Overall, research has shown that PWA produce gesture in communication. Some research suggests that PWA produce more gestures compared to non-brain damaged controls (Carlomagno et al., 2005; Rousseaux et al., 2010; Sekine & Rose, 2013) but that they differ in the types of gestures they produce in spontaneous speech (Sekine & Rose, 2013; van Nispen et al., 2016). PWA with a relatively intact conceptual system, as typically seen in non-fluent aphasia, were found to produce more meaningful gestures (Sekine & Rose, 2013), whereas those with a more fluent aphasia used more abstract and unspecified gestures (Cicone et al., 1979; Sekine & Rose, 2013). PWA with less severe linguistic impairments, such as in anomic aphasia, produced the types of gestures that were comparable to controls. Keeping in mind that the number of studies is small, a number of researchers have, based on findings such as these, proposed that gesture and language rely on the same underlying system and break down together in aphasia (for a brief discussion, see Cicone et al., 1979; Hogrefe et al., 2012).

In addition to looking at gesture production as such, researchers have also looked at the communicative effectiveness of gesture in aphasia. These studies show that gestures can add communicative value to the message conveyed by PWA in speech (de Beer et al., 2017; Hermann et al., 1989; Hogrefe et al., 2013; Mol et al., 2013; Rose et al., 2017). One study showed that on average, between 22% - 92% of gestures produced by PWA were essential for understanding their message, as compared to 5% for controls (van Nispen et al., 2017). These essential gestures conveyed information in the absence of speech, added information that was missing in speech or helped clarify information presented in speech (Dipper et al., 2015; van Nispen et al., 2017). These findings would argue against the simultaneous breakdown of gesture and language, as gesture compensates for loss of meaning in the linguistic channel. Therapy studies have shown that the use and/or comprehension of gesture can improve after gesture-training (Daumüller & Goldenberg, 2010; Marshall et al., 2012; Marshall et al., 2013; Roper et al., 2016), with effects shown on communication measures (Caute et al., 2013). Many of the studies on gesture production employ decontextualized gesture elicitation methods that lack the interactive, co-constructive nature of face-to-face communication. As different communicative situations may elicit different gesture behaviours (Hogrefe et al., 2012), it remains unclear whether the abovementioned results can be generalised to face-to-face communication. Rose, Mok and Sekine (2017) suggested that the lack of ecological validity in these studies might underestimate the communicative effectiveness of gesture in aphasic speech. Their study of spontaneously produced pantomime gestures in conversational discourse showed that speech and gesture combined had a strong communicative effect in aphasia (Rose et al., 2017). In a semi-structured conversational setting, even PWA with severe aphasia were shown to compensate for their verbal impairment by producing meaning-laden gestures (Hermann et al., 1989; Rose & Douglas, 2003). The same was found in a smaller study of spontaneous conversation between subjects with severe aphasia and a friend (Hermann et al., 1988). Importantly, a number of studies have suggested gesture production can be influenced by two factors that frequently co-occur with aphasia: the presence of limb apraxia and impaired semantic processing (Cocks et al., 2013; Fucetola et al., 2006; Hogrefe et al., 2012; van Nispen et al., 2016). Overall, it seems gesture plays an important role in communication in aphasia. It remains largely unknown, however, how gesture contributes to the comprehensibility of the PWA in face-to-face communication, and how gesture interacts with the language component in conversation (de Beer et al., 2017; Rose, 2006).

Much less research has been done on gesture comprehension in aphasia. A number of studies have suggested that gesture comprehension is impaired in aphasia (Gianotti & Lemmo, 1976; Rousseaux et al., 2010), and that comprehension difficulties are more frequent in PWA with semantic processing difficulties and PWA with posterior lesions compared to anterior lesions (Cocks et al., 2009; Daniloff et al., 1986; Ferro et al., 1980; Gianotti & Lemmo, 1976). Non-fluent aphasia, in turn, has been related to normal gesture comprehension (Rose, 2006). As in production, gesture comprehension is also said to be affected by the presence of limb apraxia (Eggenberger et al., 2016).

A few small studies have assessed the added value of observing multiple channels (gesture and speech, for example) in comprehension. Results have shown that adding gesture to speech can lead to improvements in comprehension in aphasia (Cocks et al., 2009; Eggenberger et al., 2016; Yorkston et al., 1979). Interestingly, it is still unclear whether PWA benefit from the presentation of multiple modalities by integrating the available information (multimodal gain; Eggenberger et al., 2016; Yorkston et al., 1979), or by relying on a single, possibly less impaired modality such as gesture (Cocks et al., 2018; Cocks et al., 2009). Records (1994), for example, showed that as ambiguity increased in speech, PWA relied more heavily on gesture (pointing behaviour) to construe meaning. Cocks et al. (2018) and Cocks et al. (2009) hypothesized that the lack of multimodal gain observed in their study could be caused by an impaired allocation or reduced availability of attentional resources, which prevents PWA from processing all the available information. When gesture and speech provide congruent information, however, it seems possible for gesture to contribute to improved comprehension in communication in aphasia, either by contributing to a multimodal message or by offering an alternative channel to rely on in communication. The methodological limitations of the studies that have been done currently make it difficult to generalize findings to communication. It therefore remains unknown how gestures produced by the conversation partner during communication contribute to comprehension of the PWA, as well as to the overall efficiency of the interaction.

Face and eye movements

NHC

In NHC, it has been shown that people monitor each other's faces closely during conversation. Interlocutors gather information from facial movements (Bavelas & Chovil, 2000; Clark, 1996; Ekman, 1979, 1997), eye gaze (Goodwin, 1981; Hanna & Brennan, 2007; Kendon, 1967) lip movements (McGurk & MacDonald, 1976) and eyebrow movements (Flecha-García, 2010) to inform communication. Much research has been done on facial expressions and how they convey an underlying emotional state of a person (Parkinson, 2005). In interaction, facial expressions or facial movements can serve a communicative function on their own, or in combination with other signals such as speech (Chovil, 1997; Frith, 2009). It is assumed that facial expression can be used to communicate efficiently on a wide variety of topics, including emotions (Chovil, 1997), and to indicate levels of speaker certainty (Dijkstra et al., 2013; Swerts & Krahmer, 2005). Facial expressions can be used for linguistic purposes such as marking emphasis (Birdwhistell, 1970), indicating understanding, dislike, confusion and disbelief or difficulty in recalling an event (Chovil, 1991-1992; Ekman, 1979). Eyebrow movements have been related to structuring and emphasising information in a verbal message (Ekman, 1979; Flecha-García, 2010). Smiles, along with nods and verbal expressions such as 'yeah', have been shown to function as back channels to indicate continued attention and involvement in conversation, to signal the listener's level of understanding and level of agreement (Brunner, 1979). Many of these facial movements are argued to only be interpretable in their conversational context, and not stand on their own necessarily (Chovil, 1997). Furthermore, research has shown that gaze plays an important role in coordinating face-to-face communication (Bavelas et al., 2002; Hanna & Brennan, 2007; Kendon, 1967), for example by regulating turn exchanges (Bavelas et al., 2002; Goodwin, 1981; Kendon, 1967). Gaze can also be relied upon as an indication of continued attention and the direction of attention (Argyle & Cook, 1976; Emery, 2000; Goodwin, 1981; Itier & Batty, 2009). Speakers use gaze to monitor listeners' understanding (Kendon, 1967), to seek and elicit a response and feedback (Bavelas et al., 2002; Rossano, 2013), to resolve temporal ambiguity in conversation (Hanna & Brennan, 2007), to emphasize or reinforce a verbal message and to monitor conversation for possible difficulties (Emery, 2000). Gaze has been shown to combine with other cues (for example with speech and other signals from the face) in complex ways to create a composite message (Argyle & Cook, 1976). Visual cues from lip movements have been shown to help listeners anticipate what auditory information is coming, such as in the case of auditory and visual incongruencies (McGurk & MacDonald, 1976), or when there is noise on the auditory signal (e.g. Jordan and Sergeant, 2000).

A different line of research has assessed the effect of visibility of the conversation partner's face on the efficiency of communication. Rather than focusing on specific elements of the face, these projects assess the effect of being able to see the face of the other speaker compared to not being able to see the face at all, thus exploring the combined effect of the above-mentioned elements. A number of studies have shown that efficiency on a collaborative task is heightened when the interlocutors can use the visual channel in communication (Boyle et al., 1994). Efficiency was measured by the total time and the number of turns it took to complete the task. Overall performance was not affected in this study, meaning that subjects could still complete the task successfully without the use of the visual channel, but it took them longer and it required more turn exchanges between the interlocutors. The reliance on signals from the conversation partner's face seems to depend on the task at hand: Lysander and Horton (2012) and Clark and Krych (2004) found no facilitative effect of mutual visibility on their collaborative card-matching and lego-building tasks, respectively. Instead, efficiency depended on having a shared view of the task-relevant materials, of the objects both interlocutors were referring to (i.e. when it affected common ground, see section Common ground). Lysander and Horton (2012) argued that the lack of effect of mutual visibility on task efficiency was likely to have been caused by the need to attend to the stimuli. In addition, it seemed the NHC in their study were able to solve communicative difficulties through other modalities, such as the verbal one. These NHC might not have needed the additional information from another modality to understand their interlocutor. In short, during communication, a lot of information can be conveyed through the face, independently or combined with other modalities such as gesture and language.

PWA

In aphasia, much less research has been done on the influence of face and eye movements in conversation. In production, PWA have been shown to use facial movements in interaction to show emotions (Laakso, 2014a) and to indicate problems in conversation, such as with eyebrow movement, smiling and laughter (Kaukomaa et al., 2014; Laakso, 2014a). Goodwin (1995) provided a detailed description of how a man with severe aphasia used eye gaze to inform his conversation partner of his attentiveness to what was said, as well as to demonstrate his departure from being a listener by diverting his gaze. More generally speaking, PWA with left hemisphere lesions are often assumed to have intact pragmatic abilities in communication, which would include face and eye-movements as described above.

Very little research has looked at the use of visual information from the face by PWA to aid communication. A few studies have suggested that PWA might have difficulty integrating auditory and visual information (Preisig et al., 2015; Schmid & Ziegler, 2006; Youse et al., 2004). This is line with the claim that PWA might not be able to benefit from multimodal gain in their comprehension of gesture (Eggenberger et al., 2016). Preisig et al. (2015) suggested that the impairment of the auditory channel interferes with the integration of that signal with the available visual information. According to Preisig et al. (2015), PWA then rely on the signal that carries the most information (the auditory signal), rather than on the combination of the two. For example, they showed that during co-speech gesture, PWA exhibited similar fixation patterns compared to NHC on the speaker's hands when they were observing natural dyadic conversation. Interestingly, independent of co-speech gesture, PWA showed a reduced fixation on the speaker's face. This could indicate that PWA did not, or could not, compensate for their difficulty in comprehension of verbal information by focusing on visual cues from the face. In their case-study, Youse, Cienkowski and Coelho (2004) showed PWA did not benefit from the bi-modal presentation (visual and auditory), compared to the unimodal condition (auditory), on a speech perception task. This supports the claim that PWA have difficulty integrating information from different modalities. From the literature it remains unclear, again, whether or not PWA rely on visual information from their conversation partner's face to better comprehend their message.

Prosody

NHC

In addition to the content of the verbal message (*what we say*), we can convey information by changing the way in which we say something. Prosody refers to variations in speaking rate, pitch, loudness and voice quality that each play a part in conveying meaning (Hellbernd & Sammler, 2016). In NHC, a large body of research has provided support for the idea that the manner in which we say something can change the meaning of a message at a linguistic and a paralinguistic level (Bolinger, 1986, for reviews, see Cole, 2015; Cutler et al., 1997; Hellbernd and Sammler, 2016; Wagner and Watson, 2010). At a linguistic level, prosody can express semantic relationships, disambiguate syntactic structures (Cutler et al., 1997; Wagner & Watson, 2010), group words into phrases (Wagner & Watson, 2010), signal the relative prominence or importance of a word and by signalling illocutionary force (marking an utterance as a statement, question, etc., Cole, 2015; Eberhard et al., 1995; Wagner and Watson, 2010; Witteman et al., 2011). Paralinguistically, prosody conveys information regarding the emotional state of the speaker (Cole, 2015; Scherer, 1986), as well as speaker certainty, confidence and doubt

(Jiang & Pell, 2017; Swerts & Krahmer, 2005) and speaker attitude and beliefs (Bolinger, 1986; Ladd, 1996). Prosody has also been found to play a role in the managing of interaction, also referred to as conversational prosody, for example by managing turn changes (Ford & Thompson, 1996; Selting, 2005) signalling the end of a turn (Bögels & Torreira, 2015), marking a new topic, expressing agreement with the interlocutor, expressing intentions and facilitating the flow of discourse through pitch variation in backchannels ("mm-hm", "okay", "yeah", Cole, 2015; Hellbernd and Sammler, 2016; Wennerstrom, 2001).

Importantly, prosody is one of many channels of information that are used in face-to-face communication to convey meaning. Prosody interacts with other communicative channels such as facial expressions, smiles, head nods, eyebrow movements and eye gaze to convey meaning (Cole, 2015; Dijkstra et al., 2013; Flecha-García, 2010; Kendon, 1980; McNeill, 1992; Swerts & Krahmer, 2005). Across speakers, there is much variation in the use of prosody, which makes it a less reliable cue for meaning in interaction on its own (Cole, 2015; Hirschberg, 2002). Importantly, however, prosody is used and attended to by interlocutors to improve comprehension and plays a role in the building of meaning of face-to-face communication (Cole, 2015; Hellbernd & Sammler, 2016). Research has shown that to guide turn projection during conversation (i.e. when interlocutors expect a turn to end), adults and children benefit most from having both lexico-syntactic and prosodic information (i.e. multimodal gain). When the two provide contrasting information, lexico-syntactic information has been shown to be weighed more heavily (Lammertink et al., 2015). Based on their research with NHC (children and adults), Lammertink and colleagues (2015) suggest that to fully benefit from prosodic information for turn structure in conversation, some lexico-syntactic information is necessary. This idea is supported by other research (Casillas & Frank, 2017; Männel & Friederici, 2010). Finally, there are cross-cultural differences in the interpretation of and reliance on facial expression and intonational differences in conversation (Crespo Sendra et al., 2013).

PWA

Though prosody is believed to have a communicative function, it remains relatively understudied in aphasia (for a review of the literature, see Geigenberger and Ziegler, 2001). Much research has focused on the hemispheric specialization for different prosodic features (Witteman et al., 2011), where the emphasis is on the difference between right and left hemisphere impairments. Often, these studies do not specify whether or not their left-hemisphere impaired subjects include those with a diagnosis of aphasia or not. In the aphasiology literature, more research has been done on the role of prosody in production than on comprehension. Even less work has been done on the contribution of prosody to comprehension in conversation. A number of studies has attempted to describe the different characteristics of prosody in the production of people with fluent and non-fluent aphasia. Generally speaking, some aspects of prosody (different across aphasia types) have been shown to be relatively intact. Aspects such as fundamental frequency (F0) and timing in prosody have been shown to deviate compared to NHC (Beeke et al., 2009; Danly et al., 1983; Danly & Shapiro, 1982; Rhys et al., 2013; Seddoh, 2000). The question that is most relevant for the current discussion is not necessarily how prosody is different from healthy controls, but how much prosody contributes to the communicative effectiveness in aphasia, in both comprehension and production. At the moment, the answer to this question is unclear. Different approaches have been used in the literature to attempt to answer this question. Walker, Joseph and Goodman (2009) showed that PWA produced prosodic structures that were different from those produced by controls on a word and sentence production task. Crucially, identifying the intended meaning in those utterances by naive listeners was more challenging on the items produced by PWA compared to those produced by controls. A number of studies have reported on the compensatory use of prosody by PWA in communication. By combining the limited verbal output, ranging from a few words to lexically empty syllables, with variations in pitch and volume, non-fluent PWA have been shown to convey meaning. Examples are signalling a demand for attention, calling a listener, expressing uncertainty, agreement, enthusiasm or appreciation, managing interaction and turn-taking and finally requesting for something to happen such as for someone to continue or stop guessing, or for the provision of information (Beeke et al., 2007; Beeke et al., 2009; Goodwin, 1995, 2000; Lind, 2007; Oelschlaeger & Damico, 1998; Rhys et al., 2013). Dogil, Hildebrandt and Schürmeier (1990) presented a case study of a PWA with fluent aphasia who compensated for his language impairment by effectively using unimpaired prosodic skills.

A small number of studies have looked at the comprehension of prosody in aphasia. Emotional prosody, for example on a prosody and facial expression matching task, is suggested to be relatively unimpaired in aphasia (Barrett et al., 1999; Geigenberger & Ziegler, 2001; Pell & Baum, 1997; Perlman Lorch et al., 1998), though the opposite has also been reported (Pell, 1998; Pell & Baum, 1997). In contrast, linguistic prosodic processing has been shown to be impaired in aphasia, such as the ability to recognise focus/emphasis on prominent entities in an utterance (Baum, 1998; Geigenberger & Ziegler, 2001) and the ability to indicate whether a sentence is a statement or a question (Pell & Baum, 1997; Perkins et al., 1996; Seddoh, 2006). Pashek and Brookshire, (1982) and Kimelman and Mcneil, (1987) showed that the use of emphatic stress can facilitate comprehension of spoken language for some PWA. Pell and Baum (1997) showed that prosody recognition by PWA was impaired on linguistic stimuli that required the processing of syntactic/semantic as well as prosodic cues simultaneously. The authors argued that it was the processing of multiple linguistic cues which might have been beyond the PWA's cognitive capacity (Pell & Baum, 1997). Importantly, the above-mentioned studies assessed the comprehension of prosodic structures in aphasia in a decontextualized, non-interactive setting. How prosody is processed during everyday communication is not yet clear. A different approach to assess the role of prosody in comprehension was taken by researchers who studied eye-movements of PWA, who in turn observed spontaneous, dyadic conversations. Healthy controls were shown to shift their eye-gaze in anticipation of a change in turn, which is commonly predicted by lexico-syntactic information and prosody. As lexico-syntactic information increased healthy controls were shown to benefit more from variance in intonation in predicting upcoming turns. PWA did not show this reliance on intonation cues (Preisig et al., 2016), suggesting that perhaps PWA cannot rely on the linguistic prosody or are unable to integrate information from the two modalities. In conclusion, there is some support for the idea that PWA can utilise prosody in production to communicate effectively, though most of the support for this claim relies on observational research with non-fluent PWA. If and how fluent PWA use prosody to communicate effectively remains unclear. Whether or not PWA can use prosody to support comprehension in conversation, is also unclear. The findings so far indicate that the interpretation of multiple signals might be more difficult for PWA, which could suggest that PWA might not benefit from the presence of prosodic information in conversation. More research will have to be done to draw stronger conclusions.

Although the use of a number of different modalities has been studied in aphasia, these studies are limited in their generalisability to face-to-face communication because they have been studied in isolation from other modalities in a non-interactive setting. Systematic analyses of the advantage of communicating through multiple channels, verbal and non-verbal, should be done in an interactive setting to better understand how multimodal communication is affected in PWA.

Common ground

Research with NHC shows that interlocutors use what has been said (communicative context), what is physically present (situational context) and what is part of shared experiences (personal and communal common ground) to guide how they produce and understand language during conversation, for example by using more detailed descriptions when speaking to another person who doesn't share a particular piece of knowledge (Brown-Schmidt & Hanna, 2011; Brown-Schmidt et al., 2015; Hanna et al., 2003; Heller et al., 2012; Schober & Brennan, 2003). There is ongoing debate regarding the cognitive mechanisms that underpin common ground during communication, i.e. whether there is active tracking of what is part of shared knowledge between two speakers, or whether the interpretation of references are made based on domain-general systems such as memory, with a limited role for a perspective-based interpretations when needed (Kronmüller & Barr, 2015). For clarity, research on each type of common ground will be discussed separately below.

Communal and personal common ground

NHC

The effect of having shared past experiences, beliefs and knowledge with another interlocutor (i.e. communal or personal common ground) on face-to-face communication shows that when people have more common ground, this can indeed lead to more efficient communication. Research with NHC has shown that familiar interlocutors use more abbreviated and informal language compared to unfamiliar pairs, relying on shared knowledge and experience during communication (Clark, 1996; Herrmann, 1983b; Hornstein, 1985). In line with this, unfamiliar conversation partners have been shown to use more gestures compared to familiar conversation partners (Kistner, 2017), possibly reflecting the tendency to be more explicit and elaborate to avoid misunderstandings with an unfamiliar conversation partner. On the other hand, familiar conversation partners have been shown to initiate more topics, ask more questions and provide more minimal turns during conversation compared to strangers (Boyle et al., 1994; Hornstein, 1985). During a collaborative task, Boyle, Anderson and Newlands (1994) showed that despite the increase in number of turns and words, familiar pairs showed more 'efficient' communication with fewer interruptions and overlaps in speech. Higher levels of instructor gaze indicated better interpretation of auditory/verbal, visual and paralinguistic cues from familiar partners compared to unfamiliar interlocutors, due to the existing shared experiences, knowledge and beliefs (Herrmann, 1983a).

PWA

Although it remains largely unknown *how* familiarity of the conversation partner affects communicative efficiency of the PWA, it is generally believed that it does affect communication for PWA (Ferguson, 1994, 1998; Green, 1982; Howe et al., 2008; Laakso & Godt, 2016; Perkins, 1995; Wirz et al., 1990). Questionnaires on communication often distinguish between familiar and unfamiliar conversation partners (e.g. the disability questionnaire of the Comprehensive Aphasia Test, Howard et al., 2004). Interestingly, a recent study with a small sample of PWA (most with mild anomic aphasia) showed no significant differences on linguistic characteristics such as sentence production (sentence frame and relevance of the lexical items in the sentence frame) and morphological and verb tense/mood errors, nor in the overall judgement of communicative success in natural conversation with a familiar conversation partner and with an unfamiliar SLT, suggesting that some elements of conversation can remain stable across different conversation partners (Leaman & Edmonds, 2019). Kistner (2017) showed that NHC and PWA used more gestures when speaking to an unfamiliar conversation partner compared to a familiar speaker. This might reflect the fact that when speaking to an unfamiliar person, one cannot rely on implicit, abbreviated and informal language and thus more elaborate, explicit language and gestures are used.

Communicative context

NHC

Speakers and listeners rely on the communicative context, i.e. what has already been said or communicated during conversation, to guide their own production and comprehension during interaction. For example, the production of certain words and sentences by one interlocutor, can influence the selection of words and sentence constructions by the other. Speakers tend to express themselves in similar ways at the lexical, semantic and syntactic level (Branigan et al., 2000). Priming studies have shown that speakers implicitly tend to produce sentences and lexical items that are similar to those produced by their conversation partner (Bock et al., 2007; Branigan et al., 2000; Mahowald et al., 2016). When participants work on a collaborative task they converge on specific descriptions (e.g. describing a maze as paths between two points or as rows and columns, Branigan et al., 2000) and lexical expressions that refer to particular stimuli (e.g. 'the ice skater' for a specific abstract tangram figure, Clark and Wilkes-Gibbs, 1986). NHC have also been shown to flexibly and successfully rephrase and restate talk of others or themselves during conversation, referred to as reported speech (Hengst et al., 2005; Myers, 1999). This makes language production computationally less taxing, as the choices for word or sentence structure are "to a considerable extent driven by the context and do not need to be a burden for the speaker" (Pickering and Garrod, 2004, p. 15). When interlocutors work with the same stimuli on a collaborative task, they tend to converge on the same type of referring expressions for which they progressively use fewer words, require fewer turns and provide less content (reference to a tangram figure develops from 'a person who's ice skating, except they're sticking two arms out in front' to 'the person ice skating, with two arms' to 'the ice skater', Brennan and Clark, 1996; Clark and Wilkes-Gibbs, 1986; Fussell and Krauss, 1992; Garrod and Anderson, 1987; Horton and Gerrig, 2005; Isaacs and Clark, 1987; Schober, 1993). The same effect has been found for gestures: gestures became less complex, less informative, less precise, and less elaborate when they were directed at an interlocutor with shared knowledge on the task (Gerwing & Bavelas, 2004; Holler & Stevens, 2007; Mondada, 2007). As the stimuli become part of common ground, it seems interlocutors can exert decreasing effort to refer to the same entities.

Crucially, common ground is constructed uniquely by two conversation partners. When, halfway through the task, one of the partners is replaced, the decrease in number of words, turns and content is reversed, i.e. efficiency decreases (Brennan & Clark, 1996; Schober & Clark, 1989; Wilkes-Gibbs & Clark, 1992). In addition, listeners are slower to respond to the same established reference from a new speaker compared to the same utterance provided by the speaker who established the reference in the first place (Metzing & Brennan, 2003). In fact, the repeated use of the same referring expressions is expected by listeners (Barr & Keysar, 2002; Shintel & Keysar, 2007): they show surprise when speakers change their referring expression (Metzing & Brennan, 2003), or ask questions to ensure the same entity is targeted (Garrod & Anderson, 1987). This is in line with research that shows that listeners build up expectations about what is to come, based on what they have heard so far (Skipper, 2014). Similarly, research has repeatedly shown that the context of a sentence or a gesture restricts the number of possible expected meanings of a word (Kutas & Federmeier, 2011; Skipper, 2014). This effect has also been shown at the level of text and discourse (for a review, see van Berkum, 2009), supporting the idea that the language system integrates word, sentence, discourse and common ground information in the interpretation of language (Barr & Keysar, 2002; Kutas & Federmeier, 2011). Research has shown that the recent discourse history can help subjects resolve temporal ambiguities and allows for the use of shorter references (for a review, see MacDonald et al., 1994).

In short, during face-to-face communication, interlocutors can use the communicative context to minimize the efforts made in production by co-coordinating lexical items and syntactic structures with their conversation partner and by relying on the 'givenness' of information, which allows speakers to use shorter, less complex utterances. Comprehension can also be facilitated by the communicative context, as it restricts the number of possible interpretations of a word or expression and allows listeners to predict what will be communicated next.

PWA

In aphasia, less research has been done on the use of common ground in communication. Though the use of the communicative context in interaction has not been studied extensively, there is evidence to support the idea that PWA benefit from having a communicative context to build their own expressions on and to aid comprehension. Similar to non-brain damaged controls, PWA have shown responsiveness to priming effects at the lexical level: hearing or reading a word can make it easier to produce a semantically related or identical target word in picture naming tasks (Cornelissen et al., 2003; Renvall et al., 2003; Renvall et al., 2007). A similar facilitatory effect resulted from the presence of a semantic-syntactic environment (i.e. "social exclusion" for the word "exclusion") on a word repetition task (McCarthy et al., 2017). The responsiveness to this kind of context has been shown to depend on the nature of the impairment: if the underlying impairment is more phonological in nature, contextual phonological cues will be more beneficial. If the impairment is more semantic in nature, semantic cues (such as "social exclusion" for "exclusion") will have more of a facilitatory effect (Martin et al., 2004; Martin & Laine, 2000). Similar priming effects have also been shown for syntactic structures: PWA were increasingly likely to produce specific syntactic structures after hearing them during a picture description task (Cho-Reyes et al., 2016; Hartsuiker & Kolk, 1998; Rossi, 2015; Saffran & Martin, 1997). In addition, sentence-level intervention based on priming mechanisms have shown to improve picture description sentences in PWA (Lee & Man, 2017; Mack et al., 2017; Weinrich et al., 2001). Finally, in their exploratory study (Pashek & Tompkins, 2002) showed that for both subjects with mild anomic aphasia and NHC the linguistic context facilitated lexical retrieval in connected speech (video narration task) as compared to a confrontation naming task. This suggests that the communicative context may positively influence linguistic processing for PWA. This effect might, however, differ between fluent and non-fluent aphasia syndromes (Williams & Canter, 1982). How the communicative context influences face-to-face communication for PWA remains unclear.

In addition to automatic priming effects, a small number of studies has suggested that reported speech, i.e. the conscious repeating of output from a conversation partner to produce a similar syntactic structure or lexical item, is used by some PWA in everyday interactions (Hengst et al., 2005). Despite the high number of errors and failed attempts to repeat complete utterances, reported speech has been shown to contribute to successful communication in aphasia. In a case study, Oelschaeger and Damico (1998) showed that the explicit repetition of the conversation partner's utterances enabled one PWA to achieve conversational goals (i.e. expressing agreement, uncertainty, etc.) that would otherwise not have been possible due to his very limited spontaneous verbal abilities.

Like NHC, PWA have been shown to use increasingly fewer turns and shorter, more simplified references during a collaborative referencing task with familiar conversation partners (Hengst, 2003; Meuse & Marquardt, 1985). This supports the idea that PWA can rely on common ground and produce increasingly shorter, less complex utterances to refer to 'given' information during interaction. Finally, the presence of a communicative context has also been shown to support comprehension in aphasia: strongly predictive sentence contexts have been shown to facilitate lexical retrieval and production in PWA (Dickey et al., 2014; Love & Webb, 1977; Warren et al., 2016), though this effect is slower compared to non-brain damaged controls. Similarly, PWA showed an N400 effect similar to that of NHC when hearing a semantically unexpected word in a sentence, though this effect is less pronounced and delayed in PWA (Hagoort et al., 1996; Khachatryan et al., 2017; Swaab et al., 1997). PWA were also able to, implicitly, predict upcoming syntactic structures based on the context of the sentence (Hanne, Burchert, De Bleser, et al., 2015; Hanne, Burchert, & Vasishth, 2015). Having a communicative context which limits the number of possible meanings of an utterance can thus alleviate some of the processing demands involved in production and comprehension. It is not known whether PWA can benefit from this type of context during face-to-face communication, especially given the time-pressures of real-world communication and the potential delay in processing observed in the above-mentioned studies. Conversation Analysis on exactly this process has shown that, in a more general sense, PWA use the communicative context (i.e. its *sequential context*) as a resource to construct their turns during conversation and aid their comprehension of what others are communicating (Beeke et al., 2007).

Situational context

NHC

The physical environment, or the referential situation, is used to support production and comprehension during face-to-face communication (Knoeferle & Guerra, 2016). Lysander and Horton (2012) and Clark and Krych (2004) showed that communicative efficiency of their participants depended on the shared view of the task-relevant materials. Overall communication was more efficient when the materials were visually and referentially available to both participants compared to when they were not. In production, research has shown that NHC monitor their surroundings for non-linguistic ambiguity before speaking to ensure their utterance is informative in the current environment (Rabagliati & Robertson, 2017). Speakers thus adapt their expressions during communication based on the visual availability of the objects they are describing to their conversation partners. For example, if only one out of two buckets is visually available to the listener, speakers have been shown to use a less specific description such as 'the bucket', compared to when both objects are visually available to the listener. The utterance then includes more detail to specify, for the listener, which bucket is referred to (i.e. 'the small bucket', Brown-Schmidt and Duff, 2016; Yoon et al., 2012). More support for the reliance on perceptually available information also comes from developmental research and studies of second language (L2) learning. Children have been shown to develop the ability to change their referring expressions on the basis of the availability of information in discourse and perceptual availability of the referents for their conversation partners between the ages of 2 and 4 years old (Matthews et al., 2006; Moll & Tomasello, 2006; Salomo et al., 2011). Furthermore, children and L2 learners have been shown to acquire the ability to use displaced reference (i.e. reference to objects and events not currently present) later than reference to the here-and-now (Sachs, 1983). Research in second language learning has supported the idea that displaced reference is more effortful than speaking of the here-and-now, and that it requires increased linguistic complexity (Gilabert, 2007; Ishikawa, 2007; Robinson, 1995; Robinson & Gilabert, 2007). Indeed, when speaking of the here-and-now, people can point at, touch, exhibit and present physical objects to support communication (Clark, 2005). Indirect evidence comes from research on the processing of concrete and abstract concepts: research has shown that it is easier for NHC to produce and understand concrete concepts compared to abstract concepts (Evans et al., 2012; Paivio, 1991; Roxbury et al., 2014). Though concreteness is not synonymous to visual or physical availability, concrete concepts are more tangible, have a higher imageability (i.e. it is easier to generate a mental image), higher contextual availability (i.e. it is easier to think of environments or contexts in the real world in which the objects could appear) and can be experienced through the senses (seeing, touching, etc.), whereas more abstract concepts are less tangible, have lower imageability, lower contextual availability and are less often experienced through the senses as they often do not have real-world referents (Paivio, 1986; Schwanenflugel et al., 1992). According to Zwaan (2014), information regarding more abstract concepts requires the involvement of more long-term memory processes and increased reliance on linguistic processing, which could be qualified as more effortful to access.

Research has also provided support for the idea that the visual environment can affect and restrict the way (ambiguous) linguistic input is interpreted (Chambers et al., 2002; Eberhard et al., 1995; Huettig et al., 2011; Tanenhaus et al., 1995) and it can help predict what linguistic information is coming up next (Huettig et al., 2011; Skipper, 2014). Memory-impaired subjects with hippocampal amnesia who could not rely on common ground (information stored in memory) to resolve linguistic ambiguities were shown to use visual information to guide behaviour (Rubin et al., 2011). It appears that the presence of referents in the visual environment can aid comprehension by limiting the possible interpretations of the linguistic information, i.e. reducing the computational load during comprehension, as long as an element of what is discussed refers to the visual environment.

PWA

Very little is known on how the situational context influences communication in aphasia. In clinical practice, PWA are trained to compensate for their language loss by, if possible, pointing to objects in the physical environment to support communication. An observational study by Howe, Worrall and Hickson (2008) indicated that the availability of a physical referent in the environment can facilitate communication in real world settings. Visual information in the form of relevant, contextualized photographs, or a tv program showing a specific setting that clearly show situations, places, experiences and people, have been shown to facilitate reading comprehension (Dietz et al., 2013) as well as communication in aphasia (Howe et al., 2008). With the help of such aids, conversations can last longer, more content is exchanged and the total number of exchanges increases (Beukelman et al., 2015; Garrett & Huth, 2002; Ho et al., 2005; Hux et al., 2010; Ulmer et al., 2016). The use of such contextually rich photographs or videos is hypothesized to facilitate communication because it creates a shared communication space that includes content and background information that the PWA can refer to in support of comprehension and expression (Beukelman et al., 2015; Ho et al., 2005; Howe et al., 2008; Hux et al., 2010). The presence of a shared communication space through photographs is comparable to having a referential context during communication, in the sense that not all information has to be retrieved from memory (computational demands are lightened) or to be coded linguistically, because it is visually available (Beukelman et al., 2015; Dietz et al., 2009). Howe, Worrall and Hickson (2008) also suggested that the familiarity of a setting or particular physical environment can influence the ease with which the PWA can rely on this during communication. In line with the literature on non-brain damaged controls, research on aphasia has also shown that it is easier for PWA to process concrete words compared to abstract words (Alyahya et al., 2018; Sandberg & Kiran, 2014). As discussed above, this provides indirect support for the idea that objects that are more likely to have real-world referents (i.e. can be pointed at, drawn, imagined, etc.) are easier to understand and name compared to objects that are less likely to have real-world referents. Needless to say, more research is needed to explore whether PWA can use context (personal, communicative and situational) effectively during functional, real-world communication, whether these processes are affected by aphasia and when the use of the physical environment to support communication is easy and when it is more difficult.

Discussion

Language has traditionally been studied as a decontextualized, linguistic phenomenon. Researchers have, over the past few decades, realized that this traditional approach does not allow us to understand the way language functions when it is used for communication in the real world. This is true for language research in general, as well as for aphasia rehabilitation specifically, where it is essential to measure functioning and intervention outcomes at the level of everyday communication. In light of the central importance of communication for aphasia rehabilitation, it is imperative that a more systematic, theoretically founded approach to the study of everyday language use is applied to the study of aphasia.

In this paper we summarised a framework for situated language use, borrowed from the fields of communication sciences, psychology, linguistics and sociology (see Table 1). Litera-

Components	Definition	Sub-components
Interactive	Joint activity between two people. Actions of one person depend on those of the other	• Feedback / backchannels • Co-construction of dialogue • Familiarity
Multimodal	Multiple interdependent channels of communication are available and integrate into a single composite message. Different channels replace, supplement, complement and emphasize speech.	• Language • Prosody • Gesture • Facial expressions • Body posture
Contextual (relies on common ground)	Common ground provides interlocutors with context that allows them to assume a degree of "givenness" of information, or directly use physical referents during communication. This relieves the communicative burden.	Pre-existing: • Communal common ground • Personal common ground Discourse representation: • Situational context • Communicative context

Table 1. The key components that characterize language in use (based on Clark, 1996).

ture on NHC and PWA was reviewed to illustrate how communication or language use in situ is inherently different from language when studied as a linguistic phenomenon, as language in vacuo. Language in situ is (1) multimodal, (2) interactive and (3) reliant on common ground. A number of conclusions can be drawn from the current review.

Clinical Implications of the current framework

Assessment

The review supports the finding that performance on standardised linguistic tests does not directly translate to tests or assessments of functional communication or communicative competence (Holland, 1982; Marini et al., 2011). There is a breadth of additional skills (monitoring, tracking common ground, producing and comprehending multimodal signals) that are typically not included in standard impairment-based aphasia assessment batteries. As we currently do not have a clear understanding of how performance on different tasks (i.e. picture naming, picture description, spontaneous or semi-structured monologue, etc.) relates to real-world communication, these tasks may be largely uninformative when considering communicative ability in the real world. Current practice for quantifying everyday communication is that a large number of heterogeneous instruments are used (for a review of existing measures, see Doedens and

Meteyard, 2020). The proposed framework allows existing measures of everyday communication in aphasia to be evaluated on how well they capture communication in a comprehensive manner (Doedens & Meteyard, 2020). For the purpose of synthesizing research findings and drawing stronger conclusions regarding therapeutic effectiveness in the future, it is imperative that consensus and consistency in outcome measurement of communication is reached (Wallace et al., 2014), and that theoretically sound measures are used.

Furthermore, attempts to capture someone's communicative ability in a single number are too reductive (Barnes & Bloch, 2018). The framework used here delineates three major components, which in turn can be broken up into different sub-components, that each can independently influence communication. It is likely that, due to the heterogeneity of aphasia symptoms, these components will be differently impaired in each person (Brady et al., 2016) resulting in a different overall communication profile for each PWA. This profile will, in turn, interact differently across various external factors such as different conversation partners, different settings and contexts that may be more or less supportive for communication (Harmon, 2020; Ramsberger & Menn, 2003). Quantifying a person's ability to 'communicate' as a single number will not capture this variability. The aim of measures of communicative ability should be to compile a profile of skills. Note that this is, in a way, similar to how a number of aphasia batteries currently provide scores across different component linguistic skills.

Therapy

The proposed framework suggests that communication requires a balancing act between different abilities, one of which is the processing of linguistic information such as phonology, lexico-semantics and syntax. Processing linguistic information in the dynamic environment of real-world communication is inherently different when compared to working with linguistic materials in an isolated, controlled environment. For some PWA, the lack of generalisation of therapy effects might be due to their inability to apply the newly trained (decontextualized) linguistic skills to the dynamics of real-world communication. In order to re-learn how to walk, it might not be sufficient to solely rely on a rigorous gym protocol to strengthen the leg muscles. For some people, additional training might be required to (re)train the muscles to coordinate their actions to walk, jump, and climb various kinds of stairs and uneven surfaces again. For PWA, the rehabilitation of their communication skills might require training the use of linguistic materials (that have been targeted in impairment-based approaches) in increasingly complex, communication-like and increasingly cognitively demanding settings, such as one-to-one conversation and group therapy, to ensure these skills effectively carry over to real-world communication (Bastiaanse & Prins, 1994).

Exploring ways of incrementally building complexity into the therapeutic setting is part and parcel of many SLTs' daily practice. These kinds of approaches are increasingly being formalised and reported (Breitenstein et al., 2017). Studies on aphasia rehabilitation in group settings, for example, often exemplify such a hierarchical approach towards generalisation of treatment (Elman & Bernstein-Ellis, 1999; Fama et al., 2016; Hoover et al., 2015; Kagan & Simmons-Mackie, 2007; Stahl et al., 2016). Other examples include studies that assess the treatment of one linguistic level (i.e. word retrieval) integrated into the context of a higher linguistic level (i.e. sentence or discourse level) with the aim of facilitating generalisation of therapy effects into everyday communication (Boyle, 2011; Herbert et al., 2003; Murray et al., 2007; Raymer et al., 2006; Webster & Whitworth, 2012). It is rare, however, to find studies that extend the therapeutic intervention to the level of dynamic, interactive, multimodal exchanges as described by the current framework. Most intensive comprehensive aphasia programs (ICAP) combine decontextualized individual and computer treatment with interactive group therapies and functional communication therapy (Breitenstein et al., 2017; Hoover et al., 2017; Rose, Cherney, et al., 2013), thereby including different levels along the decontextualized-contextualised hierarchy. There is an increasing variety of ICAP programs (Rose, Cherney, et al., 2013) defined by their intensity and the targeting of each level of the WHO ICF (impairment, activity, participation, and wellbeing, World Health Organization, 2001). There is a risk that with such approaches we may lose sight of the critical elements of therapy - the therapeutic mechanisms - that produce gains in functional communication. Finally, there are many different 'conversational' therapies that directly target skills at the level of everyday communication. Surprisingly few, however, focus on training conversational skills of the PWA themselves (Simmons-Mackie et al., 2014).

In sum, we already have a rich base of rehabilitation practice to draw upon and expand. Our argument is that, given the importance of functional communication, efforts should be focused on therapies that explicitly incorporate interactive, multimodal and contextually driven therapy protocols. Interactivity means that therapy must involve at least one other person with whom goal driven communicative tasks are taking place. These tasks should mimic or seek to mimic real-world situations in some form. Multimodality means that the therapy employs multiple channels of communication - such as speech, eye-gaze, prosody, gesture, writing or drawing -

in both production and comprehension. Common ground and contextually driven means that there is a shared understanding and goal for communication between the two (or more) interlocutors. It also means that the physical environment is taken into account when conducting a therapy session, either by creating a more naturalistic setting in the clinic room (e.g. the use of physical props such as objects to be discussed or pictures of scenes), or by varying the location in which communicative tasks are taking place. As long as the communicative task takes place between two people and lasts for more than a few exchanges, communicative context will automatically be built. All this may be as simple as playing a simple communication game or as complex as a prolonged conversation on an abstract topic. It is interesting to note that paired or group therapeutic settings will almost immediately meet all the above criteria.

Theoretical Implications of the current framework

The framework breaks down situated language use into different behavioural components. Using this structure, we have reviewed the available evidence, outlining cognitive skills, language processing demands and situational factors that impact everyday communication. We will now summarise key findings and highlight areas that should be fruitful avenues for future research.

Interactivity

When considering the interactive nature of situated language use, there is a substantial and robust evidence base for communication partner training. Communication with PWA can be improved when their conversation partner has an improved knowledge of aphasia and has been trained in the use of communication strategies. These approaches should be an essential element of aphasia therapy for all practitioners. The production and comprehension of feedback during communication for PWA has received less attention. There is some evidence that the production and comprehension of feedback is preserved for left-hemisphere stroke, and that PWA can be trained to produce more and better targeted feedback to manage the conversation with a specific partner. Further work is needed to explore how the use and understanding of feedback can be easily assessed, how it relates to an individual's cognitive profile and aphasia symptoms, and whether it is typically amenable to training and intervention.

Multimodality

A wider body of research has looked at multimodal communication in aphasia, although it has typically separated different channels (e.g. gesture, gaze, prosody). There is a strong evidence base for gesture (comprehension and production) in aphasia. Gesture has been shown to be an important part of the communication process for PWA, and research shows that the use of gesture is different in real-world communication compared to on decontextualized tasks in the lab. The impairment of gesture use (comprehension and production) varies across aphasia types and severities. A number of intervention studies have provided support for the idea that gesture production and comprehension can be effectively trained through therapy. Although some research has been done to assess gesture use during real-world communication, more research is needed to fully understand its role in communication for PWA, especially across different impairment profiles. The finding that gesture use and comprehension differs between decontextualized and more naturalistic settings highlights the need for more research on the latter.

A topic of real interest should be the production and comprehension of multiple communication signals. It is not clear whether all PWA benefit from the presence of multiple modalities, and whether they are able to integrate the available information to their benefit during comprehension (i.e. multimodal gain). For example, there is early evidence that PWA have difficulty integrating visual and auditory signals, or difficulty integrating prosodic information alongside semantics and syntax. In production, total communication - using any and all available means of communicating - is often implemented as a strategy for people with moderate to severe aphasia who have more limited verbal output (Rautakoski, 2011; Rautakoski, 2008). The strategic use of multiple communication signals and the requirement to switch between them, or emphasize some over others, is one factor that likely makes some PWA 'better' communicators (Holland, 1977). We should be keen to understand how this skill is preserved or impaired, and how it can be trained.

Common ground

Healthy adults use pre-existing common ground (e.g. speaker familiarity), common ground that arises during a conversation and the physical environment to minimize the effort required for both production and comprehension during communication. For example, they co-ordinate their speech at the word and sentence level with their conversation partner(s) and rely on shared knowledge to use shorter and less complex utterances. There is evidence that some of these skills are preserved in aphasia, as PWA use reported speech and the communicative context to construct turns during conversation. We do not yet fully understand how well PWA use perceptually available information and the physical environment to minimise effort during everyday communication. Low tech AAC (e.g. communication books, photographs) has been shown to facilitate communication for PWA, but there is no systematic understanding of when and how the physical environment and situational context is used by PWA during real-world communication.

Cognition

Situated language use is complex, requiring that a range of skills be deployed and coordinated in real-time. A key conclusion from the review and the areas for future research highlighted above is that real-world communication likely involves cognitive skills beyond 'purely' linguistic processes. Real-world communication therapies are also likely to require meta-cognitive training. That is, training PWA to understand real-world communication as a skill set, reflect on their own skills and implement strategies to improve. For example, this would apply to multi-modality, such as consciously switching between different modalities, or monitoring for feedback during interactive communication.

Cognitive 'non-linguistic' impairments have been shown to be important contributors to the success of aphasia rehabilitation, for example, attention and working memory skills (e.g. Salis et al., 2017). Research has shown that these cognitive resources are often reduced or impaired for PWA, including executive functioning (cognitive flexibility, switching and inhibitory control), attention and memory (long-term and working memory) (Chiou and Kennedy, 2009; El Hachioui et al., 2014; Murray, 1999, 2012). Furthermore, impaired cognitive functions have been associated with particular symptoms experienced by PWA and their ability to communicate in the real world. Impaired attention (sustained and selective attention) have been suggested to affect auditory comprehension and spoken language during communication, for example when understanding longer chunks of information (Ferstl et al., 2005; Groenewold et al., 2014; Murray, 2012). Executive functions are said to be involved in (self-)monitoring during communication, when different types of linguistic information (i.e. semantics, syntax) are integrated, and when relevant information has to be retained and manipulated during interaction (El Hachioui et al., 2014; Helm-Estabrooks, 2002).

The current review highlights the need for clinicians to consider the presence of potential cognitive impairments and how these might impact on therapeutic effectiveness. We should actively consider whether some level of cognitive therapy - or strategizing around cognitive impairments - would be a beneficial part of *any* aphasia therapy.

Conclusion

We have presented a systematic, theoretically founded framework of real-world communication. The framework provides a delineated set of components that are involved in communication, which provides clear steps for future research to explore the influence of each component on real-world communication for PWA. It is of crucial importance for the development of effective assessments and interventions in aphasia rehabilitation to have a thorough understanding of what communication is, what skills are required to communicate in the real world, and how the behaviours targeted in therapy can generalise to real-world language use. The authors hope this paper will illustrate and emphasize the importance of studying, assessing and treating *communication* as a behaviour that is different from *language* as a solely linguistic phenomenon and that working at the level of *communication* requires taking into account the different task demands and resources that might be used to communicate effectively.

Acknowledgements

The authors would like to thank Prof. Herbert Clark and Dr. Arpita Bose for helpful comments on an earlier version of this manuscript. We would also like to thank our colleagues at the School of Education, Communication and Education Sciences, Newcastle University and our colleagues who attended the British Aphasiology Society Research Update Meeting 2018 for their invaluable input and feedback.

Declarations

Funding

The first author was supported by the Magdalen Vernon Studentship from the School of Psychology and Clinical Language Sciences, University of Reading.

Conflicts of interest/Competing interests

Not applicable

Availability of data and material

Not applicable

Code availability

Not applicable

Authors' contributions

The idea for the article was shared between both authors. The literature search was conducted by the first author, as well as the writing of the first draft. The second author critically revised the work.

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Chapter 3 | Measures of functional, real-world communication for aphasia: a critical review.

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Abstract

Aims: The aim of this article is to identify which existing instrument of functional communication from the aphasia literature best fits with a theoretically founded definition of real-world communication.

Background: Aphasia is a language impairment caused by acquired brain damage such as stroke. For successful rehabilitation, a thorough understanding of naturalistic, real-world communication is imperative, as this is the behaviour speech and language therapy (SLT) ultimately aims to improve. In the field of aphasiology, there currently is a lack of consensus about the way in which communication should be measured. Underlying this is a fundamental lack of agreement over what real-world communication entails and how it should be defined.

Methods & procedures: In this critical review, we review the instruments that are currently used to quantify functional, real-world communication in people with aphasia (PWA). Each measure is checked against a newly proposed, comprehensive, theoretical framework of situated language use, which defines communication as (1) interactive, (2) multimodal, and (3) based on context (common ground).

Outcomes & results: The instrument that best fits the theoretical definition of situated language use and allows for the quantification of communicative ability is the Scenario Test.

Conclusions: This article provides a start in a more systematic and theoretically founded approach to the study and measurement of functional, real-world communication in aphasia. More work is needed to develop an instrument that can quantify communicative ability across different aphasia types and severities.

KEYWORDS: Language use, functional communication, aphasia, participation, outcome measures.

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Introduction

One of the most important goals of speech and language therapy (SLT) is for People With Aphasia (PWA) to communicate as effectively as possible in their everyday lives - i.e. to see improvements at the level of functional communication (Thompson et al., 2008; Wallace et al., 2016). Traditionally, aphasia is diagnosed by administering pen-and-paper batteries such as the Western Aphasia Battery-Revised (Kertesz, 2009). In these tests, language production and language comprehension tasks are presented to the client on an item-by-item basis – for example, picture naming, or word-to-picture matching. The client is often given ample time to respond in a one-to-one setting, where all possible forms of distraction are removed. These tests assess the client's capacity to process linguistic information at the letter/sound, word- and sentence level, and sometimes in connected speech. Performance on these traditional tests falls into the *impairment* level of the International Classification of Functioning (ICF), whereas *functional 'real world' communication* sits across both the levels of *activity* and *participation*. There is a general agreement in the field of aphasiology that these highly constrained, decontextualized linguistic tasks are not sufficient to describe or predict a person's ability to communicate in everyday life (Beeke et al., 2011; Holland, 1980). Given the importance of communication[1] for rehabilitation, there is a surprising lack of literature on how aphasia affects functional, real-world communication as an activity or as a communicative task, and how therapy can influence communicative abilities at this level (Simmons-Mackie et al., 2014).

Despite the overall agreement that communication is a different construct compared to decontextualised language processing (Frattali, 1992; Holland, 1982), it has proven difficult, within the field of aphasiology, to agree on how communication should be measured. In the Core Outcome Set (COS) ROMA report (Wallace et al., 2018) experts in the field struggled to reach consensus for a measure of communication. According to Wallace and colleagues (2018), this was related to the complexity of the phenomenon and the "lack of understanding and consensus around how 'effective communication' is best operationalized in treatment research" (p. 4). SLTs predominantly use the traditional (decontextualized, impairment-based) instruments to assess treatment outcome, despite viewing communication as the most important outcome of therapy (Wallace et al., 2014) - possibly reflecting the same lack of consensus

[1]The ability to communicate in the real world or in one's own everyday life will be referred to as functional communication or simply as communication. This refers to skills, including language skills, required to communicate in various situations one might come across in one's day-to-day life. Communication or functional communication is defined in contrast to 'language' or 'linguistic' skills, which represent the ability to process language in isolation, as demonstrated in decontextualised tasks in the clinic.

as in the COS ROMA report. Similar trends are seen in published research where outcome measures often do not include a measure of communication. When they are included, instruments are so heterogeneous that it is often not possible to conduct meta-analyses or to reliably predict communicative rehabilitation outcomes for PWA (Brady et al., 2016). Clearly, there is a problem: although there is a general agreement that functional communication is the construct we ultimately aim to influence through therapy, there is a lack of agreement on how this should be achieved and how change should be measured. Underlying this lack of agreement is the absence of a structured, theoretically driven understanding of what functional, real-world communication is (Wallace et al., 2018). In order to provide the most effective aphasia rehabilitation a comprehensive understanding of real-world communication is required. To quantify and measure the effectiveness of our therapies at a meaningful level, we need an ecologically valid measure of communication.

The aim of this article is to identify existing, objective measures for people with aphasia that best fit with a theoretically founded definition of communication and makes it possible to investigate which cognitive (linguistic and non-linguistic) skills underpin communication. We first review existing instruments that are commonly used in the clinical and/or academic setting to quantify communication in aphasia. Following this, a theoretical definition of communication will be discussed – this frames communication as *situated language use*. Finally, each existing instrument will be evaluated against this theoretical definition to decide which existing instrument best incorporates all components of situated language use. We hope this encourages a more structured and systematic approach to the study of real-world communicative skills in aphasia and to further development of this area of research in aphasiology.

Current approaches to measuring communication in aphasiology

The term 'functional communication' has been used in a wide variety of ways in the aphasia literature (Elman & Bernstein-Ellis, 1995). What counts as functional communication and how to measure it has been a thorny issue for over 30 years (Elman & Bernstein-Ellis, 1995; Holland, 1982; Holland, 1980; Kearns, 1992). As a result of different interpretations, a large number of instruments have been developed with the aim of capturing 'functional communication' and so it remains difficult to properly define, agree upon and measure the most important outcome for aphasia rehabilitation (Brady et al., 2016; Wallace et al., 2014). A literature search was run to identify instruments or methods of analysis used in the literature that aim to capture or assess 'functional communication' or 'conversational success' (conversation/exchange of information at a conversational level). We excluded methods that assessed a single sub-component (e.g. in spoken output and connected speech selecting only topic coherence or story grammar). The following electronic databases were searched: PsychINFO, Cochrane Database of Systematic Reviews, Medline, Web of Science, CINAHL, PubMed and Google Scholar. Search terms are listed in Table 1. Journal articles in English and published after 1985 were included, which is around the time 'functional communication' became a topic of interest in the field. Titles and abstracts were reviewed by a single reviewer (WD) to assess the relevance of the found articles. Finally, full-text articles were read to check for the actual measure, and reference lists were checked to identify other relevant papers.

Search terms
Aphasia
AND therapy OR intervention
AND "functional communication" OR "conversational success" OR "everyday communication"

Table 1. Search terms used for literature search in electronic databases: PsychINFO, Cochrane Database of Systematic Reviews, Medline, Web of Science, CINAHL, PubMed and Google Scholar.

Table 2 presents all the instruments reviewed. The instruments are grouped as follows (1) standardized tests, (2) non-standardized tests, (3) observational profiles rated by the clinician; (4) observational profiles rated by a proxy or the client (5) linguistic analysis of connected speech and (6) sociological analysis of interaction. For a more extensive discussion of these and additional measures, please see (Manochiopinig et al., 1992; Patterson & Chapey, 2008; Spreen & Risser, 2003).

Standardized tests

Standardized tests such as the Communicative Abilities in Daily Living 2(CADL-2; Holland et al., 1999), Amsterdam-Nijmegen Everyday Language Test (ANELT; Blomert et al., 1994) and the Scenario Test (van der Meulen et al., 2010) quantify functional communication as the degree of communicative success in hypothetical, simulated everyday situations, elicited by pictures and questions, or role play with the clinician (i.e. visiting the doctor's office or picking up a shirt from the dry cleaners). The tests attempt to capture functional communication through the simulation of a sample of possible real-life encounters and measuring the degree of success in

Type of instrument	Name of test
Standardized tests	• Communicative Abilities in Daily Living 2 (CADL-2; Holland et al., 1999) • Amsterdam-Nijmegen Everyday Language Test (ANELT; Blomert et al., 1994) • Scenario Test (van der Meulen et al., 2010)
Observational profiles (clinician rated)	• Functional Communication Profile (FCP; Sarno, 1969) • Revised Edinburgh Functional Communication Profile (Wirz et al., 1990) • American-Speech-Language-Hearing Association Function Assessment for Communicative Skills in Adults (ASHA FACS; Frattali et al., 1995)
Observational profiles (client or proxy rated)	• Communicative Effectiveness Index (CETI; Lomas et al., 1989) • Assessment of Communicative Effectiveness in Severe Aphasia (ACESA; Cunningham et al., 1995) • Functional Outcome Questionnaire for Aphasia (FOQ-A; Glueckauf et al., 2003) • Communicative Activity Log (CAL; Pulvermuller and Berthier, 2008) • Communication Outcome after Stroke, client and carer version (COAST and carer COAST; Long et al., 2009; Long et al., 2008) • Aphasia Communication Outcome Measure (ACOM; Doyle et al., 2012)
Linguistic analysis of connected speech	• Correct Information Unit Analysis (CIU; Nicholas and Brookshire, 1993) • Information Units (IU; McNeil et al., 2001) • Pragmatic Protocol (PPL; Prutting and Kirchner, 1987) • Conversation Analysis (CA; Beeke et al., 2007)

Table 2. List of instruments that aim to measure functional communication in aphasia.

transmitting a message in those situations.

The CADL-2 has been criticized for focusing on the transmission of a message by the PWA, without taking into account the interactive aspect of communication (Ramsberger & Rende, 2002; van der Meulen et al., 2010). The ANELT has been criticised for only measuring verbal exchanges and not taking into account the non-verbal aspects of interaction (van der Meulen et al., 2010). The use of role play, or simulating situated, more context specific communication tasks in a clinical setting, has been suggested to make additional cognitive demands that are often not required in real-life situations, such as pretending to be somewhere you're not (Ramsberger, 1994; Wirz et al., 1990). While the ANELT uses physical props to support the role-play (i.e. a shirt with a hole in it at the drycleaners), the Scenario Test and CADL-2 use illustrations or pictures of a scene that are initially shown, and then taken away when PWA are asked to respond. Finally, a criticism of the Scenario Test is that many PWA with some verbal ability can perform at ceiling, as a full score can be acquired with a response of a few single words. As the test is currently structured, it is not informative across the full range of aphasia severities (this is unsurprising, as it was originally designed as a test of multimodal communication for people with a severe aphasia).

Non-standardised measures of communicative success

The Assessment of Communicative Effectiveness in Severe Aphasia (ACESA; Cunningham et al., 1995) is a measure designed to assess the communicative effectiveness of people with severe aphasia. This measure includes a structured conversation, in which the assessor asks the PWA a number of questions about familiar topics, initially allowing for yes/no answers and working towards more open-ended questions on familiar topics (e.g. 'is your husband/wife/carer alright?' and 'Tell me about where you live, about your home'). The second part of the measure requires the PWA to convey the meaning of common items, shown in objects and pictures. Communicative effectiveness is defined on a scale of recognisability of the attempt, ranging from "easily and quickly recognisable" to "completely unrecognisable, no response, recurrent gesture or vague gross movement" (Cunningham et al., 1995). Ramsberger and Rende's (2002) measure of transactional success consists of a semi-spontaneous story re-telling task: PWA are asked to watch an 'I Love Lucy' video and re-tell the storyline from the video to a conversation partner. Transactional success is defined by the number of main ideas expressed by the conversation partner of the PWA, when retelling the story as told by them by the PWA.

Observational profiles (clinician rated)

There are a number of instruments that quantify functional communication by relying on observations made by the clinician. With the Functional Communication Profile (FCP), Sarno (1969) was the first to develop such an instrument. Sarno compiled a list of communicative behaviours across different categories (reading, understanding, speaking, gesturing, etc.), such as "reading street signs" or "speaking on the telephone" that could be ticked off as executed by the PWA or not, including a judgement of how effectively this was done. A number of observational profiles have been published since, including the Revised Edinburgh Functional Communication Profile (Wirz et al., 1990), the American-Speech-Language-Hearing Association

Function Assessment for Communicative Skills in Adults (ASHA FACS; Frattali et al., 1995) and the Therapy Outcome Measure Activity Scale (TOM, Enderby et al., 2006). Functional communication is quantified in these observational profiles as an overall score of ability, effectiveness or independence on a number of communicative activities, such as 'expresses feelings', 'tells time', or 'participates in conversations', or a description of pragmatic skills that the PWA exhibits or not (i.e. 'responding to open questions', 'greeting' and 'initiating a new topic'), as well as an indication of the modalities used during communication. The rationale for using an observational instrument is that it is based on naturalistic, spontaneous behaviour and administration is feasible in a clinical setting. However, the FCP has been criticized for measuring functioning in relation to pre-morbid levels (Ramsberger, 1994) and to be linguistically biased, with no measure of non-verbal communication (Cunningham et al., 1995). Glueckauf et al. (2003) criticised the ASHA-FACS for measuring the degree of independence in communication (i.e. can someone perform a task without help), but not including a measure of communicative success (i.e. how effective is communication). The observational nature of the instruments is considered by some to be subjective and has been argued to result in an indirect measure of functional communication (Blomert et al., 1994; Glueckauf et al., 2003; van der Meulen et al., 2010), as well as being ill-suited to capture how real-time communication unfolds for PWA (Barnes & Bloch, 2018). For the FCP (Sarno, 1969), and the ASHA FACS (Frattali et al., 1995) communication is judged on the basis of indirect observation (i.e. memory of multiple conversations that have previously been observed), rather than directly observing and scoring behaviour.

Observational profiles (client or proxy rated)

The third category includes observational profiles that are rated by the client or a proxy (e.g. a partner or carer) rather than a clinician. These instruments are built on the assumption that the clinician only has limited opportunity to observe the client in everyday situations typical for them (Lomas et al., 1989), while the proxy has a much better sense of the level of functioning of the client in day-to-day life. In addition, Davidson and Worrall (2000) suggested that clinicians may focus more on the potential of the client rather than actual performance in their judgements of functional communication. On a larger scale, health care providers have become more person-centred, meaning that a high value is given to the client's perspective in therapy goal setting (Worrall, 2006) and to their judgement of what represents meaningful therapy outcomes (Wallace et al., 2016). The inclusion of the client perspective in therapy outcome measures has thus become a key part of health care policy making (Frattali et al., 1995; Irwin et al., 2002; Rudd, 2016). As such, patient reported outcome measures (PROMS) have become increasingly valuable, including observational measures of communication as judged by PWA themselves.

Observational profiles that aim to measure functional communication in aphasia include the Communicative Effectiveness Index (CETI; Lomas et al., 1989), the Assessment of Communicative Effectiveness in Severe Aphasia (ACESA; Cunningham et al., 1995), the Functional Outcome Questionnaire for Aphasia (FOQ-A; Ketterson et al., 2008), the Communicative Activity Log (CAL; Pulvermuller and Berthier, 2008), the Communication Outcome after Stroke, client and carer version (COAST and carer COAST; Long et al., 2009) and the Aphasia Communication Outcome Measure (ACOM; Hula et al., 2015). Measures such as the COAST have expanded their definition of functional communication outcome to include measures of the impact of the communication impairment on the client's life (similar examples are the Aphasia Impact Questionnaire-21, Swinburn et al., 2018; Swinburn and Byng, 2006). The criticism for observational profiles as discussed in the previous section also applies here: they are considered to be subjective and indirect measures of functional communication (Blomert et al., 1987; van der Meulen et al., 2010), including the fact that for these profiles, communication is judged on the basis of indirect observation (i.e. memory of multiple conversations that have previously been observed). In addition, it has been suggested that the observations by a proxy can be biased by factors relating to the relationship with the PWA and by the proxy's emotional well-being (Glueckauf et al., 2003). Furthermore, it is difficult to control what the client or proxy bases their answers on when filling out the observational profile. For example, Fucetola and Connor (2015) showed that the CETI score was primarily influenced by expressive abilities of the PWA, not receptive communication skills, resulting in an unintentional one-sided view of a person's communicative performance in everyday life. Functional communication is quantified in a similar fashion as for the clinician-rated observational profiles: as an overall score of ability, effectiveness, impact or independence on a number of communicative behaviours.

Linguistic analysis of connected speech

Finally, there is a group of instruments that is based on the linguistic analysis of connected speech. As interest grew in what PWA could communicate at a conversational level, knowledge from studies on pragmatics and discourse has been applied to the analysis of conversation in aphasia. Both fields study language above the sentence level and are thus, in theory, relevant to the discussion of functional communication in aphasia. A number of these measures explicitly claim to measure 'functional communication' in PWA and are therefore included here. Other pragmatic or discourse measures are relevant to the study of communication, but do not claim to measure communication comprehensively: instead, these instruments assess a subcomponent of communication (such as story grammar and topic coherence, see Pritchard et al., 2018 for a review) and are therefore not included in the current discussion. Examples of instruments based on a linguistic analysis of communication are the Correct Information Unit Analysis (CIU; Nicholas and Brookshire, 1993) and the Information Units approach (IU; McNeil et al., 2001) which aim to assess the informativeness of connected speech by identifying phrases (or units) that represent crucial, relevant information for a specific story. The informativeness of a story that is retold is defined by the number or percentage of units that are expressed correctly and intelligibly. It is difficult to achieve high inter-rater reliability on these measures (Oelschlaeger & Thorne, 1999; Ramsberger & Rende, 2002), though other measures of discourse with PWA such as Story Grammar, Topic Coherence, Reference Chains and Predicate Argument Structure have been shown to be psychometrically robust (Pritchard et al., 2018). Another instrument that is based on linguistic analysis of functional communication is the Pragmatic Protocol (PPL; Prutting and Kirchner, 1987). The PPL is an observational tool but is discussed in this category because of its linguistic origins. The tool can be used to indicate whether a set of pragmatic aspects of language are observed or not in conversation, such as "turn taking interruption/overlap", "physical proximity" and "vocal intensity" (Prutting & Kirchner, 1987). The pragmatic aspects of behaviour, if observed, are also judged on whether they are applied appropriately or inappropriately (i.e. to facilitate/neutrally influence communication, or not). The aim of the PPL is thus to identify a pattern of pragmatic behaviour impairments, based on the observation of 15 minutes of spontaneous conversation. The PPL is an observational tool and therefore, the same criticism applies as for the second and third categories mentioned above.

Analysis of interaction

Conversation Analysis (CA) surfaced in aphasiology around the turn of the 20th century, emphasizing the importance of studying spontaneous, natural conversation (Beeke et al., 2007) and to take into account the interactive nature of conversation. Though originally applied to audio recordings, CA can also include the study of non-verbal behaviour during conversation (i.e. video materials). CA is based on the assumption that conversations are products of a structured interaction in which the sequential order of turns represents an important organizational feature of the conversation. The overall aim of applying CA to the study of aphasia is to analyse what causes problems and disruptions to the organization of conversation, and to identify adaptive strategies to overcome these problems. To do this, it typically focuses on how conversation unfolds between a PWA and a specific communication partner (a dyad). This methodology has provided useful information for the assessment of natural conversation and it lends itself well to training programmes for PWA and their conversation partners (Beeke et al., 2007; Wilkinson, 2015). Due to the observational nature of the methodology, it remains difficult to synthesize findings from CA and to describe behaviour at the group level, though a number of attempts have been made (Booth and Perkins, 1999; for a brief discussion, see Prins and Bastiaanse, 2004).

Interim summary

A wide range of instruments have been created to measure functional communication, each with different purposes: either to determine treatment effectiveness, the generalization of therapeutic interventions, to use for therapy planning or to develop our theoretical knowledge of functional communication in aphasia. The conceptualizations and operationalisations of functional communication in the literature show overlap, as all aim to capture language or communication in conversation or everyday life. In a theoretical and methodological sense, however, they are quite different (Irwin et al., 2002; Linnik et al., 2016), often focusing on particular component of communication that is of particular interest for the measure created, such as verbal output (ANELT, Blomert et al., 1994), the patterns of interaction that structure conversation (CA, Beeke et al., 2007) or including impact as part of a measure of communication (COAST and carer COAST; Long et al., 2009). The variety across these instruments reflects the challenging nature of capturing the complex, multifactorial phenomenon of communication, as well as the lack of fundamental agreement on what real-world communication is. A theoretically founded definition of communication that is comprehensive and does not emphasize one element over another is therefore imperative and would enable researchers to scrutinize the validity of the abovementioned measures, as well as to make suggestions for the improvement of the instruments.

A definition of situated language use

Over the past decades, much research has been done on the topic of communication with healthy adults in the fields of communication science, psychology, linguistics, neuroscience, psycholinguistics and sociology. Much of this work has yet to be translated into aphasiology. This body of research provides important clues on what components influence a person's ability to use language in a real-world setting, and can inform the endeavours in aphasiology to develop a theoretically founded definition of functional, real-world communication (Simmons-Mackie et al., 2014; Webster et al., 2015).

From as early as the 1940s, box-and-arrow models of the communication process have been published in the literature. Initial models were very much focused on information transfer, often describing communication as a linear, one-way process from a sender, the transmission of the message, a channel through which information can travel to a receiver (Shannon & Weaver, 1949). Later models added components such as the interpretation of meaning of a message by the sender and receiver (Schramm, 1954), the influence of feedback during communication as well as the use of multiple modalities (Westley & MacLean, 1957). Berlo (1960) further built on this to include contextual factors such as communication skills, attitudes and the influence of social support on the communication process. A number of research fields have focused specifically on a particular component of communication, such as non-verbal communication (i.e. gesture, facial expression and body movement; Goodwin, 1995; Kendon, 1980; McNeill, 1992), the patterns of interaction that structure conversation (Conversation Analysis: Barnes and Bloch, 2018; Beeke et al., 2007) or the purpose of communication (interactional or transactional; Simmons-mackie and Damico, 1997). Although useful, these do not provide a comprehensive model or description of communication, rather they describe a particular component of the process. There are many different ways in which to approach and describe the process of real-world communication, depending on the focus of the model, the scope, the theoretical underpinnings and its explanatory purpose. For the purpose of the current paper, a model or framework that attempts to describe communication comprehensively rather than focusing on one element of the process is required. To be useful for practical application, it should help delineate both the individual (cognitive skills) and the situational (contextual) factors that are important for communication. It is precisely because 'functional communication' has this complexity, spanning levels of the ICF and incorporating more than just an individual's abilities, that its definition and measurement has been so problematic.

From our reading (Doedens & Meteyard, 2018), we propose that Clark (1996) provides such a description, with sufficient descriptive detail to take stock of existing instruments. A thorough review of this topic is beyond the scope of this article, but see (Doedens & Meteyard, 2018) for an extended review. Clark (1996) outlines three core characteristics of communication as 'situated language use'. It is always (1) interactive, (2) multimodal and (3) reliant on common ground (see Table 3). Within those three characteristics, sub-components are listed to further break down exactly which variables play a role. The relatively simplistic structure of the framework means it can function as a starting point for the discussion of communication – situated language use - in aphasiology.

Components	**Definition**	**Sub-components**
Interactive	Joint activity between two people. Actions of one person depend on those of the other	• Feedback / backchannels • Co-construction of dialogue • Familiarity
Multimodal	Multiple interdependent channels of communication are available and integrate into a single composite message. Different channels replace, supplement, complement and emphasize speech.	• Language • Prosody • Gesture • Facial expressions • Body posture
Contextual (relies on common ground)	Common ground provides interlocutors with context that allows them to assume a degree of "givenness" of information, or directly use physical referents during communication. This relieves the communicative burden.	Pre-existing: • Communal common ground • Personal common ground Discourse representation: • Situational context • Communicative context

Table 3. The key components that characterize language in use (based on Clark, 1996).

Face-to-face communication

Communication in everyday life varies across settings, modalities and ways of communicating (speaking with a sibling at home, listening to an audio book in the car, performing for an audience in the theatre, writing a letter to a friend, etc). The ability to communicate, as well as the way in which people communicate across these different settings also varies. To evaluate the principles that govern situated language use, researchers have started by studying the most basic form: face-to-face communication (Barnes & Bloch, 2018; Bavelas & Chovil, 2000; Clark, 1996; McDermott & Tylbor, 1983; Pickering & Garrod, 2004), as it is the most commonly used and pervasive form of communication, it is universal to all human societies, it is the basis for typical language acquisition in children and it does not require education or special skills (Bavelas & Chovil, 2000; Clark, 1996). Indeed, Davidson, Worrall and Hickson (2008) showed that face-to-face conversation is the most frequently occurring communicative activity in daily life for PWA. The reasoning is that once the principles that govern face-to-face communication are teased out, language use in other communicative situations, such as speaking on the telephone, can be derived from the basic face-to-face exchange (Clark, 1996).

Language use is interactive

Many researchers agree that face-to-face communication is a joint activity (Clark, 1996; Schegloff, 1982). This means that language use is achieved by two or more people who coordinate their actions to achieve a common goal. Every decision made during a conversation will depend on the actions of the other. Face-to-face communication is therefore an inherently interactive process, in which two or more participants work together and coordinate their actions to create meaning. The whole, as well as the individual actions of each individual, can be studied within that process. This means that when language production and comprehension are studied outside of the interactive process (i.e. in isolation, or based on the behaviour of one person), they will be tapping into inherently different processes and task demands as compared to language when it is used for communication. It is worth noting here that this may be a critical reason why a number of impairment-based therapies for aphasia (e.g. picture naming therapies for word finding) do not show reliable generalisation to functional, real-world communication (Webster et al., 2015). The interactive nature of communication is therefore a core component of face-to-face communication that should be taken into account when assessing language performance in a real world setting (Barnes & Bloch, 2018; Clark, 1996; Schegloff, 1982).

Language use is multimodal

Face-to-face communication is a fundamentally multimodal phenomenon (Bavelas & Chovil, 2000; Clark, 1996; Kendon, 1980; McNeill, 1992). A number of different modalities or channels of expression are used during communication, such as facial expressions, gesture, prosody, speech and body movements. These channels interact and are interdependent: they integrate into a single composite message. Channels are combined to replace, supplement, complement and emphasize speech, as well as to express emotion (Kendon, 2004; McNeill, 1992). By studying language in isolation, the complexity and interdependence of the different channels are ignored (Vigliocco et al., 2014), and a wealth of information that is relevant for communication is missed. When people communicate with each other in the real world, they use all channels to express meaning, as well as to monitor and understand what the other participant is communicating (Clark & Krych, 2004). Therapeutic approaches that support, encourage or train 'total communication' (i.e. not just focusing on verbal input and output) are common in aphasia rehabilitation (Nykanen et al., 2013; Pound et al., 2000; Rautakoski, 2011), highlighting the importance of having a measure that captures multimodality in communication.

Language use is based on common ground

Finally, face-to-face communication allows interlocutors to rely on context during the exchange (Clark, 1996). Clark (1996) refers to context for face-to-face communication as common ground: the set of shared knowledge, beliefs and assumptions that exists between two speakers. There are different types of common ground, as described in Table 5.

Type	**Sub-type**	**Definition**
Pre-existing	• Communal common ground	Communal common ground refers to shared beliefs and knowledge based on a shared nationality or religion. Customs that are specific to a certain country or culture, will be shared and readily understood between people from that culture.
	• Personal common ground	Personal common ground reflects the number of shared experiences two participants have had together, also referred to as the level of acquaintedness or personal familiarity.
Discourse representation	• Situational context	The situational context includes what is physically present in the perceptual environment.
	• Communicative context	The communicative context is an accumulation of what has been referred to earlier in conversation (through any modality).

Table 4. The different sub-types of common ground, as described by Clark (1996).

There will be a degree of common ground that exists even before two interlocutors start their conversation (pre-existing common ground), and there is common ground that builds up during conversation (discourse representation). A key premise is that whatever is part of common ground will require less effort (time and/or energy) to refer to during face-to-face communication (Boyle et al., 1994; Horton & Gerrig, 2005), meaning that the more common ground two interlocutors share, the greater the ease with which they can communicate. In some cases, the existence of more common ground can allow the interlocutors to rely less on (complex) linguistic processing for the exchange of information, by relying on the 'givenness' of information in dialogue and producing shorter and less 'complete' utterances. A simple example is using pronouns ('he' or 'she') instead of proper names, or two friends who use the same slang terms. For comprehension, interlocutors can rely on context to restrict the number of possible interpretations for a sentence they have heard (Skipper, 2014).

When measuring a person's ability to communicate in the real world, their ability to rely on common ground should be taken into account. Knowing if and how a person can use common ground to support conversation can help provide greater insight into the way in and the degree to which a person can compensate for their linguistic difficulties in conversation.

A theoretically founded measure of communication in aphasia

The framework described above identifies three components that define functional communication, namely that it is (1) interactive, (2) multimodal and (3) based on common ground, including (3a) shared knowledge between speakers and the variation in this across different speakers, (3b) the physical environment and (3c) the communicative environment. In this section of the paper the existing instruments reviewed above will be checked against the proposed theoretical framework. In addition, we will evaluate whether the instruments provide information on how these components influence communication for PWA. This evaluation is summarised in Table 5.

Standardized tests

The CADL-2 (Holland et al., 1999) is administered by the clinician who asks the PWA questions, requiring the PWA to respond to a given situation, without receiving any form of (structured) feedback from the clinician. Thus, although there is another person present, the CADL-2 therefore does not fully take into account the interactive aspect of communication. The CADL-2 does take note of the use of different modalities in communication, allowing verbal and non-verbal responses on the items. Finally, the CADL-2 takes into account some elements of common ground: it does not explore the PWA's communicative abilities across different speakers, but it attempts to re-create different situations and environments in which someone might need to communicate (e.g. a doctor's office), assessing the PWA's ability to communicate in different settings. Different images are used to provide information on the setting and to situate the question that is posed to the PWA. Since the test does not place PWA in the actual, physical environment, the use of physical context by the PWA to support communication is not explored optimally. Thirdly, the type of questions posed to the client (test-questions, rather than conversational questions i.e. 'What should you wear or use on a day like this?') means no substantive communicative context is created between the interlocutors. Exploration of the reliance of PWA on the communicative context is therefore not possible.

The ANELT (Blomert et al., 1994) is set up in a similar fashion to the CADL-2. The test is set up as a role-play, but essentially elicits a monologue from the PWA, with no interaction or feedback exchanged between the clinician and the client. As the ANELT only scores verbal responses, it does not include the multimodal component of communication. Common ground is partially taken into account: different settings in which PWA might find themselves in everyday life are assessed and physical props are used to support the role-play. This allows the clinician to further explore the ability of the PWA to use the physical environment to their advantage. The test does not assess the ability of the PWA to communicate with different conversation partners. It also does not fully assess the influence of the communicative context: PWA are asked one question per scenario in order to avoid negative effects of potential stroke-induced short-term verbal memory problems (Blomert et al., 1994), meaning very little communicative context is built.

The Scenario Test (van der Meulen et al., 2010) assesses multimodality and interactivity in a face-to-face setting, as the test requires the administrator to interact with the client and provide different levels of feedback and help throughout the scenarios of the test. All forms of communication, be it verbal, gestural, written, drawn or use of a communication aid are recorded and contribute to the final score on the test. Although the interaction remains artificial, efforts have been made to structure the feedback as it would be given in a natural setting. The influence of common ground is partially assessed: the ability of the PWA to communicate across a number of different situations is assessed. Similarly to the CADL-2, the test uses illustrations to 'set the scene' for the scenario, to which the PWA is asked to respond. The lack of physical objects or props, however, means the use of the physical environment by the PWA to communicate is not assessed. Each scenario in the test includes three different questions, with structured feedback (i.e. a brief interaction), for each question. This means a small amount of communicative context is built for each scenario and therefore theoretically allows the clinician to explore whether the PWA uses the communicative context (i.e. earlier references) to their advantage. However, exploration of this aspect of communication is not part of the official scoring guidelines. Finally, the test does not assess the ability of the PWA to communicate with different conversation partners.

Non-standardised measures of communicative success

In Ramsberger & Rende's (2002) measure of transactional success, the authors have created a fully interactive task where interlocutors can communicate and provide feedback in a natural manner. As the interlocutors provide feedback spontaneously, systematically assessing the ability of PWA to use different kinds of feedback during communication is not straightforward. The test itself therefore is interactive, but it does not measure how the PWA relies on the conversation partner during communication. Similarly, the measure takes into account all modalities of communication, but the scoring of the test does not report on the use of different modalities by the PWA. This also applies to the use of the physical environment. Finally, common ground is taken into account partially: the ability of the PWA to communicate in different settings is not assessed, but the measure does allow for the assessment of communicative abilities across different conversation partners. Finally, although it does not report on this explicitly in the outcome of the measure, it does take into account the communicative context, as the PWA and their conversation partner speak for an extended period of time about the same topic. The measure of transactional success is defined by the ability of the conversation partner of the PWA to re-tell the story as they have understood it from the PWA. This therefore is an indirect measure of the communicative abilities of the PWA through the interpretation of the conversation partner.

The ACESA, like the ANELT and CADL-2, is not an interactive test. The examiner poses the questions to the PWA, but no further interaction takes place. The measure is partially multimodal, as it does not allow for the use of writing and drawing during communication. The ACESA does not take into account the influence of common ground: it does not assess the influence of different communication partners, different settings in which one can communicate nor the use of the physical environment. The measure partially takes into account the influence of the communicative environment, as the structured conversation could be seen as building up a communicative context that can be used by the PWA.

Observational profiles (clinician, client or proxy rated)

Observational profiles are based on the observation of naturalistic communication and therefore implicitly take into account, to some degree, the three components of communication. The profiles vary considerably in the way and the degree to which these components are explicitly assessed, however. For ease of exposition, we will walk through each component (interactivity, multimodality and common ground) and directly compare profiles, rather than dealing with each profile in turn.

Many profiles include a mix of interactive and non-interactive items. The FCP includes a number of behaviours that are explicitly interactive (e.g. 'understanding a simple conversation with one person'), while the majority of the items are focused on non-interactive, linguistic skills (e.g. 'saying long sentences', 'understanding television'). The CETI (Lomas et al., 1989), on the other hand, focuses heavily on interaction: 15 out of 16 items refer to interactive communicative behaviours. The FOQ-A incorporates the interactive component of communication by assessing communicative acts (e.g. 'the person can make routine verbal requests') and by assessing the ability of the PWA to monitor conversation ('this person can recognize mistakes in his or her speech when he or she makes routine verbal requests'). The majority of items on the CAL (Pulvermuller & Berthier, 2008), the ACOM (Hula et al., 2015), the (carer) COAST (Long et al., 2009; Long et al., 2008), the ASHA-FACS (Frattali et al., 1995) and the TOM Activity Scale (Enderby et al., 2006) implicitly assess the interactive aspects of communication by referring to 'communicating' or 'conversation' (i.e. 'how well could you have a chat with someone you know well?' on the COAST, 'participates in conversation' on the ASHA-FACS and 'talk about your day with family or friends' on the ACOM).

The degree to which the use of multimodal communication is explicitly assessed varies across profiles. The R-EFCP (Wirz et al., 1990) is most explicit, as it specifically aims to describe the modality in which the speech acts are performed. On the ASHA-FACS most items are indirectly multimodal ('requests information'), while a few are more explicit ('understands facial expression/tone of voice'). The FOQ-A explicitly assesses verbal and non-verbal communication ('this person can answer 'who, what where, when and why' questions correctly either verbally or with gestures'). On the CETI, CAL, COAST, ACOM and FCP, most items are implicitly multimodal (e.g. 'communicating his/her emotions', 'having a one-to-one conversation with you' on the CETI; 'talk about your day with family or friends' on the ACOM) with a small number of questions explicitly assessing multimodal communication (e.g. 'how well can you use other ways to help you communicate?' on the COAST, 'responding to or communicating anything (including yes or no) without words' on the CETI and 'use of gestures' on the FCP). In addition to this, some of the profiles only explore specific modalities used for communicating, such as the FOQ-A which only assesses verbal information and gestures. The more implicit questions about communication leave enough room for different interpretations of the question (i.e. some questions might be interpreted as just being about verbal abilities).

Finally, the observational profiles vary in the extent to which they asses the influence of common ground. Common ground is not explicitly assessed on the FOQ-A and R-EFCP, while only minimally on the FCP and ASHA FACS. The latter two profiles focus mostly on different settings for conversation (e.g. 'understanding conversation with one person' vs. 'more than two people', 'speaking on the phone' and 'understand conversation in noisy surroundings' and 'following directions'). In these profiles, the influence of communicating with different people (familiar or unfamiliar) and the physical and communicative environment are not assessed. The TOM Activity Scale only explicitly mentions the influence of different environments on communication. The CETI, the CAL, the (carer) COAST and the ACOM dedicate a few items to the effect of different conversation partners (in number and type, e.g. 'having coffee-time visits and conversations with friends and neighbours' on the CETI, 'join a conversation with a group of people' on the COAST, 'have a conversation with strangers' on the ACOM) and settings (e.g. ('how does the patient communicate on the telephone' on the CAL, 'explain your health concerns to your doctor' on the ACOM), but the use of the physical and communicative environment are not explored.

Crucially, all the profiles lack specificity on how each component affects communication for each individual PWA. The observational profiles are thus useful in getting a general sense of the communicative abilities of a PWA, but do not provide detail on what specific communicative behaviours are underlying these scores.

Linguistic analysis of connected speech

More often than not, the CU (Yorkston & Beukelman, 1980), the CIU (Nicholas & Brookshire, 1993) and the IU (McNeil et al., 2001) are administered in a non-interactive setting, i.e. without the presence of a conversation partner (e.g. picture description or story re-tell task), resulting in a monologue type of output. Furthermore, these measures only assess verbal output (speech). Therefore, these measures are non-interactive and not multimodal. Common ground is partially taken into account: the use of the physical environment is not taken into account but PWA can use the communicative context if they are telling a story, though the use of this context is not explored explicitly in the scores.

The Pragmatic Protocol (Prutting & Kirchner, 1987) takes into account most of the model's components in a face-to-face communicative setting. It observes spontaneous conversation, which is inherently interactive, in which the use of all modalities of communication is allowed. Aspects of interactive behaviour (turn taking, providing feedback, etc.) as well as multimodal behaviour (eye gaze, gestures, facial expressions, etc.) are all coded in the protocol. Furthermore, the communicative context is taken into account by looking at verbal aspects such as "specificity/accuracy", which relates to making appropriate lexical choices to convey information (e.g. not under- or over specifying referents). Use of the physical environment is not taken into account explicitly. Overall, this measure is set up to judge the appropriateness of specific pragmatic characteristics in conversation (i.e. does the PWA show this behaviour and does it facilitate or impede communication), rather than to describe how communication is achieved.

Analysis of interaction

Conversation analysis focuses on directly observed face-to-face communication and explicitly takes into account the interactive, joint responsibility of communication. CA can take into account the multimodal ways in which interlocutors communicate, though speech is often used as the principal base measure (ten Have, 2007). CA emphasises the importance of taking into account the communicative context in which a statement is made, thereby partly addressing common ground. It is possible to take into account the physical environment with this methodology, for example by coding how conversation partners use or refer to objects in their environment. At present there is no standardised measure from the CA approach with norms that can be used in clinic to assess effective communicative ability of PWA, although treatment protocols based on CA principles such as SPPARC (Lock et al., 2001) and Better Conversations (Beeke et al., 2013) exist, which apply CA principles. More standardized and simplified CA approaches that can be easily applied in clinic may well come in the future (Barnes & Bloch, 2018).

Interim summary

Both the Scenario Test (van der Meulen et al., 2010) and Conversation Analysis (CA) adhere best to the definition of communication as outlined in the theoretical framework, i.e. as an interactive, multimodal and contextualised phenomenon. Both of these methods have been fruitful in generating more knowledge on communication in aphasia, as well as informing therapeutic approaches (Beeke et al., 2013; van der Meulen et al., 2010).

Crucially, the analytic purpose of the Scenario Test and CA are very different. CA is aimed at describing one aspect of communication, namely how interaction is organised between two people. This is done by looking at processes such as turn-taking, sequencing, and repairs. The purpose of CA is to describe how interaction is organised and how this might be atypical, not to explain why people show a particular kind of behaviour (ten Have, 2007), or to explain the underlying (cognitive) causes of the (a)typical interaction. Observations made through CA are inherently specific to the dyad being studied, and do not describe behaviour that can be separated from that particular conversation partner or environment. The detailed analysis that can be obtained through CA was, therefore, not designed to describe or identify general patterns and relationships between variables at the group level (Ragin, 1994, quoted by ten Have, 2007). As was stated before, there is currently no standardised instrument based on CA that could be used in clinic. Although CA provides very rich, detailed information about interaction between two people, in its current form it does not allow for an analysis of communicative ability that can be easily generalised.

The Scenario Test aims to quantify the effectiveness of communicative attempts by PWA. It provides a score for the communicative ability of the individual (in an interactive setting), while also describing the way in which communication is achieved (through which modalities and the degree of reliance on the conversation partner). The communicative behaviour as measured by the Scenario Test can then be related to other (cognitive or behavioural) measures for that individual, through comparison or further analysis of scores. This makes it possible to attempt to explain the why of the communicative difficulties experienced by the PWA in conversation. The Scenario Test has been standardized, meaning its outcome can be generalized and compared across larger groups of people. It has been shown to be a valid measure of the ability to convey information in simple communicative situations and communicative creativity (van der Meulen et al., 2010).

		Components of face-to-face communication [a]					Psychometric properties [b]
				Common ground			
Type of instrument	Name of test	Interactive	Multimodal	*Pre-existing*	*Situational context*	*Comm. context*	Reported measures of reliability and validity
Standardized tests	•CADL-2 (Holland et al., 1999)	-	•	-	○	-	•High IntC and IRR, moderate TRT. Good ConcV.
	•ANELT (Blomert et al., 1994)	-	-	-	•	-	•Moderate-high IRR, moderate-high TRT, moderate IntC, moderate-good ConcV for speech production.
	•Scenario Test (van der Meulen et al., 2010)	•	•	-	○	○	•High TRT and IntC, moderate-high IRR, high IntraRR. Good ConcV.
Non-standardized tests	•ACESA (Cunningham et al., 1995)	○	○*	-	-	○	•Low IRR, high IntraRR and moderate-high TRT.
	•Transactional success (Ramsberger & Rende, 2002)	○	○	•	-	○	•Moderate IRR, high ConstV, low ConcV, moderate TRT.
Observational profiles (clinician rated)	•FCP (Sarno, 1969)	○*	○	-	○*	-	•Moderate IRR.
	•R-EFCP (Wirz et al., 1990)	○	•	-	-	-	•N/A.
	•ASHA FACS (Frattali et al., 1995)	○	○	-	○*	-	•Moderate IntC and IRR, high IntraRR. Low-moderate ConcV.
	•TOM, Activity Scale (Enderby et al., 2006)	○	-	-	○*	-	•Moderate-high IntC, low-high IRR.
Observational profiles (client or proxy rated)	•CETI (Lomas et al., 1989)	○*	○*	○*	○*	-	•High IntC, moderate-high TRT and low-moderate IRR. Good ConcV.
	•FOQ-A (Glueckauf et al., 2003; Ketterson et al., 2008)	○	○*	-	-	-	•High IntC and good ConcV.
	•CAL (Pulvermuller & Berthier, 2008)	○	○	○*	○*	-	•N/A.
	•COAST and carer COAST (Long et al., 2009; Long et al., 2008)	○	○	○*	○*	-	•Moderate-high IntC and moderate TRT. Good ConstV.
	•ACOM (Doyle et al., 2012)	○	○	○*	○*	-	•Low-moderate ConcV.
Linguistic analysis of connected speech	•CIU (Nicholas & Brookshire, 1993)	-**	-	-	-	○	•High IRR, high IntraRR.
	•IU (McNeil et al., 2001)	-**	-	-	-	○	•High IRR and moderate-high ConcV.
	•PPL (Prutting & Kirchner, 1987)	○	○	-	-	○	•High IRR.
Analysis of interaction	•CA (Beeke et al., 2007)	•	•	-	○	•	•N/A, but see Perkins et al. (1999) for a discussion.

[a] •component is taken into account and instrument provides insight into how this component affects communication for PWA, ○component is taken into account, but instrument does not provide information on how this component affects communication for the PWA. * component is partly taken into account. ** depending on the type of task used to elicit the speech data. If the task is interactive, then this component is taken into account. Often a picture description or a story re-tell task is used, which is not interactive.

[b] Stability – measure does not vary substantially across administrations (e.g. different sessions, different materials), IntC – Internal Consistency, IRR – Inter-rater reliability, TRT – Test-retest reliability, ConcV – Concurrent Validity (correlated to other measures), ConstV – Construct validity, FaceV – Face Validity, ContV – Content validity. Some measures also reported sensitivity (to discriminate between groups or detect change), we have not reported those here for reasons of space. Psychometric properties are left blank when we have been unable to find any published data. Cut-offs based on Streiner et al. (2015) and Pritchard et al. (2018): reliability scores were labelled as follows: < 0.7 = low, 0.7-0.9 = moderate, >0.9 = high. Validity scores were labelled: ≥ 0.3 = good. For the values themselves, see Table S1 in the Supplementary materials.

Table 5. List of instruments that aim to measure functional communication in aphasia.

Thus, from the instruments we have considered, the Scenario Test (van der Meulen et al., 2010) incorporates most of the components from the theoretical framework of communication, while also providing information about how these components influence the communicative ability of the PWA. The Scenario Test is a standardized, objective measure of communication, which allows for the exploration of causal links between cognitive skills and communicative behaviours. In addition to this, the test currently exists in a format that is usable in the clinical as well as the research setting.

Psychometric properties

Our principle aim has been to consider the content validity of the instruments used to measure functional communication in aphasia rehabilitation, i.e. to evaluate whether an instrument samples all the relevant domains of a concept (Streiner et al., 2015). To do so we have selected situated language use (Clark, 1996) as a frame for understanding functional communication. Content validity is not the only property that needs to be considered for a measure to be suitable for clinical use. The instruments should also be evaluated on other psychometric properties, such as the consistency of items included in the instrument (internal consistency), the agreement in scoring between raters (inter-rater reliability), and the stability of test scores for the same person over time (test-retest reliability). To that end, we have provided a summary of measures' reported reliability and validity in Table 5 and Table S1 in the Supplementary materials. It is worth noting that, when reported, the vast majority of instruments show moderate to high reliability across raters and time-points, and good validity when correlated with other measures.

Conclusion

In this paper, we have reviewed current assessments of functional, real-world communication against a theoretically founded framework of communication – defined as situated language use. Conversation Analysis and the Scenario Test came closest to the theoretical framework described in this paper. Out of these two, the Scenario Test (van der Meulen et al., 2010) was selected as the best fit for capturing real-life communicative ability in PWA in an objective, standardized manner, in a clinical setting.

In its present form, the Scenario Test has a number of limitations. As it uses role-play there are cognitive demands placed on PWA by asking them to pretend to be in a situation. It is difficult to consider how this could be altered, but an increased use of props or materials may help reduce some of this burden. The lack of physical referents also limits the test since it removes contextual support that the PWA would have in the real-life equivalent of the situation. The Scenario Test is also prone to ceiling effects for those with mild to moderate verbal impairments. More complex scenarios or a change in scoring may help it to capture a broader range of abilities, to make it useable for PWA with any level of aphasia severity.

The authors hope that the framework presented in this paper will encourage researchers to apply more scrutiny to the concept of functional communication and the instruments used to measure it. It is of crucial importance for the development of effective interventions to have a thorough understanding of real-world communication and of how to capture it.

Acknowledgements

This work was supported the Magdalen Vernon Studentship from the School of Psychology and Clinical Language Sciences, at the University of Reading, UK. We would like to thank Prof. Herbert Clark for helpful comments on an earlier version of this manuscript. We would also like to thank our colleagues at the School of Education, Communication and Language Sciences, Newcastle University, our colleagues who attended the British Aphasiology Society Research Update Meeting 2018 and our fellow members of the ABCD Lab at the University of Reading for their invaluable input and feedback on this work.

Declaration of interest statement

The authors report no conflict of interest.

Supplementary Figures

Type of instrument	Name of test	Psychometric properties [1]	
		Evaluation of reliability and validity values [2]	Reported measures of reliability and validity [3]
Standardized tests	1. CADL-2 (Holland et al., 1999) 2. ANELT (Blomert et al., 1994) 3. Scenario Test (van der Meulen et al., 2010)	1. High IntC and IRR, moderate TRT. Good ConcV. 2. Moderate-high IRR, moderate-high TRT, moderate IntC, moderate-good ConcV for speech production. 3. High TRT and IntC, moderate-high IRR, high IntraRR. Good ConcV.	1. IntC (Cronbach's a = .93), TRT (.89), IRR (.99) ConcV (WAB = .66). 2. IRR (.70-.92), TRT (coefficient of stability: .739-.991), IntC (.7-.72), ConcV (verbal communication: PPMC = .97-.99, AAT = .81-.83). 3. IntC (Cronbach's a = .96), TRT (ICC = .98, p<.001), IRR (ICC = .86-1, p <.001), IntraRR (ICC .96-1, p< .01), ConvV (Scenario Test .85, AAT .79, CETI .5, p <.01).
Non-standardized tests	1. ACESA (Cunningham et al., 1995) 2. Transactional success (Ramsberger & Rende, 2002)	1. Low IRR, high IntraRR and moderate-high TRT. 2. Moderate IRR, high ConstV, low ConcV, moderate TRT.	1. Low IRR (Kendall's coefficient of concordance .05-.23, p<.05), High intraRR (Spearman rank correlation coefficient = 1, p< .01), TRT (Spearman rank correlation coefficient = .86-.98, p<.001). 2. IRR (main ideas: .88, comprehensiveness: .71), moderate ConcV (CADL-2, rs=.6, p = .012), ConstV (main ideas analysis and comprehensiveness ratings rs=.96, p<.01, picture description: rs=.84, p<.01), moderate TRT (.8, p>.01).
Observational profiles (clinician rated)	1. FCP (Sarno, 1969) 2. R-EFCP (Wirz et al., 1990) 3. ASHA FACS (Frattali et al., 1995) 4. TOM, Activity Scale (Enderby et al., 2006)	1. Moderate IRR. 2. N/A. 3. Moderate IntC and IRR, high IntraRR. Low-moderate ConcV. 4. Moderate-high IntC, low-high IRR.	1. IRR (> .87) (Spreen & Risser, 2003). 2. N/A 3. IRR (.88-.92), IntraRR (.94-.99), IntC (.78-.82), ConcV (WAB = .73, Functional Independence Measure (Granger, 1993) = .61-.83, ratings of FC by clinicians and family members = .58-.63) (Spreen & Risser, 2003). 4. IntC (ICC= .77-.91), IRR (.42-.96, this increased with training). FaceV and ContV (acceptable by expert panel).
Observational profiles (client or proxy rated)	1. CETI (Lomas et al., 1989) 2. FOQ-A (Glueckauf et al., 2003; Ketterson et al., 2008) 3. CAL (Pulvermuller & Berthier, 2008) 4. COAST and carer COAST (Long et al., 2009; Long et al., 2008) 5. ACOM (Doyle et al., 2012)	1. High IntC, moderate-high TRT and low-moderate IRR. Good ConcV. 2. High IntC and good ConcV. 3. N/A. 4. Moderate-high IntC and moderate TRT. Good ConstV. 5. Low-moderate ConcV.	1. IntC (Cronbach's a =0.9), TRT (.87-.99), IRR (.62-.81), ConcV (global rating partner = .62**, WAB AQ = .52**, Speech Questionnaire Speaking = .43*, Understanding = .56*) (*= p<.01, ** p<.05). 2. IntC (Cronbach's a =.97), ConcV (ASHA-FACS Social Communication and Basic Needs subscales = .86 (p<.01) and .53 (p<.01), CETI = .74, p <.01, WAB-AQ = .80, p <.001) (Ketterson et al., 2008). 3. N/A 4. Client version: IntC (Cronbach's a = .83-.92, ICC=.72-.88), TRT (ICC = .72–.88), ConvV (Frenchay Aphasia Screening Test = .41-.52). 5. ConcV (ASHA FACS = .63, Porch Index of Communicative Ability (Porch, 2001) = .69, Boston Diagnostic Aphasia Exam Severity Rating Scale (Goodglass et al., 2001) = .72, all p<.001).

Table S1. (cont. on next page). List of instruments that aim to measure functional communication in aphasia.

Type of instrument	Name of test	Psychometric properties [1]	
		Evaluation of reliability and validity values [2]	Reported measures of reliability and validity [3]
Linguistic analysis of connected speech	1. CIU (Nicholas & Brookshire, 1993) 2. IU (McNeil et al., 2001) 3. PPL (Prutting & Kirchner, 1987)	1. High IRR, high IntraRR. 2. High IRR and moderate-high ConcV. 3. High IRR.	1. IRR (.9-.98), IntraRR (.95-.99). 2. IRR (model stories: .96-1, retells: .92-.97), ConcV (Percent CIUs = .75-.96, Percent Accurate and Complete Story Propositions = .79-.96, both p<.05). 3. IRR (left and right hemisphere damaged adults = .91-1).
Analysis of interaction	1. CA (Beeke et al., 2007)	1. N/A, but see Perkins et al. (1999) for a discussion.	1. N/A.

[1] IntC – Internal Consistency, IRR – Inter-rater reliability, IntraRR – Intra-rater reliability, TRT – Test-retest reliability, ConcV – Concurrent Validity (correlated to other measures), ConstV – Construct validity, FaceV – Face Validity, ContV – Content validity. Some measures also reported sensitivity (to discriminate between groups or detect change), we have not reported those here for reasons of space. Psychometric properties are left blank when we have been unable to find any published data.

[2] Cut-offs based on Streiner et al. (2015) and Pritchard et al. (2018): reliability scores were labelled as follows: < 0.7 = low, 0.7-0.9 = moderate, >0.9 = high. Validity scores were labelled: ≥ 0.3 = good.

[3] Values as reported in the original articles. If psychometric values are taken from a different paper, the source is reported in this table.

Table S1. (Cont. from previous page.) List of instruments that aim to measure functional communication in aphasia.

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Chapter 4 | Using a face-to-face collaborative communication task to understand functional communication in aphasia.

Doedens, W.J., Bose, A. & Meteyard, L. (to be submitted)

Abstract

Introduction: Communication in the real world is interactive, multimodal and embedded in context. Systematic investigations of communication in post-stroke aphasia often do not consider all of these components of communication, which has limited the generalisability of such findings. Part of the reason for this, is the methodological challenge in maintaining experimental control, while maximising the naturalistic aspects of the behaviour under study. More research is needed, however, to extend existing knowledge on communication in post-stroke aphasia and to expand the evidence base for assessment and intervention.

Aim: The aim of the current study was to identify which characteristics of functional communication differentiated people with post-stroke aphasia (PWA) from controls on an interactive, multimodal and contextualised lab-based experimental task, and to establish whether PWA show evidence of learning during communication.

Methods & procedures: Sixteen PWA (very severe to mild aphasia severity) and sixteen matched controls completed six trials of a referential communication task with a familiar conversation partner. Performance of both groups was compared on measures of communicative success, efficiency, patterns of interaction and multimodal communication. Changes on these measures as a result of repeated practice on the task were analysed for evidence of learning across trials.

Outcomes & results: The results showed that aphasic communication was characterised by a reduction in the amount of information that was communicated effectively (communicative success), and a marked shift in the modalities that are used for communication (a smaller number of words produced, greater time spent using gesture and drawing/writing compared to controls). PWA and NHC showed similar behaviours in terms of interaction on the task. The results showed evidence of learning and adaptive communication for PWA dyads on the task.

Conclusion: These findings show that functional communication in post-stroke aphasia is characterised by a reduction in the amount of information that is communicated successfully, and a redistribution of modalities used for communication. While some PWA show evidence of learning in communication, more research is needed to understand what factors underpin this ability. Methodologically, these results suggest that the referential communication task is a promising method for systematic, ecologically valid investigations of functional communication in aphasia.

KEYWORDS: Functional communication, aphasia, referential communication task, dialogue, collaboration.

Introduction

Aphasia is a language impairment caused by acquired brain damage such as stroke. This language impairment has a detrimental impact on a person's ability to communicate in their everyday life. The presence of aphasia has far-reaching, negative consequences on many aspects of life that, directly or indirectly, involve communication. It affects a person's ability to maintain friendships and social networks (Cruice et al., 2006; Hilari & Northcott, 2016; Northcott et al., 2016), their sense of independence (Worrall et al., 2011), mood and overall quality of life (El Hachioui et al., 2014; Hilari, 2011; Kauhanen et al., 2000; Lam & Wodchis, 2010). The ability to communicate in the real-world is one of the most important facets of functioning that People With Aphasia (PWA) want to improve through speech and language therapy (Wallace et al., 2017; Worrall et al., 2011). Understanding how real-world communication is affected by the presence of post-stoke aphasia is crucial for the development of meaningful, effective aphasia rehabilitation.

Research into real-world communication (often referred to as *functional communication*) in aphasia has been growing since the 1980s. Despite this, the current understanding of how communication in the real world is affected for PWA, and which environmental (external) and cognitive (internal) factors influence this process remains limited. This makes it difficult to assess functional communication (Brady et al., 2016; Doedens & Meteyard, 2020), to target it in treatment and to predict how therapeutic effects will generalise to real-world behaviour. A number of aspects of real-world communication have received extensive attention in research. For example, research on the influence of the conversation partner's knowledge of aphasia and their ability to enable PWA to communicate efficiently has grown over the past few decades (Kagan et al., 2001; Simmons-Mackie et al., 2016; Wilkinson et al., 2010). Greater knowledge on how such external, environmental factors influence communication for PWA have had a direct, positive impact on interventions, and health-care institution policies, all aimed to improve the communicative circumstances of PWA (e.g. Hickey et al., 2004; Horton et al., 2015; van Rijssen et al., 2018). Other strands of research have focused on internal, cognitive factors such as impairments in non-linguistic cognitive functions and how they impact real-world communication. Impairments to memory, attention, and executive functions have been shown to negatively affect the flexibility needed to communicate effectively in everyday settings (Chiou & Kennedy, 2009; El Hachioui et al., 2014; Ferstl et al., 2005; Groenewold et al., 2014; Helm-Estabrooks, 2002; Murray, 1999, 2012; Salis et al., 2017; Spitzer et al., 2019). Though research is still ongoing, the approach to understanding the impact of post-stroke aphasia on real-world communication remains limited (Doedens and Meteyard, 2020, chapter 2 of the current thesis). A systematic investigation of functional communication and the mechanisms that underpin this behaviour in post-stroke aphasia is needed. Experimental, lab-based research provides the unique opportunity to explore the influence of multiple internal (cognitive) and external (environmental) factors on a person's communicative abilities in a controlled manner. While observational work is often praised for its ecological validity, experimental research is needed to answer questions of causality in functional communication. In this study we address the need for more systematic research on communication by using a lab-based experimental paradigm from research with healthy adults to study communication in PWA.

Lab-based research on real-world communication

Collaborative communication tasks (also referred to as barrier tasks, referential communication tasks, or language games; Hanna et al., 2019; Tanenhaus and Brown-Schmidt, 2007) present a well-established means to research real-world communication in the lab. These tasks were originally designed to investigate referential utterances in interactive dialogue in neurologically healthy controls (Krauss & Glucksberg, 1969). During such a task, at least two people have to collaborate. The amount of information available to each participant differs, requiring the two participants to communicate to successfully complete the task. A classic example of such a task is 'card matching', where two participants are seated across from each other at a table, each has an identical set of cards in front of them. The cards are ordered differently (left to right, or in some other arrangement) for each participant and the aim of the task is for the two sets of cards to be ordered in an identical fashion. One of the two participants has the 'target' order placed in front of them (labelled the 'director' or 'instructor'), and the two participants have to figure out, together, how the second participant's cards (labelled the 'follower' or 'listener') should be arranged. The dyad can communicate freely, asking each other questions, interrupting each other, and so on. They can also see each other, which means communication is unrestricted and participants are free to use gesture, facial expressions, body posture, etc. to communicate. Variations to the 'card matching' version of the task have been used, varying the complexity of materials and the modality in which they are presented (e.g. tracing a route on a map as in Boyle et al., 1994; building structures with lego blocks as in Clark and Krych, 2004, matching letters and colours as in Hanna et al., 2019). This task provides a controlled environment in which unscripted, interactive communication can be observed between two people. It makes it possible to investigate how meaning is created within the context of two people communicating (Clark & Wilkes-Gibbs, 1986; Hengst, 2003).

Variations of this setup were used in aphasia research in the late 1980s and early 1990s (Busch et al., 1988; Carlomagno et al., 1991; Cubelli et al., 1991; Duffy et al., 1984; Feyereisen et al., 1988; Meuse & Marquardt, 1985), with a brief revival in the early 2000s (Carlomagno et al., 2013; Hengst, 2003; Hengst et al., 2010; Purdy & Koch, 2006). The main purpose of using this paradigm was often not, however, to systematically investigate communication in aphasia. Instead, it has often been viewed as a way to assess the use of multimodal communication, as a therapy outcome measure to assess (multimodal) communication, or as an intervention for PWA.

This experimental setup has seen a much wider application in the study of interactive communication in healthy adults and children (e.g. Boyle et al., 1994; Brown-Schmidt and Tanenhaus, 2008; Clark and Krych, 2004; Clark and Wilkes-Gibbs, 1986; Fussell and Krauss, 1992; Hanna et al., 2019; Lysander and Horton, 2012), and research on impaired communication in other populations such as traumatic brain injury (e.g. Gordon and Duff, 2016), Alzheimer's disease (Feyereisen et al., 2007) and patients with hippocampal amnesia (Duff et al., 2005). The paradigm has been adapted to investigate the influence of a vast array of different cognitive and environmental factors. Examples of cognitive (internal) factors are the influence of attention and memory processes on real-time comprehension in communication (e.g. Brown-Schmidt and Tanenhaus, 2008; Metzing and Brennan, 2003) and the existence of shared and private knowledge about the target objects (Keysar et al., 2003). Environmental (external) factors that have been investigated include the presence of a shared visual workspace (e.g. Clark and Krych, 2004), the familiarity of the conversation partner (e.g. Boyle et al., 1994) and the abstractness of the objects that are discussed (Clark & Wilkes-Gibbs, 1986). The effect of these experimental manipulations has been explored on the adequacy of communication (i.e. can someone complete the task successfully?), on the characteristics of communication (i.e. how does someone communicate to complete the task?), and how it affects communication over time (i.e. how are target objects referred to over time? How do people adapt their communication as the task becomes more familiar?). Given the wide range of opportunities that this experimental paradigm provides and the breadth of existing empirical evidence from research with neurologically healthy controls, we decided to apply this paradigm to the investigation of real-world communication in aphasia.

Theoretical underpinnings of the task

The experimental setup of the collaborative communication task in its most basic form adheres to the theoretical framework of real-world communication as described by Doedens and Meteyard (2020, chapter 3 of this thesis). Communication takes place in real-time, between at least two people (i.e. it is interactive), all channels of information can be used, and participants can see each other without delay (i.e. it is multimodal) and finally, the task is embedded in a context at multiple levels. The referential world of objects used in the task are clearly defined (i.e. the situational environment), the task requires a longer communicative exchange, often repeated a number of times (i.e. the communicative context) and the amount of shared knowledge between the two participants is pre-determined (i.e. the degree of common ground). Crucially, all these components can be manipulated, to assess how PWA can flexibly communicate under different circumstances.

Outcome measures

A collaborative communication task provides a rich set of data with options for quantitative and qualitative analyses. Both in the NHC and PWA literature, a number of variables have regularly been reported: measures of time needed to complete the task, accuracy on completing the task, number of turns needed to complete the task (collaborative effort of the dyad) and the number of words produced by a participant (individual, verbal effort; e.g. Clark and Krych, 2004; Hengst, 2003; Hengst et al., 2010). In the aphasia literature, additional measures have been used to quantify how PWA communicate and how much information is exchanged. For example, counts of non-verbal communication strategies such as gesture (Duffy et al., 1984; Feyereisen et al., 1988) or the use of pen and paper for drawing and writing (Hengst, 2003). Other studies have included measures of informativeness, where the main elements of a story or the task that are communicated by a participant are counted, and presented as a function of time or the number of words (Busch et al., 1988; Carlomagno et al., 2013). Previous studies have conducted more detailed analyses of the verbal output to compare performance on this task to a different measure of communication, such as a story-retell task (Carlomagno et al., 1991), or more detailed linguistic and discourse analyses (e.g. Meuse and Marquardt, 1985). To investigate the involvement and contributions of the conversation partner, measures of the amount and types of feedback provided for PWA have also been described (and experimentally manipulated; Carlomagno et al., 2013). In short, the current paradigm provides a number of ways in which to assess communication, from communicative adequacy, to the characteristics of individual or dyad communication, and the efforts made by one or both participants in completing the task.

The current study

The aim of the current study is to investigate how real-world communication for PWA compares to that of a matched group of neurologically healthy controls (NHC) on an adapted version of a collaborative communication task. We will explore which measures can be used to characterise changes in communication due to the presence of post-stroke aphasia (comparing PWA to NHC). We selected a number of measures that characterise communication across four domains: communicative success; communicative efficiency; interaction; and the multimodal nature of communication. Finally, we will also explore whether PWA show evidence of learning or adaptive communication across repeated trials of the same task.

Communicative success. Success is measured by task accuracy (how many objects are placed correctly at the end of a trial). Given that PWA will have difficulties communicating, we might expect a dyad of a PWA and a familiar conversation partner to perform worse on the task than a dyad of two NHCs who are familiar conversation partners. However, previous research has found equally high accuracy scores for PWA and NHC dyads (Hengst, 2003; Meuse & Marquardt, 1985). Therefore, we hypothesize that PWA and NHC will perform equally on the current task.

Communicative efficiency. Efficiency of the dyad is measured by time to complete a trial. We have no specific prediction for the measure of time, as previous research has not reported on the difference between NHC and PWA on this measure, on a similar task. Previous research has shown that PWA show a general slowing of information processing (Purdy, 2002; Yoo, 2017) and they can take longer to communicate the same message (Harmon et al., 2019; Neto & Santos, 2012), suggesting that PWA might require more time to perform the current task compared to NHC.

Interaction. The interactive aspect of communication is measured by the number of clarification requests made, the ability of a person to monitor their own speech (i.e. number of self-initiated repairs), the ability of a person to provide evidence of understanding to their conversation partner (i.e. number of times verbal and non-verbal feedback is provided; referred to as back channels) and the number of turns required to complete the task. Previous research has not explored the difference in the production of back channels and clarification requests by PWA and NHC on a similar task. Although it is generally accepted that people with left-hemisphere lesions and aphasia have relatively intact pragmatic skills, it has been suggested that they might show differences in pragmatic behaviours as a consequence of the linguistic impairment (Beeke, 2012). Based on the assumption that PWA might struggle more to understand their conversation partner, we might see a greater number of clarification requests by PWA compared to NHC. The existence of more difficulties with speech production might provide more opportunity for PWA to self-initiate repairs compared to NHC (Meuse & Marquardt, 1985). We therefore expect higher rates of self-initiated repairs and clarification requests by PWA compared to NHC.

The number of turns required to complete the task reflect the amount of collaborative effort made on the task. Work from conversation analysis has shown that PWA might require more turns during conversation, due to, for example, longer repair sequences ("hint and guess" sequences between dyads, Beeke, 2012; Laakso and Klippi, 1999). However, previous research with a smaller group of PWA and NHC on a referential communication task showed no differences in the number of turns between PWA and NHC. Based on these findings, we hypothesize that both groups might require equal number of turns on this task (Meuse & Marquardt, 1985).

Multimodal communication. Multimodal aspects of communication are measured by the number of words produced, time spent gesturing and time spent drawing/writing. Previous research on the difference in the number of words used on the current task is inconclusive: Meuse and Marquardt (1985) found a (statistically nonsignificant) trend for a small group of PWA (described as Broca's) producing more words compared to NHC, while Busch et al. (1988) suggested non-fluent PWA might use fewer words to achieve the same results. These researchers did not assess this difference statistically, however, partly due to the large variance found in the NHC group. Based these findings, we hypothesize there might not be a statistical difference between the number of words at the group level for PWA and NHC, but that differences in number of words produced will vary according to aphasia severity.

Research on the difference in number of gestures produced by PWA and NHC is inconclusive, often showing an influence of task on the way gesture is used alongside speech. A study by

Sekine et al. (2013) showed that when gesture rate is calculated per number of words produced on a personal narrative dialogue task, PWA produced more gestures compared to NHC. However, in a recent study of lab-based, unscripted dyadic conversation, no differences were found at the group level in the number of gestures between PWA and NHC (Kistner, 2017). Based on these findings, we hypothesize that we will not find differences in gesture time between PWA and NHC. Previous research with NHC has not included the use of pen and paper. Hengst (2003) describes some PWA choosing to use drawing/writing as a communication strategy. We therefore cannot predict how PWA and NHC will compare on the time spent drawing/writing on the current task.

Learning. In line with Clark's model of collaborative grounding, we expect that as PWA repeat the task and create more common ground with their conversation partners, we will observe reductions in efforts across all communicative domains (Clark & Wilkes-Gibbs, 1986; Hengst, 2003; Hengst et al., 2010). However, as previous research has found both groups performing at ceiling, we do not expect to any changes in communicative success (task accuracy) scores over time (Hengst, 2003; Meuse & Marquardt, 1985). If the current task does show a lower rate of communicative success for PWA, then this may show benefits of increasing common ground (i.e. an improvement in accuracy rates over trials).

Domains of communication	**Measures**	**Predictions**	
		PWA vs NHC	**Learning**
Communicative success	• Task accuracy	PWA = NHC	No
Communicative efficiency	• Time to complete the trial	PWA > NHC	Yes
Interaction	• Number of self-initiated repairs	PWA > NHC	Yes
	• Number of clarification requests	PWA > NHC	Yes
	• Number of back channels	PWA >< NHC	Yes
	• Number of turns	PWA = NHC	Yes
Multimodal communication	• Number of words	PWA = NHC *vary by severity*	Yes
	• Gesturing time	PWA = NHC	Yes
	• Drawing/writing time	PWA >< NHC	Yes

Table 1. Hypotheses for each outcome measure in terms of the expected difference between the experimental groups (PWA vs NHC) and expected changes across trials as evidence of learning. >< non-directional hypothesis.

Ethics

Ethical clearance for the current study was provided by the School of Psychology and Clinical Language Sciences, University of Reading (Ref: 2018-093-LM). All participants provided informed consent prior to taking part in the study. Consent and information forms were adapted to aphasia friendly format for the participants with aphasia. This study was part of a larger research project investigating conversation with different conversation partners in aphasia.

Participants

Eighteen participants with post-stroke aphasia were recruited through the Aphasia Research Registry of the School of Clinical Language Sciences, University of Reading (British Academy Grant ARP scheme 190023) and local stroke groups. Two PWA were excluded from the study due to only completing three trials on the experimental task. The implications of this will be considered in the discussion. Therefore, a total of sixteen participants with post-stroke aphasia (42-72 years, M = 60.94, SD = 9.41, male = 9) and sixteen neurologically healthy control participants (NHC, 52-84 years; M = 64.94, SD = 9.66; male = 7) took part in the current study. The two groups were matched for age ($t(30) = 1.19$, $p = 0.245$) and years of education ($t(29) = -0.07$, $p = 0.946$). PWA were at least one-year post-stroke (1-14 years, M = 7.04, SD = 3.85) and were native speakers of English prior to the stroke. Exclusion criteria were an inability to provide consent due to severe comprehension or cognitive difficulties and any coexisting neurological diagnoses such as dementia. NHC were recruited through the older adult research panel at the School of Psychology, University of Reading. Exclusion criteria were a history of neurological illness. All subjects reported normal or corrected-to-normal vision and hearing.

Each participant took part alongside a familiar conversation partner (CP). PWA self-nominated a person who they spoke to regularly (partner, friend or family member, aged 22-72 years, M = 54.12, SD = 15.12, see Table 2). For PWA, all CPs lived in the same house with the PWA (except those labelled child, ex-partner or friend). For NHC, partners were recruited as the CP (aged 51-79 years, M = 64.12, SD = 7.57, see Table 1 in the Supplementary Materials). All CPs lived in the same house with their partner. All CPs reported normal or corrected-to-normal vision and hearing. None of the NHC reported a history of neurological illness.

Background measures

PWA completed the Western Aphasia Battery – Revised (WAB-R; Kertesz, 2009). The aphasia quotient score (AQ) ranged from 11.60-94.2 (M = 65.88, SD = 26.59), with severities ranging from very severe to mild (see Table 2). Thirteen out of sixteen PWA had some degree of weakness (hemiparesis) on the right-hand side due to the stroke. All PWA were mobile enough to attend the experiment at the University clinic and used their unaffected arm and hand effectively. One PWA attended the clinic in a wheelchair.

All participants without aphasia completed the Montreal Cognitive Assessment (MCA score: 17-30; M=27.23, SD=2.49). Six participants (2 FCP to NHC, 3 FCP to PWA and 1 NHC) scored below the cut-off score of the test.

Procedure

The participants were invited to take part in a study about conversation in aphasia. For PWA, background tests were administered either at the School of Clinical Language Sciences, University of Reading or at the participant's home. NHC were invited to the University of Reading for background testing. For the experimental session, all participants visited the Speech and Language Therapy Clinic at the University of Reading.

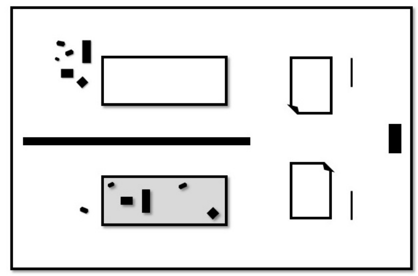
Task

The experimental design consists of a collaborative, referential communication task (Clark & Krych, 2004; Krauss & Glucksberg, 1969) as discussed in the introduction. The task elicits unscripted, interactive and multimodal communication, replicating a real-life face-to-face communicative setting. Pairs sat across from each other at a table. Both faced identical playmobile rooms (see Figure 1). A low barrier was placed between the two participants to block the view of the other's room. Five items were placed in the instructor's room and one item was placed outside of that room with the instruction that they could ignore the latter item. For the listener, the same six were placed outside of the room. The task was presented as a game. Pairs were instructed to work together to recreate the setup from the instructor's room, in the listener's room. They were asked to communicate as they normally would, including the use of any communication aids. Pen and paper were provided for both participants, on one side of the table where the barrier did not block interactions between the two participants. Participants were instructed not to pick up an item and show it to their CP, and not to look over the barrier at

PWA											Conversation partner					
								Scenario Test								
ID	Sex	Age	Ed.	Time post stroke (months)	WAB-AQ	Severity	Type	Rawscore	Perc.	Classification*	ID	Sex	Age	Ed.	Partner type	Years knowing PWA
69	M	72	10	71	11.6	very severe	Global	35.94	34	Limited	70	F	69	11	Partner	54
43	M	57	12	58	18.3	very severe	Broca/Global	42.4	46	Okay	44	F	56	13	Partner	30
15	F	57	19	56	27.6	severe	Wernicke	20.25	14	Almost none	16	M	60	17	Partner	40
19	M	65	13	177	56.8	moderate	Broca	44.47	49	Okay	20	F	60	13	Partner	40
45	F	42	19	12	58.2	moderate	Broca	48	63	Okay-Good	46	F	43	13	Friend	10
5	M	72	16	123	61.6	moderate	Broca	41.63	42	Okay	6	F	55	13	Ex-partner	25
41	M	45	11	75	62.5	moderate	Broca	37	34	Limited	42	F	41	13	Partner	20
37	F	68	17	136	69.5	moderate	Conduction	48	63	Okay	38	M	69	17	Partner	50
47	F	70	10	116	72.2	moderate	Broca	49	68	Okay-Good	48	F	49	15	Child	49
78	F	51	15	20	74.1	moderate	Anomic	47.47	60	Okay	79	M	23	17	Child	23
11	M	66	17	56	83.8	mild	Conduction	53	93	Good	12	M	22	13	Grandchild	22
53	M	67	19	42	89.4	mild	Anomic/Transc. sensory	53	93	Good	54	F	72	14.5	Partner	33
7	F	51	16	55	90.1	mild	Anomic	54	100	Good	8	M	63	14	Partner	10
1	M	64	11	133	90.8	mild	Anomic	53	93	Good	2	F	58	18	Partner	26
67	F	65	16	110	93.3	mild	Anomic	53	93	Good	68	M	66	18.5	Partner	47
13	M	63	18	111	94.2	mild*	Transc. sen-sory	51	78	Good	14	F	60	18	Partner	42

Table 2. Descriptives for PWA and their familiar conversation partners, ordered by WAB-AQ score (lowest to highest; 0-25 is very severe, 26-50 is severe, 51-75 is moderate, and 76–above is mild, *93.8 is the cut-off for an aphasic score). Scenario Test classification is based on the percentiles of the Dutch norm group, solely used her to provide a descriptive classification. *Classification refers to the communicative ability of the PWA: "almost no communicative ability", "seriously limited communicative ability", "okay communicative ability in simple situations" and "good communicative ability in simple situations". Ed. = Education in years.

(a)



(b)

Figure 1. Schematic overview of the experimental setup. **View A** shows a side-view: two participants sitting across from each other with a low barrier between them to block only the view of the other person's workspace. **View B** shows the table from above: two identical room layouts. Participant A has five items placed in the room, plus one distractor object on the side. For participant B, all six items are placed outside of the room. Pen and paper are placed to the left-hand side for the PWA (in case of neglect, hemianopia or hemiparesis), and is provided for both participants. A button at the far end of the table (again to the left of the PWA) is used to indicate completion of the task.

the other room. Aphasia friendly images were used to visually support the instruction for all participants. After questions were answered, the experimenter left the room for the duration of the task. When the pair completed the task, they pressed a button. The experimenter subsequently re-entered, took a picture of both rooms, and showed the participants the result. Any paper used was collected by the experimenter. While participants freely discussed the outcome of the task, the next trial was set up.

Each pair completed the game six times: for each trial, roles (instructor/follower) were swapped, resulting in three instructor trials and three follower trials for each participant. The starting role was counterbalanced across participants. A different setup of items was used for each trial, the order of which was randomized for each pair.

Materials

An empty Playmobil room with five walls, four windows and one door was used for the current experiment (see Figure 2). Six Playmobil objects were selected based on psycholinguistic features that have been shown to influence lexical retrieval in PWA, i.e. high levels of concreteness, familiarity and imageability, as well as (approximately) low number of phonemes to

(a) (b)

Figure 2. Two examples of item setup in the Playmobil living room. Five items are placed in different locations in the room, one item was always left on the side as the distractor (and did not need to be placed by the listener).

facilitate naming of the items as much as possible (Nickels & Howard, 1995).

Six different room setups were created by placing five Playmobil items in various configurations across the room (see Figure 2 for examples). On each trial, a single item was used as a distractor and placed outside of the room (counterbalanced across trials). Three additional objects were used as reference objects and were always in the same position across all trials (a chest of drawers, a television set and a potted plant).

Coding

All trials were video- and audio recorded. Videos of the interactions were coded using ELAN software (2019). A total of nine measures were extracted from the data. The measures of communicative success (accuracy), communicative efficiency (trial time), and most measures of interaction (individual contributions: number of self-initiated repairs, number of clarification requests and number of backchannels) were coded for the entire dataset. Due to the time-consuming nature of the coding for a number of these measures, only a subset of the data was used for the more detailed coding procedures. A subset of eight PWA that represented the full range of WAB-AQ scores were selected for a more detailed analysis. Eight NHC (matched on age, gender and years of education to the subset of PWA) were also included in this subset. The detailed analysis was conducted on the measures of interaction (collaborative interaction: number of turns) and multimodal communication (number of words, gesture time and drawing/writing time). For this subset, only the first and last trials in which these participants took on the instructor role were analysed, resulting in a total of two trials analysed. The measures for the full dataset were coded as follows:

Communicative success

Task accuracy. Task accuracy was defined as the correct placement of the items in the follower's room as compared to the instructor's room as set up by the experimenter. The setup of the instructor's and follower's room was photographed at the end of each trial. Both images were scored by two independent judges on accuracy (correct/incorrect) of two aspects of the item: its location (in the room and in relation to other objects) and its orientation. For the people, two additional aspects were coded: the action that was undertaken (i.e standing, sitting, etc.) and the positioning of the arms. For all other objects, the action was always coded as correct, resulting in a maximum score of 3 per object, and 4 per person (a total maximum score of 20 and a minimum score of 4, examples of low, moderate and high accuracy scores are provided in Figure 3). In case of doubt due to different angles of the pictures, a grid was superimposed on the floor of each image using Kinovea software (Charmant, 2006-2011).

Communicative efficiency

Trial time. Trial time was defined as the moment participants started to communicate on a trial (speak, draw, gesture, etc) until the moment one of the participants pressed the button to signal the experimenter to come into the room. The total trial time was calculated per trial in seconds.

Interaction

Self-initiated repairs. Self-initiated repairs were defined as instances where a participant explicitly attempted to repair or change their own output (often described as the repair initiation; Schegloff et al., 1977; Wilkinson, 2006). A self-initiated repair was always an explicit correction initiated by the interlocutor themselves, without any prompts from the conversation partner. Three different types of self-initiated repairs were coded, partially based on Perkins (1993, see Table 3). Examples of word-finding repairs are also shown in the table. Repetitions of parts of words are expected in typical speech. If parts of a word are repeated without revisions, additions or explicit statements of difficulties finding a word, these were therefore not coded as a repair. All self-initiated repairs are coded, regardless of the way in which the repair is resolved (i.e. by the interlocutor themselves, collaboratively with their conversation partner or by the conversation partner). Whether a repair is successful or not was not coded (i.e. whether the

(a) **(b)**

1 **2** **3**

Figure 3. Examples of different accuracy scores. **(1): low score (a).** shows the instructor view, as it was set up by the experimenter. (b) shows the final listener view, resulting in a total score of 7 points. Adding to the baseline score of 4: the chair is in the right orientation (+1), the cat is in the correct orientation (+1), the arms of the person are correctly placed (+1). **(2) moderate score.** (a) shows the instructor view, as it was set up by the experimenter. (b) shows the final listener view, resulting in a total score of 15 points. Adding to the baseline score of 4: the lady and the chair are in the right position with the correct arm position (+6), the man is in the correct position with his arms in the correct position (+2), the cat is in the correct orientation (+1) and the table is correctly kept outside of the room (+2). **(3) high score.** (a) shows the instructor view, as it was set up by the experimenter. (b) shows the final listener view, resulting in a total score of 20 points. All 5 items are placed correctly in terms of location, orientation, action and arm placement.

correction creates a correct utterance or not, or whether the correct word is produced, or the search is abandoned). Non-verbal instances of self-initiated repairs are also included (e.g. direct gaze at the partner to provide help in a word search, Beeke, 2012). The total number of self-initiated repairs was counted for each trial and participant.

Clarification requests. Clarification requests are defined as instances when one interlocutor indicates to their conversation partner that they have not fully understood what has been said (also described as an 'other-initiated' repair; Schegloff et al., 1977). Five types of clarification requests were coded, partly based on Schegloff, Jefferson and Sacks (1977, see Table 3). Coding included verbal and non-verbal clarification requests such as eye gaze and frowning, or clear shrugs directed at the CP. The total number of clarification requests was counted for each trial and participant.

Back channels. Back channels are defined as brief responses produced by the interlocutor who is, at that moment, not the 'main speaker' (Schegloff, 1982; Tolins & Fox Tree, 2014; Yngve, 1970). These minimal responses are also referred to as continuers and acknowledgements in the literature (Clark & Brennan, 1991). Back channels do not represent full turns and are often interjected in the main speaker's turn, as an indication of continued understanding by the 'listener', or permission to continue (Goodwin, 1986; Schegloff, 1982). Brief interjections into the continued talk of the 'main speaker' such as vocalisations (e.g. 'uh huh', 'yeah', 'oh' and 'wow') and gestures (e.g. head nods) were coded as back channels. The total number back channels was counted for each trial and participant.

Detailed coding

Interaction

Number of turns. Following Duff et al (2005) turns were coded as utterances produced by one participant, which could be both verbal and non-verbal. A change in turn was coded as a change in speaker. When two participants communicated simultaneously, both utterances were counted as a turn. Transcription annotations that were up to 200 milliseconds apart were merged to form one annotation or turn (defined as a micropause by Riggenbach, 1991).

Multimodal communication

Number of words. The audio files were fully transcribed in PRAAT (Boersma & Weenink, 2020). As described in Duff, Hengst et al. (2005) and Clark and Fox Tree (2002), fillers were

Type of code	Description	Example
Self-initiated repairs		
Revised repair	The interlocutor repeats the main clause with modifications	"the man goes under the chair…. no I mean he goes on the chair"
Addition repair	The interlocutor provides additional information to the main clause	"the sofa is in opposite the window…the small window"
Word finding repair	The interlocutor explicitly has word-finding difficulties (repetitions without revisions, additions or explicit statements of difficulties finding a word are not included).	"the d…d… oh what is that word?"
Clarification requests		
Request for elaboration or clarification	The interlocutor asks their CP to provide more information on what has been said. This type of clarification request includes most wh-questions.	"Which window?" or "Where?"
Statement of not understanding	The interlocutor indicates that they did not follow what their CP said.	"I don't understand" or "Huh?"
Partial or complete repetitions	The interlocutor repeats (part of) a phrase as produced by the CP, sometimes with a questioning intonation, to check if they have understood correctly.	CP1: "by the window on the left" CP2: "by the window on the left?"
Insertion	When the CP is speaking the interlocutor inserts a word or phrase that fits into the utterance of the CP. This can happen, for example, when the CP pauses to search for a word. The insertion functions as an evaluation for the interlocutor to assess if they have correctly understood the utterance of the CP.	CP1: "and then the sofa is facing the.." CP2: "the tv cabinet?" CP1: "yes, the tv cabinet"
Indirect request for clarification	The interlocutor asks for a repetition of what has been said, indirectly indicating they (might not) have not fully understood or followed.	"Please speak more slowly"

Table 3. Different types of self-initiated repairs and clarification requests that were coded.

counted as words (e.g., um they both = three words), contractions were counted as one word (e.g., won't = one word) and verbal back-channel or continuer responses (i.e., uh huh, yeah, m hm) were each counted as one word (e.g., uh huh = one word). Transcribed annotations were exported from ELAN (MPI: The Language Archive, 2019) and the total number of words was calculated in Microsoft Excel.

Gesture time. Visible movements of the hands, face and body were coded as gestures. Gestures which, as judged on the video, would not have been visible to the conversation partner (e.g. pointing at an object in one's own room) were coded separately (i.e. as 'not visible'). Gestures were coded following Silva, Holler, Ozyurek and Roberts (2020) and Kita et al. (1997): annotations started at the first identifiable moment of a visual depiction (the 'stroke') and ended at the beginning of a halt or retraction. Annotations therefore did not include "gesture preparation and retraction, nor extended freezes (i.e. 'holds') before an initial stroke or after a final stroke" (Silva et al., 2020, p.9). The total time gesturing visibly was calculated per trial in seconds.

Drawing/writing time. Time spent drawing or writing something on paper were coded as well. Annotations started right before the pen touched the paper and ended when the pen was removed from the paper (and was consequently put down, or not used). Brief moments where the pen did not touch the paper, but the person writing/drawing did not engage in any other activity (such as speaking or dropping the pen), were not coded as the end of an annotation. The total time using pen and paper was calculated per trial in seconds.

Statistical analysis

The data did not meet assumptions of normality and showed significant differences in variance between groups. To avoid relying on assumptions of normality, a bootstrap procedure was used (with 10,000 bootstrap samples as recommended by Rousselet et al., 2019). Outliers and differences in variance between groups were dealt with by choosing robust analyses based on the median (percentile bootstrap: *sppba*, *sppbb* and *sppbi* in Wilcox, 2012) and 20% trimmed means (bootstrap-t: *bwtrimbt* in Wilcox, 2012). The results from the median analysis are reported in the paper. When there was a difference in outcome, results from both analyses are discussed. An alpha threshold of .05 was used to determine statistical significance. All analyses were conducted using the software R version 3.6.3 (2020).

To explore the difference in performance between PWA and NHC, as well as the differences across trials, a between-by-within 2 (group: PWA/NHC) x 6 (trial: 1/2/3/4/5/6) robust analysis was conducted on the measures of trial time, accuracy, number of self-initiated repairs, number of clarification requests and the number of backchannels. For the detailed measures (i.e. number of turns, number of words, gesture time and drawing/writing time), the same analysis was conducted as a between-by-within 2 (group: PWA/NHC) x 2 (trial: 1/6) robust analysis.

For the measures that significantly differentiate between PWA and NHC, the individual data points representing the average across trials are plotted by group and colour coded for aphasia severity. Individual patterns of behaviour were also plotted for those measures that show significant change across trials. Separate plots were created for each PWA, showing the change in the measure across trials. Each plot is colour-coded for aphasia severity (as measured by the WAB-AQ).

Results

Communicative success

Accuracy

For two participants in the NHC group, accuracy scores are missing for one trial due to technical issues. As the chosen analysis cannot be run with missing trial data, these two participants will be removed from the dataset for the accuracy analysis.

The median accuracy scores are shown by group in Figure 4a. The PWA group shows outliers at the lower end of the accuracy score. The 2x6 analysis confirms the observed difference: the main effect of group is significant (PWA/NHC, test statistic = 3, $p < .001$), with lower accuracy scores for PWA dyads (median = 15, CI = 14.08, 17.17) compared to NHC dyads (median = 18.33, CI = 17.17, 18.67).

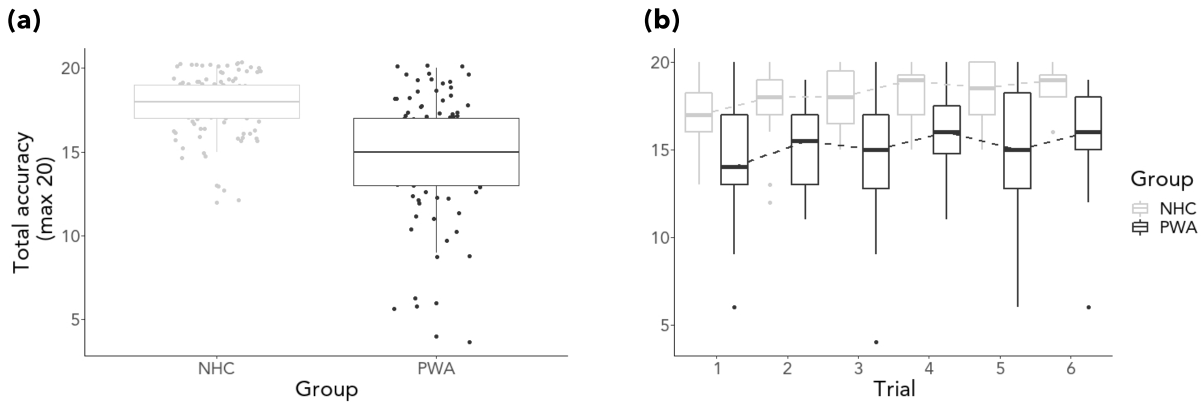


Figure 4. Graphs showing median and interquartile range of accuracy scores, (a) by group and (b) by group, across trials.

There was a significant main effect for trial in the trimmed means analysis (1-6; p = .036)[1], indicating a significant difference in accuracy across trials. Pairwise comparisons show that the significant effect is driven by a significant difference between trial 1 and 6, with higher accuracy scores in the last trial (median = 18, CI = 17, 19) compared to the first trial (median = 16, CI = 14.5, 17; p < .001, against critical value p = .0033).

There was no significant interaction for group*trial (p = .305), indicating that the pattern of improvement of accuracy scores was similar for both groups (Figure 4b).

Individual performance on task

Average accuracy scores on the task are plotted for each individual participant in Figure 5. Data for PWA has been grouped by aphasia severity, as measured by the WAB-AQ. Average performance on the task roughly matched with aphasia severity: the more severe the impairment, the lower the overall accuracy on the task. This pattern seems clearest for the mild-moderate level of impairment, while performance on the task by the severe-very severe groups might not be as strongly related to the language impairment. These effects are confounded by the uneven spread of data points across aphasia severities.

[1] The main effect of trial was not significant based on the median analysis (p = .094). A potential ceiling effect means that the median might not reflect the improvements in performance of each group between trials as reliably as the trimmed means. We will therefore rely on the trimmed mean analysis here.

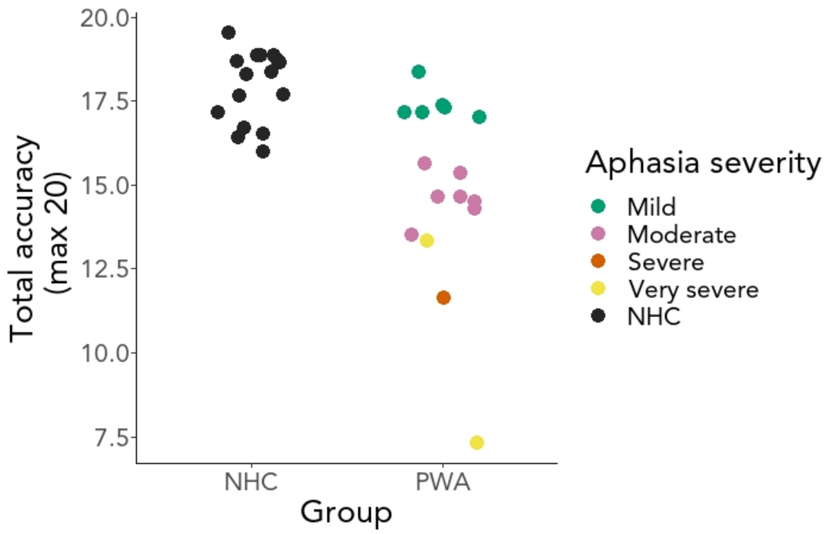


Figure 5. Average accuracy scores for each individual by group and aphasia severity, as measured by the WAB-AQ.

Individual patterns of change across trials

Accuracy scores are plotted by trial for each PWA dyad in Figure 6. The plots are ordered by aphasia severity, as measured by the WAB-AQ (starting with very severe presented in light grey, up to mild presented in black). In the PWA group, one out of sixteen dyads performed at ceiling on the first trial, suggesting that for most PWA dyads there was room for improvement on the task. The majority of PWA dyads (12 out of 16), showed an improvement in accuracy scores on trial 6 compared to trial 1 (all plots in Figure 3 without a border). Two dyads did not show a change in accuracy scores (dyads 69 and 78, plots with a black border in Figure 6), while two other PWA dyads showed a decrease in performance across trials (dyad 41: -2 from a baseline score of 14, and dyad 67: -7 from a baseline score of 20, plots with a black border in Figure 6). Dyads with no change or a decrease in accuracy scores represent all aphasia severities (from very severe to mild, as shown in Figure 6), suggesting that learning on the current task was not strongly related to the severity of the linguistic impairment in PWA as measured by the WAB[2].

[2]An improvement in accuracy scores was defined as an improvement in scores between trial 1 and 6. Note that this includes trials where PWA take on different roles. Further investigations are needed to assess the improvement of accuracy scores across trials within each role (listener/instructor)

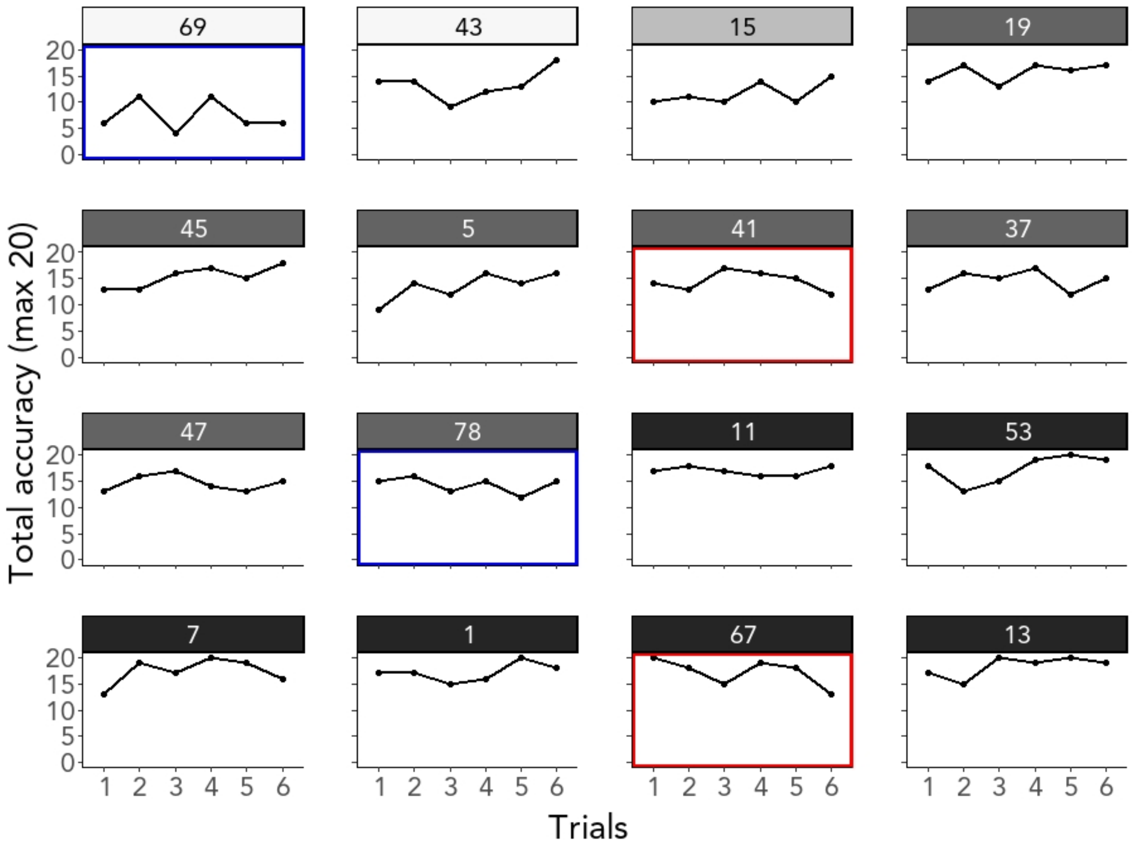


Figure 6. Plots showing the accuracy scores for each PWA dyad by trial, arranged by aphasia severity: light grey = very severe, black = mild. Plots circled in blue show no change in accuracy score between trial 1 and 6, plots circled in red show a decrease in accuracy scores between trial 1 and 6. All other plots show improved performance over time.

Finally, it should be noted that the individual plots in Figure 6 show that the influence of role (being an instructor or listener) had a bigger effect on communicative adequacy for some PWA compared to others, as evidenced by larger fluctuations in accuracy scores between trials (e.g. dyad 69, 5, 37).

Communicative efficiency

Trial time

The median trial times are shown by group in Figure 7a. The 2x6 analysis shows that the main effect of group (PWA/NHC) is not significant (test statistic = 44.37, p = .197, one-tailed), with PWA and NHC showing similar overall total trial times.

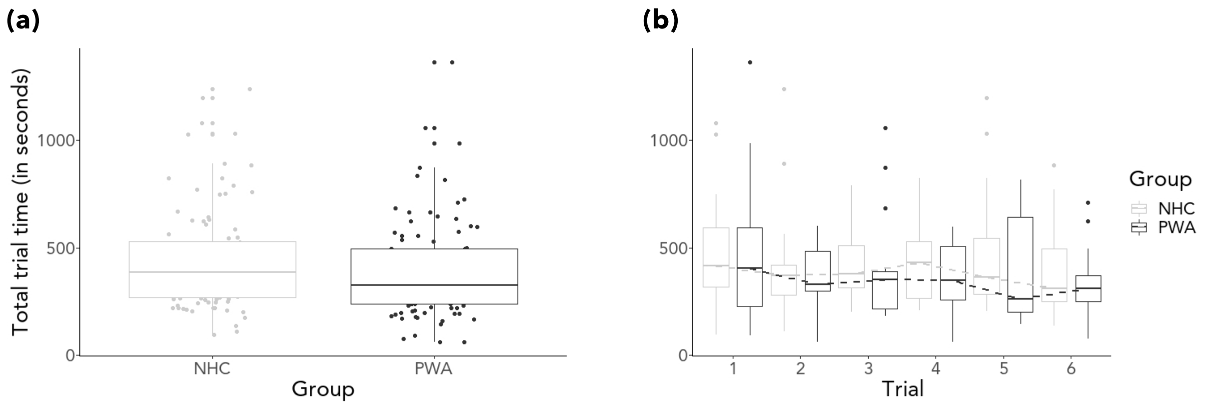


Figure 7. Graphs showing median and interquartile range of total trial times, (a) by group and (b) by group, across trials.

There was no significant main effect for trial (1-6; p = .066, one-tailed), with similar overall total trial times across all six trials. Furthermore, there was no significant interaction for group*trial (p = .786), the effect of trial was similar for both groups (Figure 7b).

Interaction

Number of repairs

The median number of self-initiated repairs are shown in Figure 8a. The 2x6 analysis shows no significant main effect of group (PWA/NHC, test statistic = 4.5, p = .129, one-tailed), with equal numbers of self-initiated repairs for PWA (median = 7.2) and NHC (median = 9).

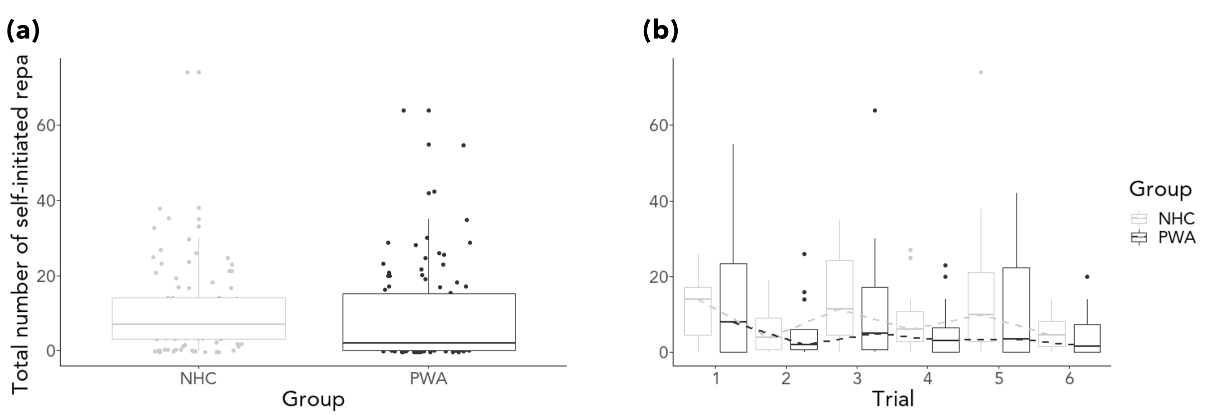


Figure 8. Graphs showing median and interquartile range of the number of self-initiated repairs, (a) by group and (b) by group, across trials.

There was no significant main effect for trial in the trimmed means analysis trial (1-6; p =

.292, one-tailed, median analysis: p = .28, one-tailed), with similar numbers of self-initiated repairs across trials.

There was also no significant interaction for group*trial (p = .814), with a similar pattern of change over the trials for both groups (Figure 8b).

Number of clarification requests

The number of clarification requests for PWA and NHC is shown in Figure 9a. The 2x6 analysis shows that the main effect of group is not significant (PWA/NHC, test statistic = 5.33, p = .099), with equal numbers of clarification requests for PWA and NHC.

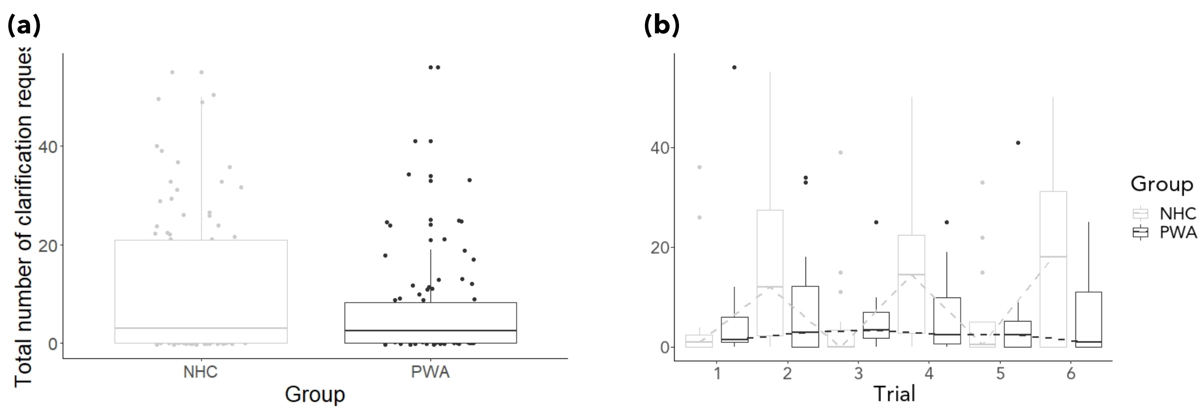


Figure 9. Graphs showing median and interquartile range of the number of clarification requests, (a) by group and (b) by group, across trials. The jagged pattern in the NHC data of graph B reflects the uneven counterbalancing of roles across participants. Within the NHC group, more subjects started as instructors on trial 1. The greater number of clarification requests in trials 2, 4, and 6 reflects the greater number of NHC taking on the listener role on those trials. For PWA, the counterbalancing of roles across trials was evenly divided.

The main effect of trial was not significant (1-6; p = .409, one-tailed), with similar numbers of clarification requests across trials.

There was no significant interaction for group*trial (p = .556), with no significant differences in patterns of number of clarification requests between groups, across trials. (Figure 9b).

Number of back channels

The median number of back channels were similar across both groups (Figure 10a). The 2x6 analysis confirms this: the main effect of group is not significant (1-6; p = .817), with similar numbers of back channels for PWA and NHC.

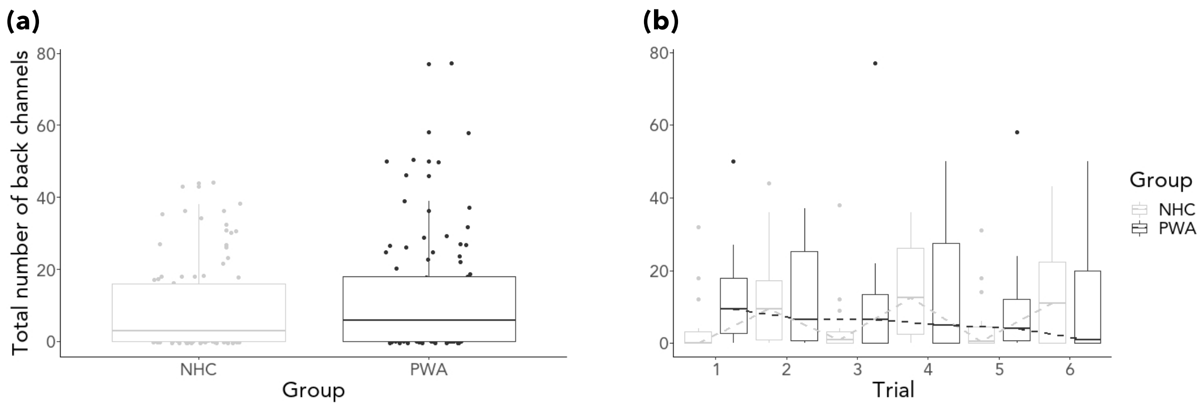


Figure 10. Graphs showing median and interquartile range of the number of back channels, (a) by group and (b) by group, across trials.

The main effect of trial was also not significant (1-6; p = .409, one-tailed), with similar numbers of back channels across trials.

Finally, there was no significant interaction for group*trial (p = .556), with no significant differences between groups in the number of back channels across trials (Figure 10b).

Number of turns

The 2x2 analysis shows that the difference in number of turns between the groups is not significant (PWA/NHC, test statistic = -15, p = .162), with PWA and NHC using the same number of turns to complete the task (Figure 11a).

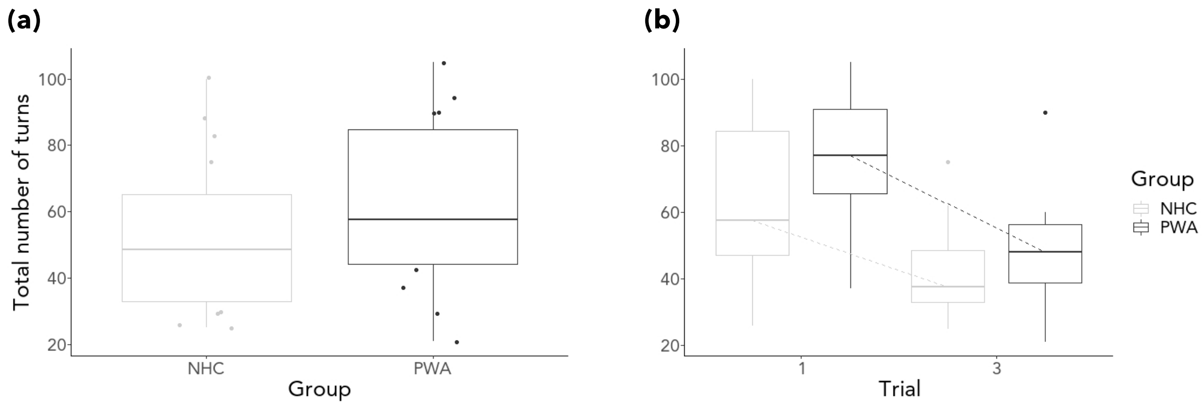


Figure 11. Graphs showing median and interquartile range of the number of turns, (a) by group and (b) by group, across trials.

The difference in number of turns across trials was significant (1-2; test statistic = 21.5, p = .004, one-tailed), with fewer turns needed for the final trial (median = 43, CI = 34, 55) compared to the first trial (median = 71, CI = 53, 88) (Figure 11b).

There was no significant interaction for group*trial (test statistic = -4.5, p = .642), indicating that both groups showed a similar pattern of change in the number of turns across trials.

Individual patterns of change across trials

The number of turns is plotted by trial for each individual PWA in Figure 12. The plots are ordered by aphasia severity, as measured by the WAB-AQ (green is very severe, purple is moderate, and pink is mild). In the PWA group, all but one participant showed a decrease in the number of turns in the last trial compared to the first trial. The only participant who showed an increase in number of turns in the last trial compared to the first trial, was also the participant who showed the lowest number of turns on the first trial (37 compared to 49-105 for the other PWA). The increase in number of turns coincided with an increase in overall trial time, suggesting that this participant was spending more time on the task in general (participant 43). One participant showed minimal change in the number of turns (PWA67, a reduction of 4 turns in trial 3). Taking into account the small number of participants, there is tentative evidence that the reduction in the number of turns across trials is not directly related to the severity of the linguistic impairment.

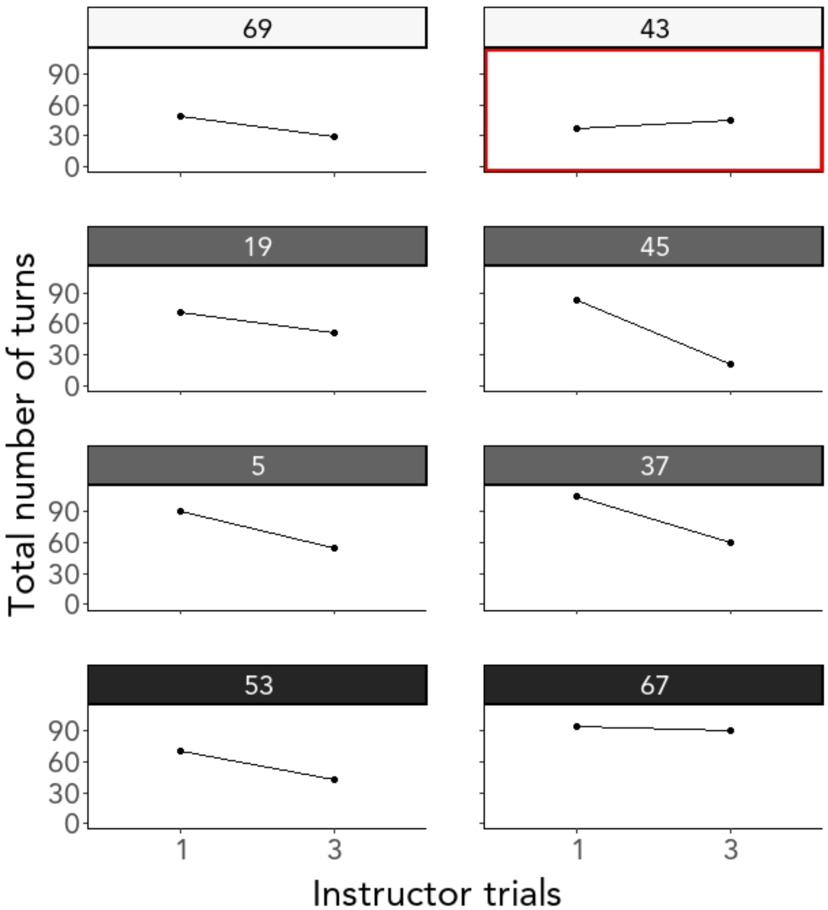


Figure 12. Plots showing the total number of turns for each PWA dyad by trial (showing only the first and last trial on which the PWA took on the instructor role), arranged by aphasia severity: light grey = very severe, mid-grey = moderate, black = mild. Plots circled in red show an increase in the total number of turns between trial 1 and 6. All other plots show a decrease in the number of turns across trials.

Multimodal communication

Number of words

Figure 13a shows a clear difference in the median number of words used by the two groups, with PWA using fewer words compared to NHC. The 2x2 analysis resulted in a significant main effect of group (PWA/NHC, test statistic = 318.5, $p = .011$), with PWA producing fewer words (median = 153.25, CI = 80, 417) compared to NHC (median = 462.75, CI = 359.5, 788.5).

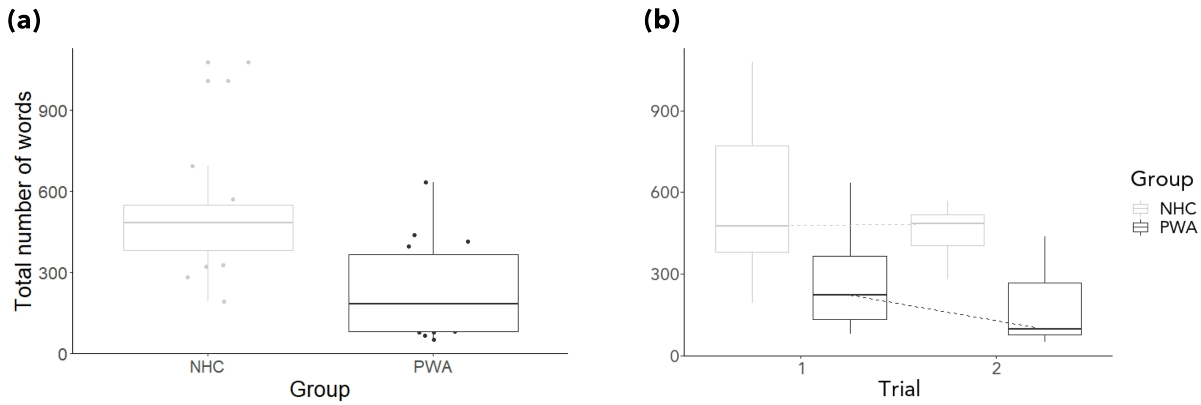


Figure 13. Graphs showing median and interquartile range of the number of words produced on the task, (a) by group and (b) by group, across trials.

There was a significant main effect for trial (1-2; test statistic = 77.5, p = .0.37, one-tailed), with fewer words needed for the final trial (median = 367, CI = 118, 468) compared to the first trial (median = 377, CI = 216, 544).

There was no significant interaction for group*trial (test statistic = -6, p = .909), with similar overall changes in the number of words across trials for both groups (Figure 13b).

Figure 13b suggests that the difference in number of words produced across trials might be driven by a change in the PWA group, rather than by a change for NHC. Planned comparisons showed that this effect was significant for PWA (p = .058, one-tailed = .029), and not for NHC (p = .069), with PWA producing more words on the first trial (median = 222.5, CI = 90, 397) compared to the last trial (median = 99.5, CI = 67, 414).

Individual performance on task

The average number of words used to complete the task are plotted for each individual participant in Figure 14. Data for PWA has been grouped by aphasia severity, as measured by the WAB-AQ. Participants with mild language impairments produced an average number of words that is similar to that of NHC. PWA with more severe impairments (moderate and very severe) produce fewer words compared to controls. For these PWA, the severity of the language impairment might be less predictive for the number of words used on the task: both groups of PWA, with a moderate and very severe impairment, produce a similar number of words during the task. These effects are confounded by the small number of data points available.

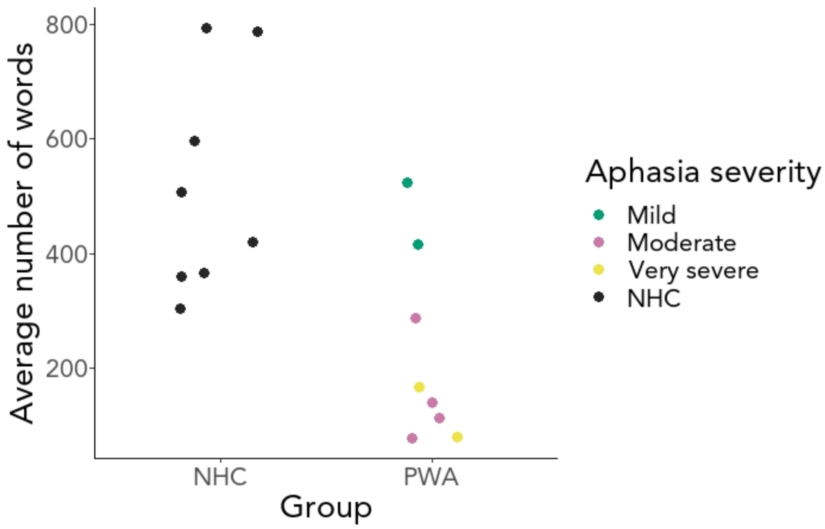


Figure 14. Average number of words used by each individual by group and aphasia severity, as measured by the WAB-AQ.

Individual patterns of change across trials

Number of words produced is plotted by trial for each individual PWA in Figure 15. The plots are ordered by aphasia severity, as measured by the WAB-AQ. In the PWA group, six out of eight participants showed a decrease in the number of words produced in the last trial compared to the first trial. Two participants showed an increase in the number of words used across trials. Participant 43 showed a small increase (from 79 words to 81). Participant 67, however, showed a bigger change (from 397 to 437 words). This participant also showed an increase in overall trial time, suggesting that this PWA was spending more time on the task in general. Based on the current sample, it seems that the change in number of words produced is not directly influenced by the severity of the linguistic impairment.

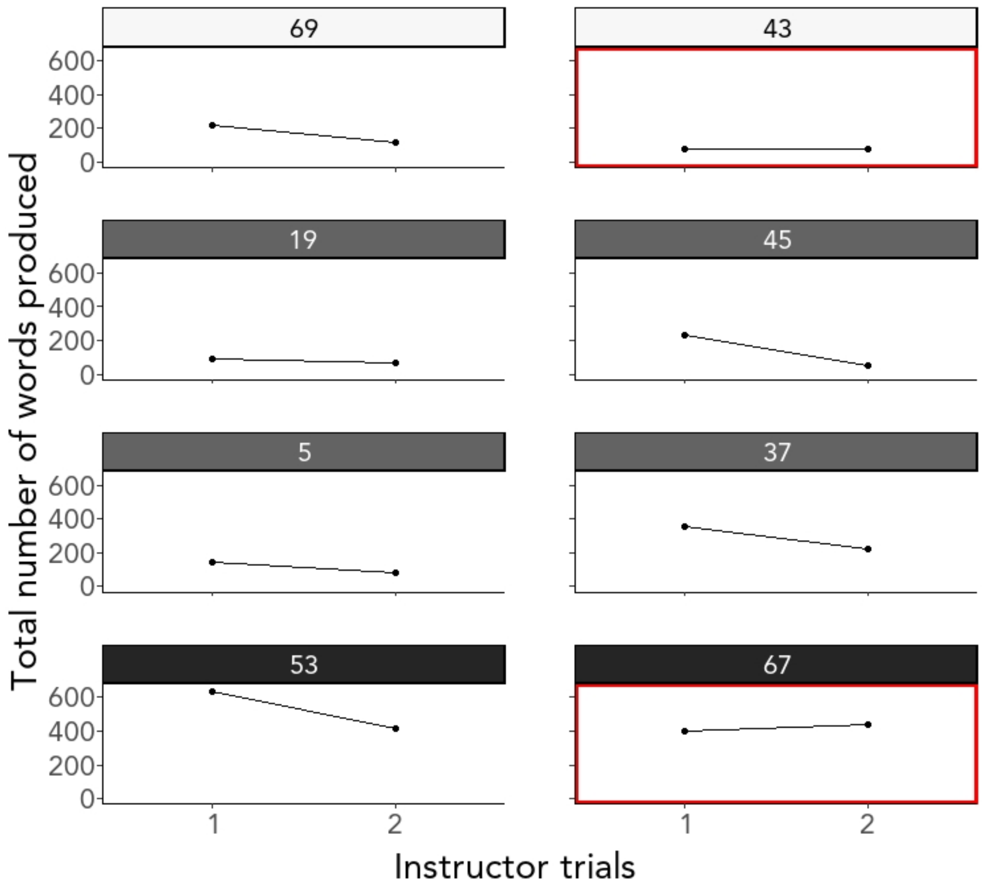


Figure 15. Plots showing the total number of words for each PWA dyad by trial (showing only the first and last trial on which the PWA took on the instructor role), arranged by aphasia severity: light grey = very severe, mid-grey = moderate, black = mild. Plots circled in red show an increase in the total number of words between trial 1 and 6. All other plots show a decrease in the total number of words used across trials.

Gesture time

Figure 16a shows a difference between PWA and NHC in the time spent gesturing. The 2x2 analysis confirms this difference: There was a significant main effect of group in the trimmed means analysis (PWA/NHC, $p = .042$)[3], with PWA spending more time gesturing (median = 43.63 sec., CI = 21.6, 68.97) compared to NHC (median = 9.47 sec., CI = 4.81, 11.86).

[3]The main effect of group was not significant based on the median analysis (test statistic = -26.74, $p = .097$). The variance of the two groups is very different. We expect the trimmed means analysis to capture the overall difference between the groups better.

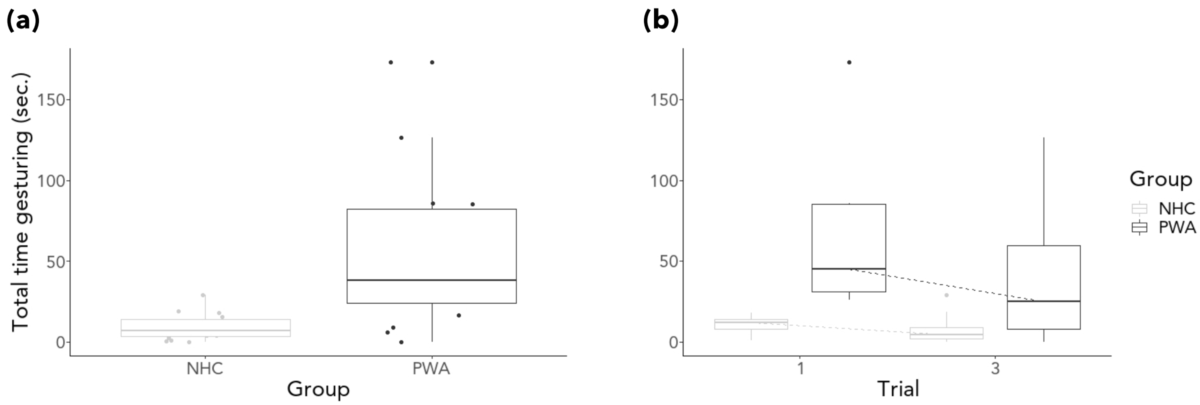


Figure 16. Graphs showing median and interquartile range of the total gesture time, (a) by group and (b) by group, across trials.

There was a significant main effect for trial (1-2; test statistic = 10.54, p = .024, one-tailed), with more time spent gesturing during the first trial (median = 22.23, CI = 13, 43.66) compared to the final trial (median = 7.49, CI = 3.91, 29.01).

There was no significant interaction for group*trial (test statistic = -20.86, p = .065), with similar pattern of change across trials for both groups (Figure 16b).

Figure 16b suggests that the difference in gesture time across trials might be bigger for PWA compared to NHC. Planned comparisons showed that this effect was significant for PWA (p = .012, one-tailed), and not for NHC (p = .119, one-tailed), with PWA spending more time gesturing in the first trial (median = 45.17, CI = 29.16, 85.69) compared to the last trial (median = 25, CI = 6, 81.34). The lack of a significant interaction effect is potentially due to the large variance within the PWA group.

Individual performance on task

The average gesture time is plotted for each individual participant in Figure 17. Data for PWA has been grouped by aphasia severity, as measured by the WAB-AQ. The distribution of the datapoints for each category of aphasia severity suggests that as the severity of the impairment decreases, participants spent more time gesturing to their conversation partner. There is, however, one participant with a moderate impairment, who is an outlier and gestures a lot more than the rest.

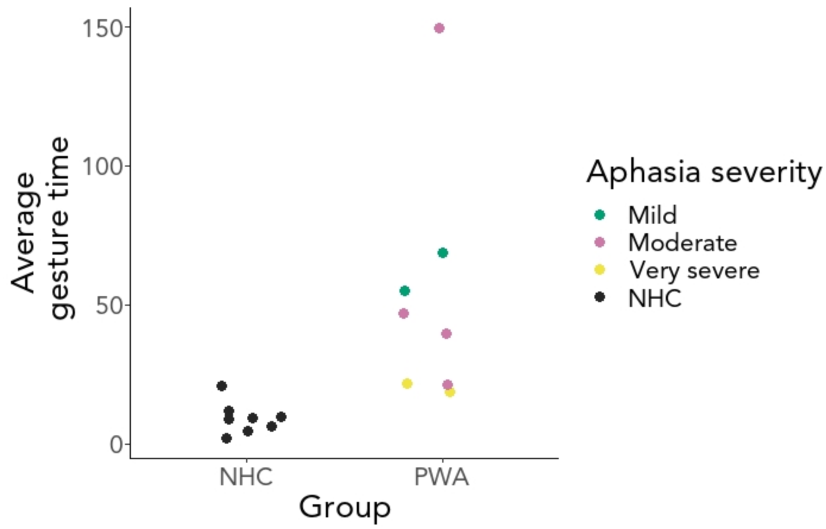


Figure 17. Average gesture time for each individual by group and aphasia severity, as measured by the WAB-AQ.

Individual patterns of change across trials

Gesture time is plotted by trial for each individual PWA in Figure 18. The plots are ordered by aphasia severity, as measured by the WAB-AQ. In the PWA group, seven out of eight participants showed a decrease in gesture time in the last trial compared to the first trial. The participant who showed an increase in gesture time on the last trial (participant 67, plot with a red border in Figure 18), also showed an increase in overall trial time, suggesting that this participant was spending more time on the task in general (participant 67, plot with a red border in Figure 18). Based on the current sample, it seems that the change in gesture time is not directly influenced by the severity of the linguistic impairment.

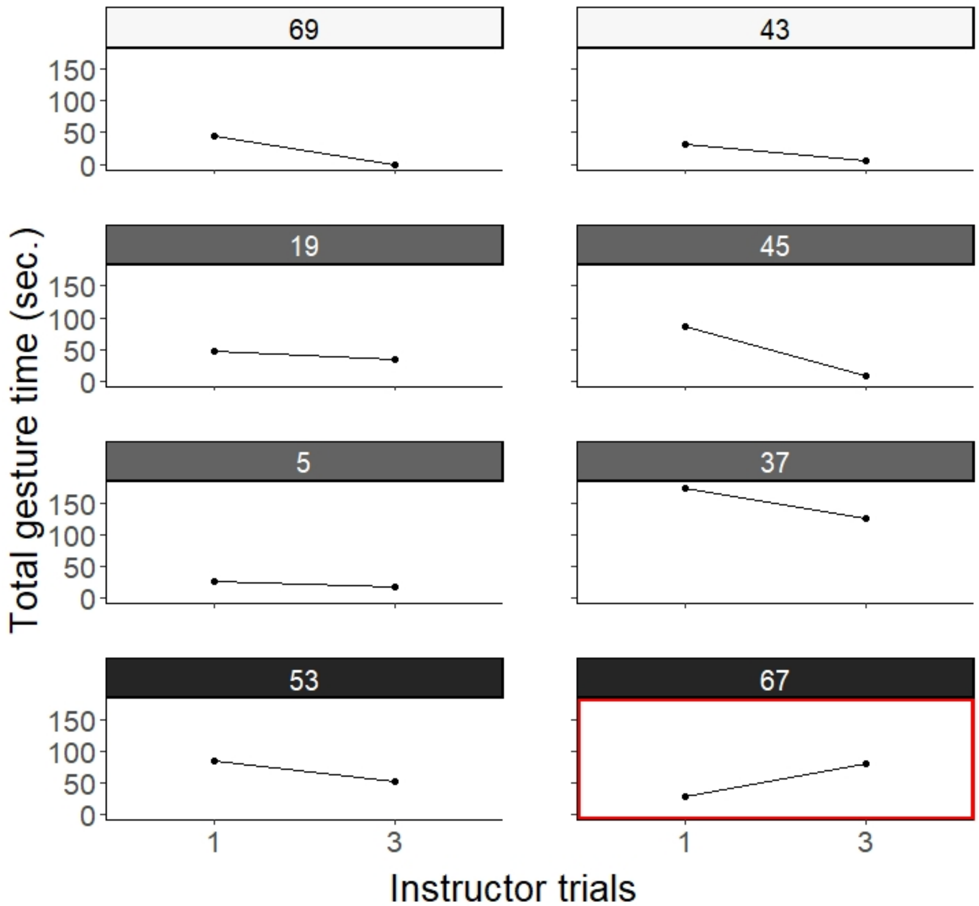


Figure 18. Plots showing the total gesture time for each PWA dyad by trial (showing only the first and last trial on which the PWA took on the instructor role), arranged by aphasia severity: light grey = very severe, mid-grey = moderate, black = mild. Plots circled in red show an increase in the total gesture time between trial 1 and 6. All other plots show a decrease in the total gesture time across trials.

Drawing/writing time

There is a clear difference in the median drawing/writing time for the two groups, as shown in Figure 19a. Within the PWA group, there is wide variation in the time spent drawing/writing. The 2x2 analysis confirms the difference between the groups: there was a significant main effect of group (PWA/NHC, $p = .042$), with PWA spending more time spent drawing/writing (median = 73.21 sec., CI = 0, 119.30) compared to NHC (median = 1.89 sec., CI = 0, 7.84).

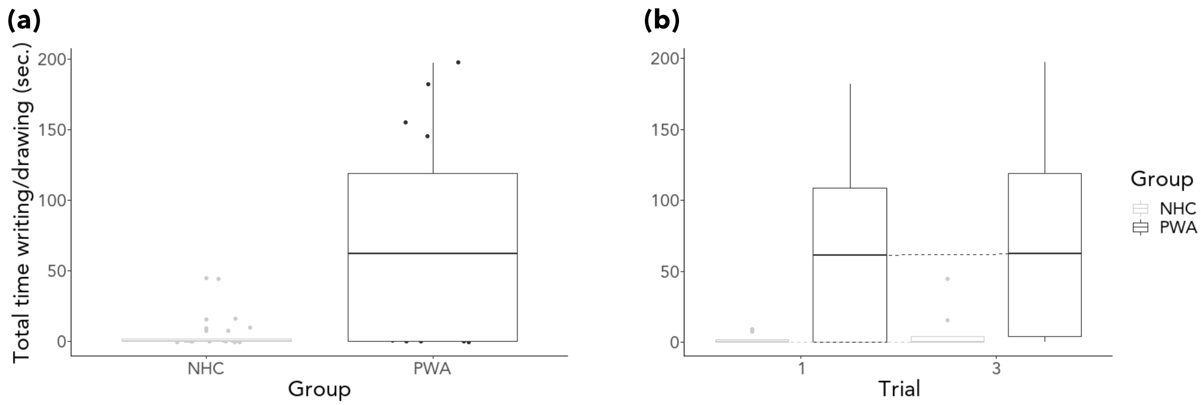


Figure 19. Graphs showing median and interquartile range of the drawing/writing time, (a) by group and (b) by group, across trials.

There was no significant main effect for trial (1-2; test statistic = 0, p = .5, one-tailed), with similar times spent drawing/writing across trials.

There was no significant interaction for group*trial (test statistic = 2.83, p = .533) , with similar pattern of change across trials for both groups (Figure 19b).

Individual performance on task

The average writing/drawing time is plotted for each individual participant in Figure 20. Data for PWA has been grouped by aphasia severity (based on WAB-AQ scores). There is no clear relationship between aphasia severity and the time spent using pen and paper to communicate on the task. While the two PWA with a mild impairment do not rely on pen and paper to support communication, neither does one participant with very severe aphasia. The use of pen and paper to communicate on the task might depend on a combination of factors in addition to the language impairment (i.e. the need to compensate for the linguistic impairment), such as whether the PWA thinks they will be able to use the modality effectively. These results are preliminary and confounded by the small number of datapoints available.

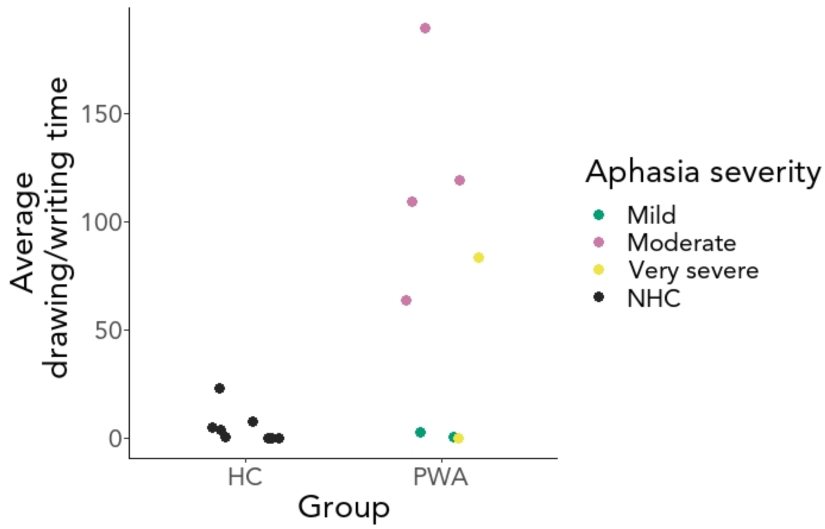


Figure 20. Average gesture time for each individual by group and aphasia severity, as measured by the WAB-AQ.

Discussion

The purpose of the current study was to explore communication in an adapted version of the referential communication task in a large group of people with aphasia and a matched group of neurologically healthy controls. To this end, two main research questions were posed, namely which measures differentiate performance of PWA from that of NHC as a group, and which measures are sensitive to changes in task performance over time and repeated practice on the task. The main findings are summarised in Table 4.

Differentiation between PWA and NHC

Out of the nine measures included in the current study, four differentiated between PWA and NHC at the group level: measures of communicative success and multimodal communication. The groups showed similar patterns of behaviour on measures of communicative efficiency and interaction (see Table 4).

Communicative success

PWA dyads achieved lower levels of communicative success compared to the NHC on the task. This difference goes against previous findings on similar tasks, where no statistical difference was found when PWA were compared against controls for accuracy (Hengst, 2003; Meuse & Marquardt, 1985). Compared to the card matching tasks used previously, the complexity of

Domains of communication	Measures	Main effect of group: PWA vs NHC	Main effect of trial & interaction: learning?	
Communicative success	Task accuracy	PWA < NHC	Yes (both groups) 1 < 6	↗
Communicative efficiency	Time to complete the trial	No	No	→
Interaction	Number of self-initiated repairs	No	No	→
	Number of clarification requests	No	No	→
	Number of back channels	No	No	→
	Number of turns	No	Yes (both groups) 1 > 6	↘
Multimodal communication	Number of words	PWA < NHC	Yes (PWA) 1 > 6	↘
	Gesturing time	PWA > NHC	Yes (PWA) 1 > 6	↘
	Drawing/writing time	PWA > NHC	No	→

Table 4. Results from the current study summarised. Arrows: blue indicates no difference across trials, green indicated a significant difference on the main effect of trial.

the current task as well as the detailed coding of the accuracy score might have resulted in a more sensitive measure, revealing differences in successful information exchange. Previous research has, for example, shown that PWA do not necessarily differ from NHC in the number of main concepts they are able to express, but the main concepts they express are less complete and less accurate compared to NHC (Nicholas & Brookshire, 1995).

The difference between PWA and NHC in communicative success provides evidence for the difficulties in communication that PWA have as a result of their linguistic impairment, even when multimodal communication is taken into account, and the variability of these difficulties within the aphasia group.

Communicative efficiency

PWA and NHC dyads did not differ on the time they spent on the task. This shows that the presence of communication difficulties did not, on the surface, affect the time a dyad was willing or able to spend on the current task to complete it. While it is often suggested that PWA need more time to transmit a message compared to people without aphasia, these findings suggest that PWA and their conversation partner might not always spend the extra time on a task, or during communication, compared to NHC.

Interaction

No differences were found between PWA and NHC on measures of interaction (i.e. self-initiated repairs, clarification requests, backchannels, and number of turns). While the similar number of turns (i.e. collaborative effort on the task) is in line with a previous study using a similar task (Meuse & Marquardt, 1985), other studies have found significant changes in conversational turn taking and the length and type of repair sequences for PWA during spontaneous conversation (Beeke, 2012; Lesser & Milroy, 1993). It is possible that the goal-oriented nature of the task kept dyads from engaging in too many repair sequences, if these were not deemed to help achieve the goal of completing the task. Further in-depth analysis of how the repair sequences unfolded in both groups could shed light on whether previous findings on the type and length of repair sequences are also found in the current experimental setup.

The current results do not exclude the possibility that there were more trouble sources in the speech of PWA, or that PWA experienced more comprehension difficulties. However, if these difficulties did exist for PWA, they did not lead to more initiations for repair or more requests for clarification for this group. It is possible that the lower accuracy score is a better (indirect) reflection of production and comprehension difficulties compared to these measures of interaction. Overall, these results show that the presence of post-stroke aphasia did not significantly change the interactive behaviours of PWA and their conversation partners during unscripted, interactive communication during a structured task. On this task, therefore, characteristics of interaction did not differentiate PWA from NHC as a group.

Multimodal communication

The results show that PWA produced fewer words compared to NHC on the task. This echoes previous studies that showed that PWA with a non-fluent presentation produce fewer words compared to other aphasia types and NHC (Busch et al., 1988). The majority of PWA included in the current study also had a non-fluent presentation, similar to the study by Busch et al. (1988). This result reflects the reduced resources available to PWA in the verbal channel for communication, as compared to NHC.

PWA were shown to spend more time using non-verbal modalities for communication such as gesture and drawing/writing compared to NHC. While previous research on gesture use has been inconclusive, these findings are in line with some studies that have reported greater gesture use by PWA compared to NHC (e.g. Carlomagno et al., 2005). Combined with the greater time spent using pen and paper to communicate on the current task, these results highlight the multimodal nature of communication of PWA. Although communication for NHC is also assumed to be multimodal (Vigliocco et al., 2014), the current findings show that the make-up of multimodal communication is different for PWA compared to NHC (de Beer et al., 2020). These findings underscore the importance of considering all modalities when evaluating functional communication in PWA. If only verbal information had been analysed for the current group of participants, the potentially significant contributions of non-verbal modalities in communication in PWA would have been missed. While the current study required the exchange of relatively concrete information (the location of relatively concrete, familiar objects), more research is needed to explore how PWA communicate more abstract information, that potentially lends itself less well to the use of gesture, drawing or writing.

Most research on gesture in aphasia includes an analysis of the types of gestures, or a count of the total number of gestures. While the time spent gesturing that was used in the current study gives an idea of the difference in gesture use by the two groups, it is possible that gesture time does not equal gesture count or meaningful content. A more detailed analysis of the number and types of gestures used would help support the claims made regarding multimodal communication in the current paper. Furthermore, a more detailed analysis of the communicative value of the gestures, drawings and writings that were used by both groups can provide insight into the relative contributions of the different modalities on the communicative effectiveness of these PWA on the current task (van Nispen et al., 2017).

Aphasia severity on measures of group differences

Visual inspection of the individual data points allows us to draw provisional conclusions regarding the relationship between communication on the current task and aphasia severity. For communicative success, the data shows that the greater the linguistic impairment, the lower overall accuracy scores on the task were, suggesting that the linguistic impairment negatively impacts the amount of information that is effectively exchanged between the dyads.

Interestingly, this relationship with aphasia severity is less clear for the number of words used. PWA with mild aphasia produced a similar number of words compared to the control group. PWA with more severe impairments (moderate-very severe) used fewer words on the task compared to those with a mild impairment. However, within these groups, there was no clear pattern between the number of words produced and aphasia severity, suggesting that for a number of PWA, the severity of the impairment might not necessarily predict the use of the verbal channel during communication. However, note that due to the small group of participants included in the current study, no distinction was made between different aphasia types (e.g. fluent or non-fluent presentations).

The time spent gesturing showed a negative relationship with aphasia severity, where the more severe the linguistic impairment, the less PWA tended to spend time gesturing. Interestingly, PWA with a more severe impairment were more similar to NHC, who tended to spend less time gesturing visibly to their conversation partner during the current task. These findings suggest that PWA with mild-moderate impairments might rely more heavily on the gesture channel to strategically compensate for a reduction in the resources available in the verbal channel (de Ruiter, 2000; Sekine & Rose, 2013). The data shows that this reliance on the gesture channel might be different for PWA with very severe impairments. More detailed investigations of the communicative behaviour of these participants can shed light on the reasons for this difference, and whether it reflects more typical communicative behaviour, or a lack of ability to rely on the gestural channel to compensate for the linguistic impairment.

Finally, whilst PWA spent significantly more time writing and drawing than NHC, there was no clear relationship between the amount of time spent writing and drawing and aphasia severity. The use of these modalities may be influenced by the impairment profile (e.g. the degree to which comprehension and production of written content is impaired, as well as visuo-spatial processing and motor function needed for effective writing and drawing; Swindell et al., 1988; Warrington et al., 1966) and whether the individual is able to use these modalities strategically to compensate during communication (e.g. cognitive flexibility for switching between modalities, Spitzer et al., 2019). More research is needed to explore factors that influence the choice and effectiveness of modalities used for communication.

Learning across trials

Consistent with previous work on collaborative referencing (Clark & Krych, 2004; Clark & Wilkes-Gibbs, 1986; Hengst, 2003), a number of variables showed a significant change across trials: Measures of communicative success (task accuracy), interaction (number of turns) and multimodal communication (number of words and gesture time).

A reduction in collaborative effort was found across trials for both groups, evidenced by a reduction in the number of turns. The dyads became more efficient at completing the task, as evidenced by a decrease in collaborative effort, and a significant improvement in communicative adequacy (accuracy). This is an important finding, as it shows that familiar PWA dyads can show improvement in their communicative adequacy simply by becoming more familiar with the communicative task at hand, through repeated practice (Hengst et al., 2010). For PWA in particular, the finding that such learning takes place on a dynamic, unstructured, real-time communicative task is highly relevant. Very little is known about general, non-verbal learning mechanisms in post-stroke aphasia, but they are assumed to be critical for treatment responsiveness and generalisation of therapy effects (Ferguson, 1999; Kelly & Armstrong, 2009; Rohter, 2014; Vallila-Rohter & Kiran, 2013). Preliminary studies have shown that non-verbal learning mechanisms can be impaired in PWA (Kendrick, 2019; Rohter, 2014). Assessment of the individual data indeed shows that not all PWA dyads showed a reduction in the number of turns, or an improvement in accuracy scores across trials. A more detailed analysis of the impairment profile (linguistic and cognitive) of the PWA that did not show learning on the current task might provide insight into the underlying factors that influence this ability. Furthermore, as the current findings are the result of the collaborative efforts of dyads rather than individual efforts of PWA, a more detailed analysis of the communicative behaviour of the dyads is warranted to explore how improvement across trials came about. For example, improvement in communication adequacy might have been the result of explicit or implicit changes in communication strategies (or lack thereof), initiated either by the PWA or their conversation partner.

Two measures showed a clear change across trials for PWA: the number of words and the time spent gesturing decreased between the first and last trials. This development suggests that PWA were able to adapt their verbal and non-verbal communicative efforts based on experience on the task and to optimise performance on the task over time. The improvement in performance across trials while efforts (turns) and characteristics of communication (number of words and gesture time) changed over time reflects, again, a process of tacit learning (Hengst, 2003; Meuse & Marquardt, 1985). The lack of change on the amount of time spent writing/drawing might suggest that this was deemed a useful modality on the current task by PWA. These learning processes should be investigated more, as they could inform communicative interventions targeted at improving communication in PWA.

On measures of communication efficiency (trial time) and most of the measures of interaction (individual efforts of interaction: the number of self-initiated repairs, clarification requests and back channels), no change in behaviour across repeated iterations of the task was observed. Despite the improvement in performance, both groups required the same number of clarifications from their conversation partner, and initiations of repairs of their own output, to complete the task.

The lack of an effect of trial for NHC on measures such as time is relatively surprising, given that previous research on referential communication has consistently found such an effect in PWA and controls (Clark & Krych, 2004; Hengst, 2003; Meuse & Marquardt, 1985). This effect might be explained by the adaptation that was made on the current task. Previous studies used identical materials and locations across trials (e.g. a series of cards ordered differently for each trial), allowing researchers to draw conclusions about the time it took to reference a set of cards over time. The cards that were used were complex enough to require a description, rather than a single word, at the beginning of the trial. For the current study, identical objects were used, but placed in slightly different locations for each trial. In addition, the description of the locations (near the window, on the sofa, in the living room, in the small room, at an angle or not, etc) was more complex compared to the description of the object (e.g. 'cat', 'man', 'sofa', 'chair', etc). The relative ease with which the objects were referred to, leads us to suspect no major changes over time in reference to the objects, while the changing nature of the locations might have minimised the observable changes in reference across trials.

Aphasia severity and learning across trials

Visual inspection of individual data points across trials for measures of accuracy, number of turns and gesture time show that there is not a clear relationship between learning across trials and aphasia severity. Whilst our results may be limited by sample size, it seems the severity of the language impairment does not predict how well someone will be able to optimise their communication adequacy and strategies due to repeated practice. Instead, other factors play a role here. Previous research suggests a reduction in general learning abilities for PWA (Vallila-Rohter & Kiran, 2013) and a role for executive control skills in learning ability for PWA (Kendrick, 2019; Rohter, 2014). These factors, more than severity per se, may be important in predicting how PWA are able to adapt their communication over time.

Conclusion

The current study shows that the presence of post-stroke aphasia significantly affected communication in two ways. The degree to which PWA were able to exchange relatively concrete information accurately with their conversation partner was negatively affected by the presence of aphasia. While many PWA were able to achieve a relatively high degree of success on the task, they still showed a reduced level of precision in information exchange compared to NHC. Furthermore, the way in which communication was achieved was also affected by the presence of aphasia. PWA, compared to NHC, relied less on the verbal (spoken) channel and more on the visual (gesture) and graphic (drawing/writing) channels to communicate compared to NHC. Interestingly, the presence of post-stroke aphasia did not affect the way the interaction was managed by the individual or dyad on the current task (measures of self-repair, clarification requests, backchannels and turn-taking), or the time that was spent on the task. Overall, these results show that in the assessment of communication in PWA, it is imperative to take into account communicative success (i.e. how much of information a person can communicate effectively) and the multimodal nature of communication (i.e. the modalities that are used to communicate such as speech, gesture, and/or writing/drawing). Future research will need to assess how these characterisations change depending on the communicative task at hand. For example, when the content is more abstract or complex as compared to the current study.

The results also show that even on this adapted version of the communication task, PWA showed evidence of learning across trials on measures of communicative success, collaborative interaction (turn-taking) and multimodal communication. The finding that learning occurred for most PWA after repeated practice (of only 6 trials) on a communication task is encouraging. This suggests that even within a more dynamic and demanding context such as the current interactive communication task, PWA can effectively rely on the increasing existing shared experience on the task (i.e. on common ground, Clark, 1996) and are able to adapt their communication strategies accordingly. Although more research is needed to explore the role of the conversation partner in the observed changes across trials, the current results provide preliminary support for the fact that PWA can, when given enough practice, adapt their communicative behaviour to the demands of the situation they find themselves in when communicating with a familiar conversation partner (Simmons-Mackie & Damico, 1995; Simmons-mackie, 1998). Crucially, the current findings show that the severity of the linguistic impairment does not predict this observed learning. More research is needed to reveal which factors do underpin this flexibility.

Methodological considerations

Taken together, these findings show that the experimental, collaborative communication task can be used to investigate communication in aphasia and how internal (cognitive) and external (environmental) factors affect this process. The lab-based setting offers the required levels of control over these factors, while at the same time providing insight into both the success and the means of communication. It is worth restating here that participants were instructed to communicate 'as they normally would' and were left alone to complete the task in their dyads. The spontaneous use of multiple modalities on the current task, despite the structured nature and lab-based setting, strengthens the ecological validity of the task, as this is the kind of mix of modalities we know is used in the real world (Vigliocco et al., 2014). The experimental setup makes it possible to compare such findings to a group of matched NHC who undergo a similar experimental manipulation, thereby strengthening the conclusions that can be drawn about the observed behaviour in the PWA group. Although the current study did not show a change in trial time to complete the task for PWA or NHC, trial time has repeatedly been a valuable measure in previous studies (e.g. Clark and Krych, 2004). Practically, time is a straightforward measure to extract from the data. The authors therefore recommend that despite the current findings, it is always included as a measure.

This study was conducted with a relatively large group of PWA, and a wide range of aphasia severities (i.e. very severe to mild). The task proved to be accessible and suitable for almost all PWA, suggesting that the degree of linguistic impairment did not directly lead to issues with participation in the current study. However, two participants had to be excluded from the study due to the presence of cognitive impairments combined with severe comprehension difficulties. The first PWA presented with a severe global aphasia. This impairment profile, combined with pre-morbid low literacy levels, meant that background testing (e.g. the WAB) could not be fully administered. Administration of the Scenario Test was also cut off early due to difficulty taking part in the pretend role play, which lead to high levels of frustration expressed by the PWA. The dyad wanted to have a go at the experimental task, but the session was ended after three trials due to difficulties experienced by the dyad in completing the task. The second PWA presented with a severe, non-fluent aphasia (WAB-AQ = 45.1). This PWA presented with additional impairments (e.g. in attention and processing speed) that made it difficult to complete a battery of executive functioning tests that were part of a bigger study. As a consequence of a long history of neurological impairments (stroke, encephalitis, and a brain tumour), the partner of this PWA also reported some changes in personality such as increased impatience when communicating. This particular dyad also completed three trials of the experimental task. Both participants experienced high levels of frustration and requested to terminate the experiment early. This suggests that a minimal level of communicative efficiency, or a sense of communicative effectiveness, is required to complete multiple iterations of the task. Furthermore, severe cognitive impairments might interfere with participation for some PWA in studies that use this particular experimental setup. It will be worth exploring whether simplified versions of the barrier task (e.g. selection and matching of objects) are suitable for individuals with more severe or complex impairments.

Furthermore, two PWA dyads and one NHC dyad showed some difficulty understanding the division of roles on the first trial of the task. These dyads were observed negotiating who would instruct who after the experimenter had left. For the NHC dyad, one participant expressed confusion about her role on the second trial (e.g. had to adjust to switching from being an instructor to being a listener). The partner of this NHC, however, was able to clarify the situation for the both of them. For the two PWA dyads, a similar situation occurred. In one case, despite extensive instruction, a PWA with severe aphasia showed confusion on how to proceed after the experimenter had left the room. The conversation partner was able to clarify the role division and the dyad proceeded to complete the trial. In the other case, the conversation partner of a person with very severe aphasia expressed confusion on how to proceed after the experimenter had left the room. In both cases, it is possible that the pre-determined roles of the task (e.g. who expresses information, who follows) might have contradicted the roles each would naturally take on during conversation (for both the PWA and NHC dyads). Ultimately, all dyads were able to complete the task. One way to ensure that all participants fully understand the task and to maximise inclusion of participants, is to include a supervised practice round with one or two items (as in Meuse and Marquardt, 1985). Overall, it is encouraging that such a large group of PWA were able to take part without the need for adaptations to the experimental setup.

More research will be needed to explore the individual patterns of behaviour across the different impairment profiles in the aphasia group. For example, it would be interesting to explore the relationship between a person's role on the task (i.e. instructor/listener), the profile of impairment in terms of comprehension and production, their communicative success on the task and how this develops over time. Furthermore, studies into the communicative behaviour of the conversation partners in the current experiment can be used to inform the extent to which changes in the communicative behaviour of the PWA came about through external cueing from the conversation partner. Finally, it currently remains unclear how well findings from this experimental study translate to communicative behaviour in a real-world setting. A number of partners of PWA who took part in the study spontaneously and informally reported that the difficulties they encountered during the task were a realistic reflection of the difficulties they encountered in communication at home. These informal reports suggest that the current task might provide a realistic view of the communicative abilities and difficulties of PWA that extend beyond the lab setting. However, other researchers have found differences between communication on a 'barrier task' and spontaneous communication (Simmons, 1993). It has, for example, been suggested that compared to naturalistic communication, a barrier task might provide a structure that PWA can benefit from. In the real world, PWA might need to do more work to negotiate possible topics of conversation, and communicative activities and to establish social goals and rules of interaction (Hengst, 2003). Further comparisons of observations of naturalistic communication and performance on the current task will have to be done to quantify how large the 'gap' is between describing communication abilities on a lab-based task such as this and spontaneous communication in the real world. This could be done by interviewing participants more formally on their experiences of communicating on the task and how this compares to communication at home. Furthermore, communicative behaviour on the task could be compared to observations of naturalistic interactions at home. While communicative success remains difficult to determine in most naturalistic interactions (e.g. this would require a clear goal or task that is achieved or not), characteristics of interaction and multimodal communication could be compared across a number of different situations (i.e. the proportion of use of different modalities, the number of self-corrections, or clarification requests made during an exchange, the number of turns and the division of the communicative burden). Greater insight into the degree to which the current task captures communication as PWA use it in the real world will help determine how generalisable the findings from these lab-based studies are.

Adaptations for treatment

Few communicative treatments currently exist that are directed at improving the communication skills of the person with aphasia themselves (Simmons-Mackie et al., 2014). The setup of the collaborative communication task, as it adheres to the theoretical framework of real-world communication (Clark, 1996; Doedens and Meteyard, 2020, chapter 3 in this thesis) has the potential to be adapted for communicative treatment purposes. The setup can provide the clinician with a structure that, within the setting of the clinic, is more like naturalistic communication than any 'in vacuo' exercise that requires the PWA to process information on their own. The referential or collaborative communication task is, in its basic setup, similar to the original design of PACE therapies (Davis and Wilcox, 1985; see Davis, 2005 for a more recent description). Indeed, the four principles of PACE fit within the theoretical framework of real world-communication (interactive: equal participation by taking turns in the 'director' role and unrestricted, natural feedback is exchanged between the participants, multimodal: participants have free choice of using communicative modalities and common ground: the amount of the information exchanged that is known to only one participants can be manipulated; Davis, 2005). Variations on the original PACE design as described by Davis (2005) and Pulvermüller and Roth (1991) illustrate the flexibility of this interactive setup in targeting different communicative goals and interactions (for example, observing differences in communicative behaviour across different conversation partners). Within the clinical setting, this method can be used as a structured approach to target specific communicative therapy goals and to incorporate "traditional language stimulation techniques into a communicatively dynamic context" (Peach, 2001, p506, as quoted by Davis, 2005). Such tasks may act as a bridge for generalisation between language-based interventions inside the clinic and naturalistic communication outside of the clinic.

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Supplementary Materials

NHC					Conversation partner						
ID	Sex	Age	Education (yrs)	MOCA	ID	Sex	Age	Education (yrs)	MOCA	Partner type	Years knowing NHC
4	female	71	17	28	3	male	70	17	23	Partner	51
9	female	63	12	27	10	male	65	16	29	Partner	47
22	female	54	16	29	21	male	64	16	27	Partner	18.5
26	female	59	17	29	25	male	61	23	28	Partner	49
28	male	63	12	28	27	female	62	13	30	Partner	45
30	female	70	14	30	29	male	71	14	27	Partner	51
34	male	67	11	28	33	female	64	14	30	Partner	32
36	male	84	11	17	35	female	79	12	29	Partner	35
49	female	60	19	28	50	male	61	14	30	Partner	42
51	female	53	17	28	52	male	56	16	23	Partner	26
55	female	52	17.5	30	56	male	57	18	29	Partner	16
58	male	72	13	26	57	female	51	21	29	Partner	22
59	male	58	15	27	60	female	60	18	26	Partner	35
61	male	67	21	30	62	female	64	17	27	Partner	28
65	male	62	13	28	66	female	62	15.5	26	Partner	42
74	male	84	10	27	73	female	79	11	26	Partner	32

Table S1. Demographics of the NHC group and their conversation partners.

Chapter 5 | Real-world communication in aphasia: the influence of speaker familiarity on a collaborative communication task.

Doedens, W.J., Bose, A., Lambert, L. & Meteyard, L. (under review).
Frontiers in Communication

Abstract

Aphasia is language impairment due to acquired brain damage. It affects people's ability to communicate effectively in everyday life. Little is known about the influence of environmental factors on everyday communication for people with aphasia (PWA). It is generally assumed that for PWA speaking to a familiar person (i.e. with shared experiences and knowledge) is easier than speaking to a stranger (Howard et al., 2004). This assumption is in line with existing psycholinguistic theories of common ground (Clark, 1996), but there is little empirical data to support this assumption.

The current study investigated whether PWA benefit from conversation partner (CP) familiarity during goal-directed communication, and how this effect compared to a group of neurologically healthy controls (NHC).

Sixteen PWA with mild to severe aphasia, sixteen matched NHC, plus self-selected familiar CPs participated. Pairs were videotaped while completing a collaborative communication task. Pairs faced identical Playmobile rooms: the view of the other's room was blocked. Listeners attempted to replicate the 5-item set-up in the instructor's room. Roles were swapped for each trial. For the unfamiliar condition, participants were paired with another participant's CP (PWA were matched with another PWA's CP based on their aphasia profile).

The outcomes were canonical measures of communicative efficiency (i.e. accuracy, time to complete, etc.). Results showed an effect of familiarity for PWA, but not for NHC. For PWA, the effect was not in the predicted direction. In the instructor role, PWA showed slower trial times with the unfamiliar partner, but similar accuracy scores in both conditions. NHC, on the other hand, showed similar trial times across CPs, but higher accuracy scores with the unfamiliar partner. In the listener role, PWA showed a pattern more similar to NHC: equal trial times across conditions, and an improvement in accuracy scores with the unfamiliar partner. Results show that speaker familiarity significantly affected communication for PWA on a familiar task, but not for NHC. This research highlights the importance of identifying factors that influence real-world communication for PWA and understanding how this effect varies across aphasia profiles. This knowledge will ultimately inform our assessment and intervention of real-world communication.

KEYWORDS: Aphasia, face-to-face communication, common ground, speaker familiarity, conversation partner.

Introduction

One-third of individuals who suffer a stroke will experience aphasia (difficulties speaking and understanding language, reading and writing, Spaccavento et al., 2013), with detrimental effects on communication and functioning in everyday life (El Hachioui et al., 2014; Lam & Wodchis, 2010). When compared against various health conditions (e.g. cancer and Alzheimer's Disease) aphasia has the highest impact on quality of life (Hilari et al., 2003; Lam & Wodchis, 2010; Spaccavento et al., 2013). The loss of functional language use affects social, vocational, and emotional well-being (Hilari et al., 2003; Spaccavento et al., 2013), preventing People with Aphasia (PWA) from participating in society and maintaining relationships.

Traditionally, the study of aphasia has focused on impairments of language, with assessment tasks that present isolated language elements (e.g. sounds, words, sentences) in highly controlled lab environments. These studies have been the foundation for the development of reliable assessment instruments and intervention plans targeted at particular profiles of language impairment (Thompson et al., 2008). However, it is generally accepted that such impairment-based performance measures do not reliably predict communication ability in the real world (Armstrong et al., 2011; Beeke et al., 2007; Davidson et al., 2008; Holland, 1982; Kolk & Heeschen, 1992; Wilkinson, 1995). Perhaps because of the complexity of language and communication, the same level of detailed analysis has not been applied to real-world communication for PWA (Leaman & Edmonds, 2019). Providing reliable assessment and evidence-based interventions at the level of communication has, for that reason, remained problematic in aphasiology (Brady et al., 2016). This is a crucial gap in knowledge, as improvement in the ability to communicate in one's own day-to-day environment remains one of the most important long-term goals reported by clinicians and PWA themselves (Thompson et al., 2008).

There is, therefore, a need for systematic, theoretically driven research on real-world communication in aphasia. Recently, we showed how a theoretical framework of situated language use, borrowed from research with neurologically healthy controls (NHC) (Clark, 1996), can be applied to aphasia rehabilitation (Doedens & Meteyard, 2020). It provides a structure along which different components of real-world communication, and their influence on a person's ability to communicate, can be examined systematically. The framework defines communication as being (1) interactive – including at least one other person, (2) multimodal – involving multiple channels of information and (3) contextual – grounded in shared situational, personal and social knowledge.

Here, we will focus on the contextual aspect of real-world communication. One part of contextual information is *common ground* shared with a conversation partner (CP) - part of which is modulated by the *familiarity* of that CP. For PWA, questionnaires on communication often distinguish between the ability to communicate with familiar and unfamiliar CPs (e.g. the disability questionnaire of the Comprehensive Aphasia Test; Howard et al., 2004; or the Aphasia Impact Questionnaire-21; Swinburn et al., 2018). The assumption is often made that it is easier for PWA to speak to a familiar person than speaking to a stranger (Ferguson, 1994; Green, 1982; Howe et al., 2008; Laakso & Godt, 2016; Perkins, 1995; Wirz et al., 1990). The familiarity advantage has also been reported by PWA as an influential factor when it comes to ease of communicating (Dalemans et al., 2010).

Speaker familiarity is more specifically defined as *personal common ground* (Clark, 1996). This constitutes a set of past experiences, beliefs and knowledge that are shared between two people. Research with NHC has shown that the presence of personal common ground can facilitate communication (Clark, 1996). In conversation, interlocutors can rely on this shared information as being 'given', i.e. not requiring too much further explanation. As a result, CPs can rely on more informal, implicit, abbreviated language in their exchanges (Herrmann, 1983). Specifically, speakers can rely on the givenness of information and produce less complete utterances (Bard et al., 2014), while listeners can use personal common ground to restrict the number of possible interpretations based on the shared knowledge (Skipper, 2014). In short, reliance on shared knowledge means communication about that 'given' information will require less effort (time, words and/or energy) to refer to during communication (Boyle et al., 1994; Clark, 1996; Horton & Gerrig, 2005; Smith et al., 2005; Zwaan, 2016). Indeed, a number of studies have shown that familiar CPs (FCP) use more abbreviated and informal language compared to unfamiliar partners (UFCP; Clark, 1996; Hornstein, 1985). On the other hand, FCP have been shown to initiate more topics, ask more questions and provide more minimal turns during conversation compared to UFCPs (Boyle et al., 1994; Hornstein, 1985). Despite the increase in number of turns and words, Boyle, Anderson and Newlands (1994) reported that FCP showed more 'efficient' communication with fewer interruptions and overlaps in speech compared to UFCPs. Overall, research with NHC suggests that speaker familiarity has an effect on the interlocutors' ease of communicating.

For PWA, the presence of personal common ground, i.e. having 'given' shared knowledge with a FCP, could mean a potential benefit as it would enable them to use less (complex) verbal and non-verbal language during conversation. Only a small number of studies have explored the influence of personal common ground on communication for PWA. Leaman and Edmonds (2019) analysed and compared the unstructured conversations of eight PWA (most with mild anomic aphasia) with a FCP and an unfamiliar SLT. The authors reported no differences on measures of communicative success, on linguistic measures such as grammaticality (morphological and verb tense/mood errors) and sentence production (correct use of a complete sentence frame and the relevance of lexical items in the frame in the discourse context), or on lexical retrieval behaviours (false starts, repetitions, pauses of 2+ seconds, etc.). These findings suggest that some linguistic characteristics of conversation for PWA might remain stable across conversation partners.

Kistner (2017) assessed gesture use by twenty PWA (ranging from severe to mild aphasia) and NHC in conversation with FCPs and UFCPs. A procedural and a narrative conversational task were used to elicit conversation. UFCPs were SLT students or researchers with knowledge of aphasia. In this study, both PWA and NHC showed an increase in the number of gestures when speaking to the UFCP as compared to the FCP. The authors hypothesized that gesture production increased to help disambiguate meaning or as speech became more complex. With the UFCP, this need increased due to the lack of shared reference. Williams et al. (1994) explored the influence of conversation topic and conversation partner familiarity for 22 PWA and ten NHC on a procedural and story-retell task. The syntactic complexity measures in the study showed no effect of CP familiarity (Williams et al., 1994). On the same dataset, Li et al. (1995) found no significant differences on discourse grammar between conversations with FCPs and UFCPs, except on the description of the setting in the story retell task, where PWA provided more detail with the FCP. The authors suggested PWA might have felt more comfortable or at ease with the familiar CP, which could have facilitated recall of that particular aspect of the story. Finally, case studies by Gurland et al. (1982) and Lubinski et al. (1980) showed that PWA used different communication styles depending on the familiarity of their CP: Gurland et al. (1982) showed a greater number of acknowledgements were produced in conversation with a familiar CP, while with the unfamiliar CP, topic-relevant turns increased. The authors suggested PWA might take on a more "passive, less informative role with the spouse (familiar CP) versus the clinician (unfamiliar CP)" (Williams et al., 1994, p. 209). Lubinski et al. (1980) compared the unstructured conversation of one PWA with a familiar (spouse) and a therapy session with an UFCP (SLT). The topic of conversation was not controlled for. The number of conversational breakdowns and repairs were assessed: similar types of conversational breakdowns were found with the FCP and UFCP. The way in which the breakdowns were repaired, however, differed significantly. UFCPs (SLT) tended to gloss over the breakdowns, while FCPs (spouse) actively attempted to repair them collaboratively with the PWA. The authors suggested that one reason for this difference was the different goals each CP had during their conversation with the PWA: the clinician often let the PWA repair the conversational trouble, while the spouse wanted to – collaboratively – discuss the plans for that day. Ferguson (1994) found no difference in trouble indicating behaviours between FCP and UFCP in a study with eight PWA, where the conversational topic was slightly more aligned. The authors found that the way these troubles were dealt with was different depending on the familiarity of the CP: UFCP more often took on the responsibility of repairing the trouble (i.e. 'other-repair'), rather than letting the PWA repair the trouble (i.e. 'self-repair'). The authors hypothesized that by not letting PWA repair the trouble as often, UFCPs might have been driven by a desire to avoid potential continued conversational breakdown. The familiarity manipulation might not have been sufficient in this latter study: the role of UFCP was filled by someone who knew the PWA less well compared to the FCP, but still had known the PWA for years.

In addition to the effect of personal common ground, there are two confounding factors that can influence the communicative ability of PWA. First, research has shown that communication for PWA is influenced by the extent of knowledge the CP has about aphasia, the language impairment and on potential communication strategies they can use to facilitate communication (Rayner & Marshall, 2003). CPs with knowledge of communicating with PWA have been shown to enable PWA to communicate more effectively and increase the PWA's level of participation in conversation (Kagan et al., 2001; Lindsay & Wilkinson, 1999; Nykanen et al., 2013; Pound et al., 2000; Simmons-Mackie et al., 2010; Wilkinson & Wielaert, 2012). PWA also specifically self-report the positive impact of communicating with someone who knows about aphasia and what communication strategies to use during conversation (Dalemans et al., 2010; Harmon, 2020).

Second, the sense of comfort and support experienced during communication has been suggested as an important factor for communicative ability (Dalemans et al., 2010; Harmon, 2020; Worrall et al., 2010). Though not exclusively, this sense of comfort and support is often associated with the familiarity of the CP. This line of reasoning suggests that the fear of not being able to express oneself due to the language impairment and subsequently the fear of 'losing face' or of being perceived unfavourably because of the communication difficulties, can make communication with an UFCP more effortful and a more negative experience (Harmon, 2020). For PWA, this could potentially result in more errors in their language production, more and longer word searches, or potentially result in avoidance of the interaction with the UFCP resulting in, for example, shorter interactions altogether. Suggestions to this end have been made in the literature (Kistner, 2017; Li et al., 1995). In a discussion of the use of compensatory communication strategies by PWA, Simmons-Mackie and Damico (1995) showed that PWA may vary their communication strategies depending on the goal in a particular context, such as 'looking okay', rather than being maximally communicatively effective. To the knowledge of the authors the sense of being at ease during communication and the influence of conversation partner familiarity has not been explored empirically.

In sum, the existing research suggests that the presence of personal common ground can influence communication for PWA. The existing evidence base is small, but it seems that the effect of conversation partner familiarity might depend on the level at which communication is measured. It seems that lower level linguistic measures such as verb or sentence production could remain stable across different conversation partners, while higher level communication strategies such as the use of gesture or the repair of conversational trouble might vary. More work is needed, however, to assess whether this advantage exists, how it manifests, whether it exists for all types of aphasia, and if it is mediated by other factors such as aphasia severity. It is crucial to control for the influence of other confounding factors such as knowledge of aphasia of the CP, the sense of comfort experienced by the PWA as well as the conversation topic.

The aim of the current study was to investigate whether CP familiarity affects communication for PWA. Participants completed a collaborative task that required communication in two different conditions: once with a FCP, and once with an UFCP. Two groups participated: PWA with a NHC conversation partner, and NHC with a NHC conversation partner. To investigate the question of personal common ground we controlled for the potential influence of two confounding factors. Knowledge of aphasia was controlled for by swapping the CPs of pairs of PWA who were matched on their linguistic and communication impairment profiles. Knowledge of aphasia was also tested through a questionnaire. The sense of comfort was controlled for by asking each familiar and unfamiliar pair to indicate the level of comfort they felt while completing the task with their conversation partner. These research questions were part of a bigger pre-registration (https://osf.io/9xwm7).

A collaborative task was used to elicit naturalistic communication between the participant pairs. Different versions of this task have been used in previous research with NHC (Boyle et al., 1994; Clark, 1996; Clark & Krych, 2004; Clark & Wilkes-Gibbs, 1986; Howarth & Anderson, 2007; Lysander & Horton, 2012) where naturalistic communication is investigated in a controlled lab setting. This experimental setup made it possible to adhere to the previously described framework of real-world communication and to manipulate variables within that framework (Doedens & Meteyard, 2020), see Table 3.

To measure the effect of the experimental manipulation on communicative success for PWA and NHC, a selection of key outcome measures was made based on previous literature on CP familiarity with PWA and NHC. Based on research with NHC, measures of trial time and task accuracy were selected. Previous research with PWA suggests that the number of times trouble is identified during conversation, can be indicative of communicative success (e.g., Beeke, 2012). We therefore also included a measure of self-initiated repair (i.e. instances where the 'speaker' initiates a self-correction) and other-initiated repair (i.e. instances where the 'listener' requests clarification on what has been said) as a measure of communicative success.

Due to the nature of the task, an additional analysis was included (not part of the pre-registration). This analysis aimed to assess the influence of role (instructor or listener) on goal-directed communication. The current study included trials in which PWA and NHC took turns in an 'instructor' role, requiring them to actively communicate new information to their CP. Conversely, participants also took on the 'listener' role, requiring them to follow instructions from their CP. Previous studies with NHC have assumed no differences in role for measures such as time taken and accuracy (Boyle et al., 1994). Therefore, no difference in roles was expected for NHC for the measures of time and accuracy. However, as PWA present with impairments of language production and comprehension, a difference in performance based on role can be expected. For the number of self-initiated repairs and clarification requests, we expected an effect of role for both groups. Self-initiated repairs are naturally expected to be more frequent when someone speaks more (i.e. the 'instructor' role), while Clarification requests are naturally expected to be more frequent when someone is in the 'listener' role.
Analysis addressed the following research questions:

1. What is the effect of speaker role (instructor/listener) on goal-directed communication?

2. What is the effect of CP familiarity (personal common ground) on goal-directed, face-to-face communication in aphasia?

3. Do PWA differ from NHC in how they respond to CP familiarity during goal directed communication?

Based on the existing literature, it was hypothesized that it will be easier for PWA to complete the task with a FCP than with an UFCP, as evidenced by the familiar pair taking less time, requiring fewer repairs, obtaining higher accuracy scores and fewer requests for clarification. Based on the case study by Lubinski et al. (1980), it could be the case that the number of repairs falls into the category of more lower-level behaviour which remains stable across conversation partners. In comparison to NHC, we expect PWA to show a similar direction of the effect of CP familiarity. Due to the presence of the language impairment for PWA, we expect the CP familiarity effect to be greater for PWA compared to NHC, i.e. we expect PWA to have more difficulty adapting to communicating with an UFCP, or to benefit more from communicating with their FCP (see Table 1).

Outcome measure	**Description**	**Hypotheses**			
		RG1 (instructor vs listener)		**RG2 (PWA)**	**RG3* (PWA vs NHC)**
		PWA	**NHC**		
Trial time	Faster times indicate 'better' communication	Instructor $\neq$ listener	Instructor = listener	fam. < unfam.	NHC < PWA
Task accuracy	Higher accuracy indicate 'better' communication	Instructor $\neq$ listener	Instructor = listener	fam. > unfam.	NHC < PWA
Self-initiated repairs	Fewer repairs indicate 'better' communication	Instructor > listener	Instructor > listener	fam. < unfam.	NHC < PWA
Clarification requests	Fewer requests indicate 'better' communication	Instructor < listener	Instructor < listener	fam. < unfam.	NHC < PWA

Table 1. Hypotheses for each outcome measure, shown for each research question (RQ): RQ1: the effect of role, RQ2: the effect of CP familiarity for PWA, RQ3: the difference in effect of CP familiarity between PWA and NHC. * hypotheses are about the difference scores between the familiar and unfamiliar conditions. A larger difference score represents a bigger impact of the experimental manipulation.

Materials and Methods

Ethics Statement

This study was carried out with ethical clearance from the School of Psychology and Clinical Language Sciences, University of Reading (Ref: 2018-093-LM). All participants provided informed consent prior to taking part in the study. Consent and information forms were adapted to aphasia friendly format for the participants with aphasia.

Participants

Sixteen participants with post-stroke aphasia (42-72 years, M = 60.94, SD = 9.41) and sixteen control participants (NHC, 52-84 years (M = 64.94, SD = 9.66) took part in the current study. PWA and controls were matched for age ($t(30) = 1.19$, $p = 0.245$) and years of education ($t(29) = -0.07$, $p = 0.946$). Nine male and seven female PWA were recruited through the Aphasia Research Registry of the School of Clinical Language Sciences, University of Reading (British Academy Grant ARP scheme 190023), as well as through local stroke groups. PWA were at least one-year post-stroke (1-14 years, M = 7.04, SD = 3.85) and were native speakers of English prior to the stroke. Exclusion criteria were coexisting neurological diagnoses such as dementia and an inability to provide consent due to severe comprehension difficulties. Seven male and nine female NHC were recruited through the older adult research panel at the School of Psychology, University of Reading. Exclusion criteria were a history of neurological illness. All subjects reported normal or corrected-to-normal vision and hearing.

All participants brought along a FCP to take part in the study with them. The PWA self-nominated a FCP who they spoke to regularly. Six male and ten female FCPs agreed to take part (partner, friend or family member between the ages of 22-72 years, M = 54.12, SD = 15.12, see Table 2 for more details). All FCPs except those labelled child (only ID 48), ex-partner and friend lived in the same house with the PWA. For NHC, partners were recruited as the FCP (aged range 51-79 years, M = 64.12, SD = 7.57, see Table S1 in the supplementary materials). All FCPs lived in the same house with their partner. All FCPs reported normal or corrected-to-normal vision and hearing and did not report a history of neurological illness.

PWA											Conversation partner					
								Scenario Test								
ID	Sex	Age	Ed.	Time post stroke (months)	WAB-AQ	Severity	Type	Rawscore	Perc.	Classification*	ID	Sex	Age	Ed.	Partner type	Years knowing PWA
69	M	72	10	71	11.6	very severe	Global	35.94	34	Limited	70	F	69	11	Partner	54
43	M	57	12	58	18.3	very severe	Broca/Global	42.4	46	Okay	44	F	56	13	Partner	30
15	F	57	19	56	27.6	severe	Wernicke	20.25	14	Almost none	16	M	60	17	Partner	40
19	M	65	13	177	56.8	moderate	Broca	44.47	49	Okay	20	F	60	13	Partner	40
45	F	42	19	12	58.2	moderate	Broca	48	63	Okay-Good	46	F	43	13	Friend	10
5	M	72	16	123	61.6	moderate	Broca	41.63	42	Okay	6	F	55	13	Ex-partner	25
41	M	45	11	75	62.5	moderate	Broca	37	34	Limited	42	F	41	13	Partner	20
37	F	68	17	136	69.5	moderate	Conduction	48	63	Okay	38	M	69	17	Partner	50
47	F	70	10	116	72.2	moderate	Broca	49	68	Okay-Good	48	F	49	15	Child	49
78	F	51	15	20	74.1	moderate	Anomic	47.47	60	Okay	79	M	23	17	Child	23
11	M	66	17	56	83.8	mild	Conduction	53	93	Good	12	M	22	13	Grandchild	22
53	M	67	19	42	89.4	mild	Anomic/Transc. sensory	53	93	Good	54	F	72	14.5	Partner	33
7	F	51	16	55	90.1	mild	Anomic	54	100	Good	8	M	63	14	Partner	10
1	M	64	11	133	90.8	mild	Anomic	53	93	Good	2	F	58	18	Partner	26
67	F	65	16	110	93.3	mild	Anomic	53	93	Good	68	M	66	18.5	Partner	47
13	M	63	18	111	94.2	mild*	Transc. sensory	51	78	Good	14	F	60	18	Partner	42

Table 2. Descriptives for PWA and their familiar conversation partners, ordered by WAB-AQ score (lowest to highest; 0-25 is very severe, 26-50 is severe, 51-75 is moderate, and 76–above is mild, *93.8 is the cut-off for an aphasic score). Scenario Test classification is based on the percentiles of the Dutch norm group, solely used her to provide a descriptive classification. *Classification refers to the communicative ability of the PWA: "almost no communicative ability", "seriously limited communicative ability", "okay communicative ability in simple situations" and "good communicative ability in simple situations". Ed. = Education in years.

All PWA completed the Western Aphasia Battery – Revised (WAB-R; Kertesz, 2009). The aphasia quotient score (AQ) ranged from 11.60-94.2 (M = 65.88, SD = 26.59), severities ranging from very severe to mild (see Table 2 for an overview). To obtain a standardised measure of communicative ability, PWA also completed the Scenario Test UK (Hilari & Dipper, 2020; Hilari et al., 2018). Scores ranged from 20.25-54 (maximum score = 54, M = 46.74, SD = 8.62; details shown in Table 2). Thirteen out of sixteen PWA had some degree of weakness (hemiparesis) on the right-hand side due to the stroke. All PWA were able to use their unaffected arm and hand effectively. All PWA were mobile enough to attend the experiment at the University clinic. One PWA attended the clinic in a wheelchair.

All participants without aphasia completed the Montreal Cognitive Assessment. Scores ranged between 17-30 (M=27.23, SD=2.49). Six participants (2 FCP to NHC, 3 FCP to PWA and 1 NHC) scored below the cut-off score of the test.

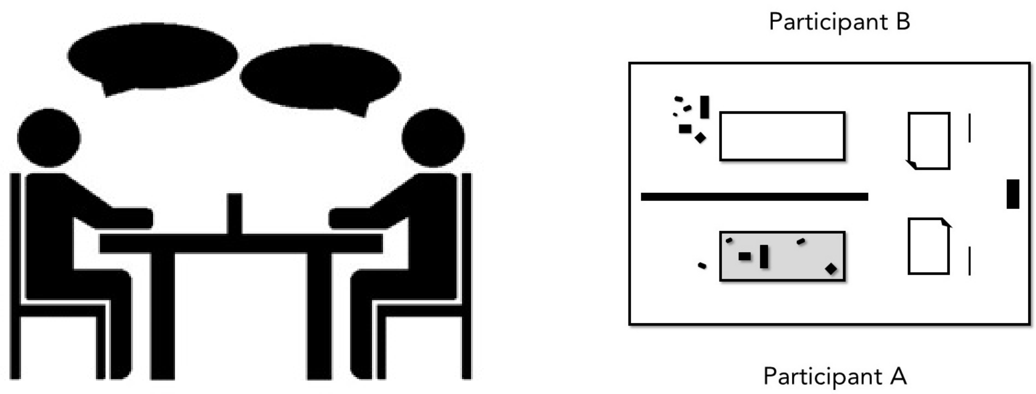
Procedure

All participants were invited to take part in a study about conversation and different CPs. Background testing with PWA was completed either at the participant's home or at the School of Clinical Language Sciences, University of Reading. All NHC completed background testing at the University of Reading.

For the experimental session, two participants and their respective FCP were invited to the Speech and Language Therapy Clinic at the University of Reading.

Task

The experimental design consists of a collaborative, referential communication task (Clark & Krych, 2004) that allows pairs to interact and communicate freely, replicating a real-life face-to-face communicative setting. Pairs sat across from each other, in front of identical playmobile rooms (see Figure 1). The view of the other person's room was blocked by a low barrier. Five items were placed in one room (*instructor*), while the other room (*follower*) remained empty with six items placed on the side of the room. Pairs were asked to replicate the setup of the instructor's room in the follower's room. They were asked to communicate as they normally would, including the use of any communication aids. Pen and paper were provided for both participants. Participants were instructed not to show items to their CP or to look over the barrier at the other room. Aphasia friendly images were used to visually support the instruction



(a) (b)

Figure 1. Schematic overview of the experimental setup. **View A** shows a side-view: two participants sitting across from each other at a table, with a low barrier between them. Participants can easily see each other, but the view of the other person's workspace is obscured by the barrier. **View B** shows the table from above: two identical room layouts. Participant A has five items placed in the room, one distractor object outside of the room. For participant B, all six items are placed on the side of the room. Pen and paper are placed to the left-hand side of the PWA (in case of neglect, hemianopia or hemiparesis), and is provided for both participants. A button at the end of the table (again to the left of the PWA) is used to indicate completion of the task. A low barrier (black bar) blocks the view of the other person's room, but not the view of their pen and paper.

for all participants. The experimenter left the room for the duration of the task. When the pair completed the task, they pressed a button. The experimenter then re-entered, took a picture of both rooms, and showed the participants the result. Any paper used was collected by the experimenter and the next trial was set up.

Each pair (familiar and unfamiliar) completed the game six times: For each trial, roles (instructor/follower) were swapped, resulting in three instructor trials and three follower trials for each participant. The starting role was counterbalanced across participants. A different setup of items was used for each trial, the order of which was randomized for each pair.

The experimental manipulations of the current study can be summarised according to the previously described framework of real-world communication (Doedens & Meteyard, 2020). See Table 3.

Materials

An empty Playmobil room with four windows and one door was used for the current experiment. Six Playmobil objects were selected based on psycholinguistic features that have

Component of the framework	Manipulation in the current experiment
Interactive	Unrestricted interaction with the CP (i.e. no restrictions on giving feedback, asking questions, etc.)
	Interaction with a single CP
Multimodal	Unrestricted use of all communicative modalities (gesture, facial expressions, body posture, intonation, language)
	Optional use of pen and paper for drawing and writing (specified as 'if you need to, you can use')
	Added option of communication aid
Common ground	
Personal	Interaction with a familiar CP and with an unfamiliar CP (*the main experimental manipulation*)
Communal	-
Communicative	Repetition of the same task across 6 trials allowing CPs to build communicative context. Theoretically, this context could have carried over into the unfamiliar condition, where the same task was repeated.
Situational	The use of 6 concrete, highly frequent, familiar, and recognisable objects and their physical location in relation to a physical space and each other.

Table 3. Description of the experimental manipulation according to the theoretical framework of face-to-face communication.

been shown to influence lexical retrieval in PWA (Nickels and Howard, 1995, see Table S2 in the supplementary materials for details). The items were selected based on high levels of concreteness, familiarity and imageability, as well as (roughly) low number of phonemes to facilitate naming of the items as much as possible.

Six different room setups were created by placing five Playmobil items in various configurations across the room (see Figure 2). One item (counterbalanced across trials) was a distractor and placed outside of the room. Three additional objects were permanently placed in the same location across all six trials, functioning as reference points for the other objects: (1) a chest of drawers with (2) a television on top and a (3) potted plant in the opposite corner of the room.

Between conditions, the physical appearance (i.e. the colour) of the cat and the hair of the woman was changed to incorporate some variation in the stimuli. Two reference objects were

Figure 2. Two examples of item setup in the Playmobil living room. Five items are placed in different locations in the room, one item was always left on the side as the distractor (and did not need to be placed by the listener).

also changed: the potted plant was replaced by a different potted plant and the television was replaced by a set of books. The location of all the items remained constant.

Familiarity manipulation

In the unfamiliar condition, each participant was matched with another participant's FCP. PWA were matched with the FCP of a PWA with a similar aphasia profile based on their WAB-AQ score and their communication score on the Scenario Test (van der Meulen et al., 2010). This way, PWA were matched with an FCP who was unfamiliar at a personal level, but who had experience communicating with someone with roughly similar communication difficulties. Where possible, PWA were also matched on age and gender (see Table S3 in the supplementary materials for more details). In the control group, NHCs were matched on gender, age and years of education (in order of priority). For the unfamiliar condition, each NHC was paired up with their matched NHC's FCP (see Table S4 in the supplementary materials for details on matching).

At the beginning of each condition, each participant was asked to rate the familiarity of their CP on an aphasia-friendly Likert scale (0 = this person is a stranger, 5 = I know this person extremely well). For both groups, the FCP was rated higher in familiarity (PWA: $M = 3.55$, $SD = 0.62$, NHC: $M = 3.97$, $SD = 0.12$) compared to the UFCP (PWA: $M = 0.52$, $SD = 0.92$, NHC: $M = 0.03$, $SD = 0.12$). The difference in familiarity ratings was significant for both groups (PWA: $t(30) = 10.97$, $p < .001$, NHC: $t(30) = 89.09$, $p < .001$).

The order of conditions was not counterbalanced: All participants first completed the familiar condition, followed by the unfamiliar condition. The authors decided against counterbalancing the order of conditions to minimise potential anxieties about communicating with an UFCP for the PWA.

Controlling for knowledge of aphasia

To control for knowledge of aphasia, all CPs of PWA filled out a questionnaire testing their knowledge of aphasia (factual knowledge and knowledge on communication strategies as described in Rayner and Marshall, 2003). Knowledge of aphasia was similar for FCP (*factual*: M = 10.1, SD = 3.02, *strategies*: M = 22.4, SD = 1.9) and UFCP (*factual*: M = 10.4, SD = 0.98, *strategies*: M = 22.3, SD = 2.75). A paired t-test showed no significant differences between FCPs and UFCPs (*factual knowledge*: V = 6, p = .854, *knowledge of communication strategies*: t(6) = 0.16, p = .877)[1].

Controlling for a sense of comfort with the CP

To control for the degree of comfort PWA and NHC felt with their FCP and UFCP during the task, all participants were asked how comfortable they felt communicating with their CP. At the end of each condition, each participant was presented with a statement ("I feel that my partner and I communicate comfortably together") and a visual 5-point Likert scale (0 = completely disagree, 4 = completely agree). For both PWA and NHC, the degree of comfort they felt with their CP was roughly equal in the familiar (PWA: M = 3.56, SD = 0.51, NHC: M = 3.71, SD = 0.47) and unfamiliar condition (PWA: M = 3.28, SD = 0.52, NHC: M = 3.53, SD = 0.62). A non-parametric paired t-test showed no significant difference between the degree of comfort they felt with their FCP and UFCP (PWA: V = 18, p = .119, NHC: V = 20, p = .299).

Coding

All trials were video and audio recorded. Videos of the interactions were coded in ELAN (MPI: The Language Archive, 2019). For the purpose of this study, the following measures were coded:

Trial time. All videos were coded for trial time. Trial time was defined as the moment participants started to communicate on a trial (speak, draw, gesture, etc) until the moment one of the participants pressed the button to signal the experimenter to come into the room.

Task accuracy. Task accuracy was defined as the correct placement of the items in the fol-

[1]Data from one PWA conversation partner is missing from the dataset, because one questionnaire was not returned.

lower's room as compared to the instructor's room as set up by the experimenter. The setup of the instructor's and follower's room was photographed at the end of each trial. Both images were scored by two independent judges on accuracy (correct/incorrect) of two aspects of the item: its location (in the room and in relation to other objects), its orientation. For the people, two additional aspects were coded: the action that was undertaken by the item (i.e standing, sitting, etc.) and the positioning of the arms. For all other objects, the action was always coded as correct, resulting in a maximum score of 3 per item, and 4 per person (a maximum score of 20 and a minimum score of 4, examples of low, moderate and high accuracy scores are provided in Figure S1 in the supplementary materials). In case of doubt due to different angles of the pictures, a grid was superimposed on the floor of each image using Kinovea software (Charmant, 2006-2011).

Self-initiated repairs. Self-initiated repairs were defined as instances where a participant explicitly attempted to repair or change their own output (often described as the repair initiation; Schegloff et al., 1977; Wilkinson, 2006). A self-initiated repair was always an explicit correction initiated by the interlocutor themselves, without any prompts from the conversation partner. Three different types of self-initiated repairs were coded, partially based on Perkins (1993) (see Table 4). For the word-finding repairs, repetitions of parts of words are expected, but if parts of a word are repeated without revisions, additions or explicit statements of difficulties finding a word, these are not coded as a repair. All self-initiated repairs are coded, regardless of the way in which the repair is resolved (i.e. by the interlocutor themselves, collaboratively with their conversation partner or by the conversation partner). Whether a repair is successful or not was not coded (i.e. whether the correction creates a correct utterance or not, or whether the correct word is produced, or the search is abandoned). Non-verbal instances of self-initiated repairs are also included (e.g. direct gaze at the partner to provide help in a word search, Beeke, 2012). The total number of self-initiated repairs was counted for each trial and participant.

Clarification requests. Clarification requests are defined as instances when one interlocutor indicates to their conversation partner that they have not fully understood what has been said (also described as an 'other-initiated' repair; Schegloff et al., 1977). Five types of clarification requests were coded, partly based on Schegloff, Jefferson and Sacks (1977) (see Table 4). Coding included verbal and non-verbal clarification requests such as eye gaze and frowning, or clear shrugs directed at the CP. The total number of clarification requests was counted for each trial and participant.

Type of code	Description	Example
Self-initiated repairs		
Revised repair	The interlocutor repeats the main clause with modifications.	"the man goes under the chair…. no I mean he goes on the chair"
Addition repair	The interlocutor provides additional information to the main clause.	"the sofa is in opposite the window…the small window"
Word finding repair	The interlocutor explicitly has word-finding difficulties (repetitions without revisions, additions or explicit statements of difficulties finding a word are not included).	"the d…d… oh what is that word?"
Clarification requests		
Request for elaboration or clarification	The interlocutor asks their CP to provide more information on what has been said. This type of clarification request includes most wh-questions.	"Which window?" or "Where?"
Statement of not understanding	The interlocutor indicates that they did not follow what their CP said.	"I don't understand" or "Huh?"
Partial or complete repetitions	The interlocutor repeats (part of) a phrase as produced by the CP, sometimes with a questioning intonation, to check if they have understood correctly.	CP1: "by the window on the left" CP2: "by the window on the left?"
Insertion	When the CP is speaking the interlocutor inserts a word or phrase that fits into the utterance of the CP. This can happen, for example, when the CP pauses to search for a word. The insertion functions as an evaluation for the interlocutor to assess if they have correctly understood the utterance of the CP.	CP1: "and then the sofa is facing the.." CP2: "the tv cabinet?" CP1: "yes, the tv cabinet"
Indirect request for clarification	The interlocutor asks for a repetition of what has been said, indirectly indicating they (might not) have not fully understood or followed.	"Please speak more slowly"

Table 4. Different types of self-initiated repairs and clarification requests that were coded.

Statistical analysis

All outcome measures showed a non-normal distribution and contained outliers. The outcome measures also showed significant differences in variance between groups. Loglinear transformations did not eliminate the problems of normality or extreme values in the data. To avoid relying on assumptions of normality, a bootstrap procedure was used to obtain a distribution based on resampling of the existing data, from which the test statistic was derived (Wilcox, 2012). Outliers and differences in variance between groups were dealt with by choosing robust analyses based on the median (percentile bootstrap) and 20% trimmed means (bootstrap-t). An alpha threshold of .05 was used to determine statistical significance. The results from the median analysis are reported in the paper. When there was a difference in outcome, results from both analyses are discussed. For all bootstrapping methods, 10,000 bootstrap samples were used (Rousselet et al., 2019).

Research question 1: An effect of role (instructor or listener).
Research question 2: An effect of CP familiarity for PWA.
To answer these research questions, we begin with an analysis for each group separately (PWA or NHC). This helps us to identify patterns for each group of participants, and to address whether role and familiarity have an effect on goal directed communication. Two factors were entered into analysis. First, the condition of familiarity (familiar / unfamiliar), as this was our principle experimental manipulation. Second, the role of the participant (instructor / listener). Role was expected to affect the nature of communication in the goal directed communication task for PWA.

Thus, within subjects 2 (role: instructor/listener) x 2 (condition: familiar/unfamiliar) robust analyses were conducted on all outcome measures: of the median (*wwmcppb* in Wilcox, 2012), and of the 20% trimmed mean (*wwmcpbt* in Wilcox, 2012). Planned comparisons were conducted for significant main effects: for a main effect of role, a dependent groups analysis on each level of condition (familiar/unfamiliar) was run on the median and 20% trimmed mean (*bootdpci* and *ydbt*, respectively, in Wilcox, 2012). For a main significant effect of condition, the same dependent groups analysis was conducted on each level of role (instructor/listener). The full results of these analyses are reported in Table S5 in the supplementary materials. Results of the planned comparisons are reported in Tables S6-S9 in the supplementary materials.

Research question 3: An effect of CP familiarity for PWA compared to NHC.
We first accounted for the effect of Role (see above) by splitting data into Instructor or Listener trials. We then completed between-by-within 2 (group: PWA/NHC) x 2 (condition: familiar/unfamiliar) robust analyses on all outcome measures: of the median (*sppba, sppbb* and *sppbi* in Wilcox, 2012) and the 20% trimmed mean (*bwtrimbt* in Wilcox, 2012). Planned comparisons on significant main effects of group (PWA vs NHC) were conducted with an independent groups analysis (pb2gen in Wilcox, 2012), to test the effect at each level of condition (familiar/unfamiliar). For a main significant effect of condition, a dependent groups analysis (*bootdpci* and *ydbt*, as described above, in Wilcox, 2012) was conducted on each level of group (PWA/NHC). The full results of these analyses are reported in Table S10 in the supplementary materials. Results of the planned comparisons are reported in Tables S11-S14 in the supplementary materials.

To assess the individual patterns of behaviour, a difference score between conditions was calculated for each role: for each participant, the value of each outcome measure for the familiar condition was deducted from the value of the unfamiliar condition. The difference scores were then plotted by group.

Results

Trial time

Research question 1: An effect of role (instructor or listener).

Research question 2: An effect of CP familiarity for PWA.

PWA

The 2 (role: instructor/listener) x 2 (condition: familiar/unfamiliar) analysis showed a main effect of role (instructor vs listener; estimated median difference = 156.65 sec., $p < .001$), with longer trial times for instructors (median = 332.49, CI = 259.57, 404.11) compared to listeners (median = 251.72, CI = 191.80, 362.96). Planned pairwise comparisons show that the difference in trial time for instructors versus listeners holds for both conditions (familiar: $p = .015$, unfamiliar: $p = .035$)[2] . For PWA, total trial times were longer when they were in the instructor role as compared to the listener role. See Figure 3.

There was a main effect of condition (familiar vs unfamiliar; estimated median difference = 167.34 sec., $p < .001$), with longer trial times in the familiar condition (median = 363.92, CI = 307.84, 404.11) compared to the unfamiliar condition (median = 251.28, CI = 198.96, 277.92). Planned comparisons show that the difference in trial time between familiar and unfamiliar conditions was significant for the instructor role ($p < .001$) and not when PWA take on the listener role ($p = .201$). In the instructor role, PWA took less time to complete a trial in the unfamiliar condition compared to the familiar condition. In the listener role, trial times were more equal. See Figure 3.

The interaction of role*condition was not significant (estimated median difference = 38.02 sec, $p = .457$).

NHC

There were no significant effects (role: estimated median difference = 173.4 sec., $p = .014$, condition: estimated median difference = 75.75 sec., p = .46 =, interaction: estimated median difference = 21.26 sec., $p = .76$). For NHC trial times were constant for both roles (instructor/listener) and conditions (familiar/unfamiliar). See Figure 3.

[2]Planned comparisons using the 20% trimmed mean did not show a significant difference between roles ($p = .136$) for the unfamiliar condition. The presence of a larger number of outliers will have affected the trimmed means analysis more than the median. We will therefore rely on the median analysis.

Research question 3: An effect of CP familiarity for PWA compared to NHC.

Instructor trials

There was no significant main effect of group (PWA/NHC, estimated median difference = 78.37 sec., p = .199), with PWA and NHC showing similar overall total trial times for Instructor trials. See Figure 3.

There was a significant main effect for condition (familiar vs unfamiliar; estimated median difference = 68.09 sec., p = .01)[3], with longer trial times in the familiar condition (median = 384.50, CI = 343.35, 491.88) compared to the unfamiliar condition (median = 284.29, CI = 259.57, 457.81). Planned comparisons within subjects showed that for PWA, total trial times were faster in the unfamiliar condition compared to the familiar condition (see Figure 3). Whilst the main effect of condition was significant, planned comparisons did not show a difference within subjects for the familiar vs unfamiliar conditions for NHC (p = .203).

The interaction of group * condition was not significant (estimated median difference = -53.52 sec., p = .253).

Listener trials

There was a main effect of group (PWA vs NHC; estimated median difference = 144 sec., p = .008). Total trial times were longer for NHC (median = 374.35, CI = 351.61, 457.16) compared to PWA (median = 270.22, CI = 173.27, 365.58). Planned comparisons between subjects showed a significant difference in the unfamiliar condition (p = .009), with trial times for PWA significantly faster than for NHC. The same comparison for the familiar condition was not significant (p = .158). See Figure 3.

The main effect of condition (estimated median difference = 60.4 sec., p = .08,) and the interaction of group * condition was not significant (estimated median difference = -53.52 sec., p = .399).

[3]The 20% trimmed means analysis did not show the significant effect for condition (Q = 3.44, Qcrit = 4.16, p = .074). The distribution of data in the two conditions is slightly different. This in combination with the presence of multiple outliers in the familiar condition will have affected outcome of the median and trimmed mean analyses differently. To avoid the influence of too many outliers, the median analysis will be used here.

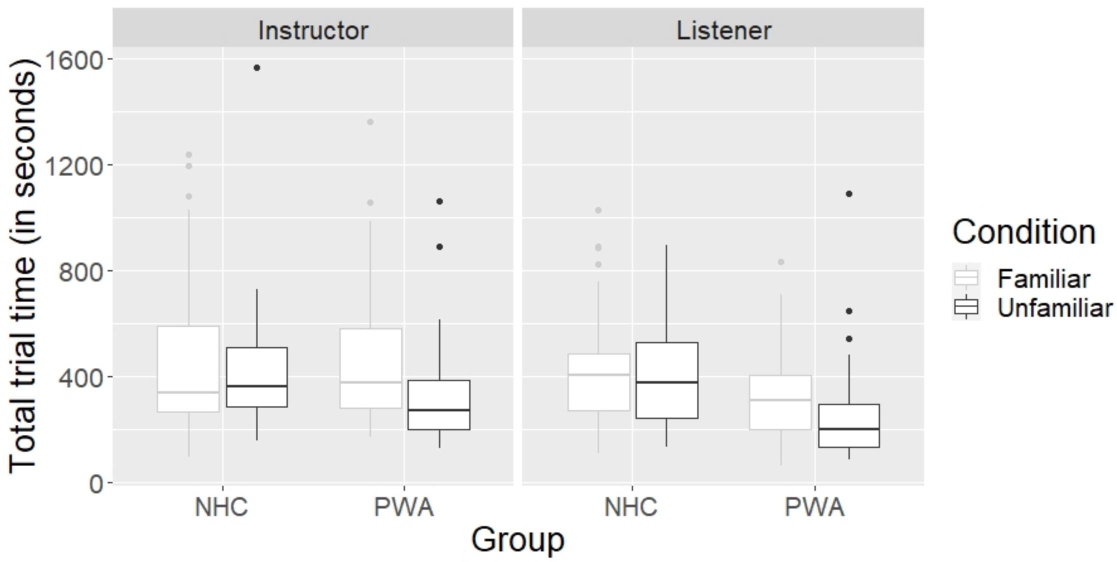


Figure 3. Boxplots showing total trial time by condition and group, for each role (instructor/listener).

Summary of results for trial time

Total trial times were longer when PWA took on the instructor role, regardless of the familiarity of the CP. In addition, total trial times for PWA were faster for the unfamiliar condition. For NHC, there was no significant difference in trial times in the familiar and unfamiliar conditions, or between the different roles. NHC total trial times were overall slower than PWA for the listener trials.

Changes at the level of individual dyads

To explore the results descriptively, we plotted the changes in total trial time for each dyad (Figure 4). Data for PWA has been grouped according the severity of aphasia for the PWA participant. In general, the spread of data points for both groups (PWA or NHC) is greater for the Instructor role. There is a trend that, as aphasia severity decreases (moving left to right along the x axis), the distribution of difference scores increases with more dyads showing faster total trial times in the unfamiliar condition (negative values). Note that this is confounded by there being more data points for moderate to mild PWA. However, it is tentative evidence that for PWA who are less severe, total trial times were likely to be faster for the unfamiliar condition.

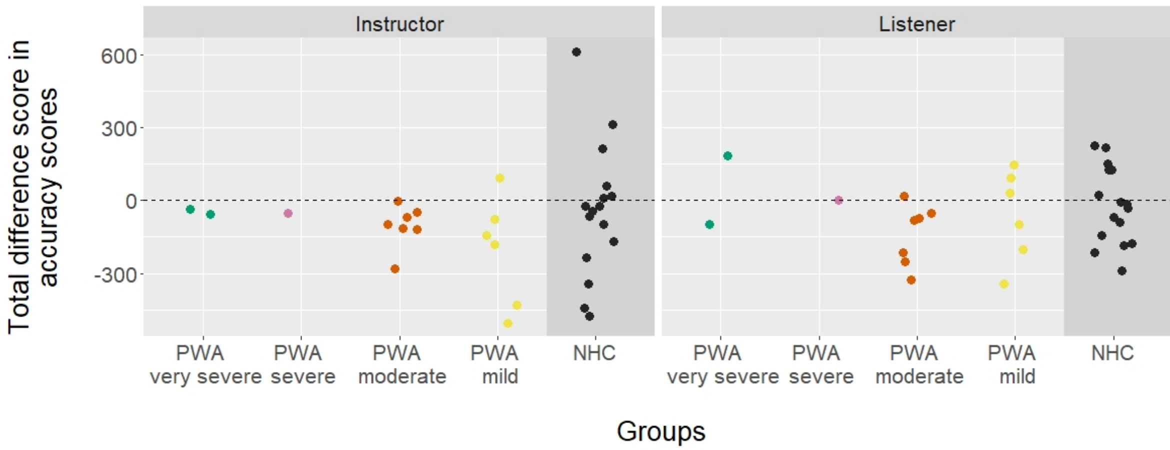


Figure 4. Plot showing individual data points for both groups for difference score between familiar and unfamiliar conditions, by role (PWA grouped by WAB categorisation). Zero represents no change in total trial time between conditions, negative values indicate a shorter total trial time in the unfamiliar condition compared to the familiar condition.

Task accuracy

Research question 1: An effect of role (instructor or listener).

Research question 2: An effect of CP familiarity for PWA.

PWA

There was a significant main effect of condition (familiar vs unfamiliar; estimated median difference = -1.67, p = .049). Task accuracy scores were higher in the unfamiliar condition (median = 16.17, CI = 15.42, 17.67) compared to the familiar condition (median = 15, CI = 14.08, 17.17). Planned comparisons showed that in the instructor role, PWA did not show a significant change in accuracy scores between familiar and unfamiliar conditions (p = .607). In the listener role, the difference in accuracy scores between conditions (familiar/unfamiliar) was significant in the trimmed mean analysis (p = .007, *median analysis*: p = .062). Accuracy was higher in the unfamiliar condition compared to the familiar condition. It therefore seems that the main effect of condition (familiar vs unfamiliar) for PWA was driven by the improvement in accuracy scores in the listener role (see Figure 5).

There was no significant main effect of role (estimated median difference = 0.67, p = .538) and no significant interaction of role*condition (estimated median difference = 1.83, p = .167).

NHC

There was a significant main effect of condition (familiar vs unfamiliar; estimated median difference = -0.67, p = .015), with NHC obtaining higher accuracy scores in the unfamiliar condition (median = 18.75, CI = 18.33, 19.0) compared to the familiar condition (median = 18.33, CI = 17.17, 18.67). Planned pairwise comparisons showed a significant effect of condition for NHC in the instructor role as measured by the 20% trimmed means analysis (p = .043, median analysis: p = .131), but not for the listener role (p = .182). As instructors, NHC obtained higher accuracy scores in the unfamiliar condition compared to the familiar condition. The main effect of condition for NHC therefore is driven more by the significant improvement in scores in the instructor role. See Figure 5.

There were no significant effects of role (estimated median difference = -0.67, p = .173) nor an interaction of role*condition (estimated median difference = -0.33, p = .338).

Research question 3: An effect of CP familiarity for PWA compared to NHC.

Instructor trials

The 2 (group: PWA/NHC) x 2 (condition: familiar/unfamiliar) analysis showed a significant main effect of group (PWA vs NHC; estimated median difference = 2, p = .004), with higher accuracy scores for NHC (median = 18.33, CI = 17.5, 18.83) compared to PWA (median = 16.17, CI = 15.0, 16.75). Planned pairwise comparisons showed that the effect of group was significant in both conditions (*familiar*: p = .022; *unfamiliar*: p = .002). In the instructor role, NHC had significantly higher accuracy scores compared to PWA (see Figure 5).

The main effect of condition (familiar/unfamiliar) and the interaction of group*condition were not significant (*condition*: estimated median difference = -0.33, p = .407, *interaction*: estimated median difference < -0.01, p = .95).

Listener trials

There was a significant main effect of group (PWA vs NHC; estimated median difference = 2.83, p < .001). PWA obtained lower accuracy scores (median = 15.58, CI = 14.17, 17.0) compared to NHC (median = 18.42, CI = 18.33, 19.17). Planned pairwise comparisons showed that the effect of group was significant in both conditions (*familiar*: p < .001, *unfamiliar*: p < .001). In the listener role, NHC had significantly higher accuracy scores compared to PWA. See Figure 5.

The main effect of condition (familiar vs unfamiliar) was significant in the 20% trimmed means analysis [4] (Q = 14.09, Qcrit = 4.36, p = .002), with higher accuracy scores in the unfamiliar condition (median = 17.67, CI = 17.17, 18.67) compared to the familiar condition (median = 17, CI = 16, 18.17). Planned pairwise comparisons showed that the effect of condition was significant for PWA in the 20% trimmed means analysis (p = .007, *median analysis*: p = .062), but not for NHC (p = .182). In the listener role, PWA had significantly higher accuracy scores in the unfamiliar compared to familiar condition. See Figure 5.

The interaction group*condition was not significant (estimated median difference = -1.67, p = .093).

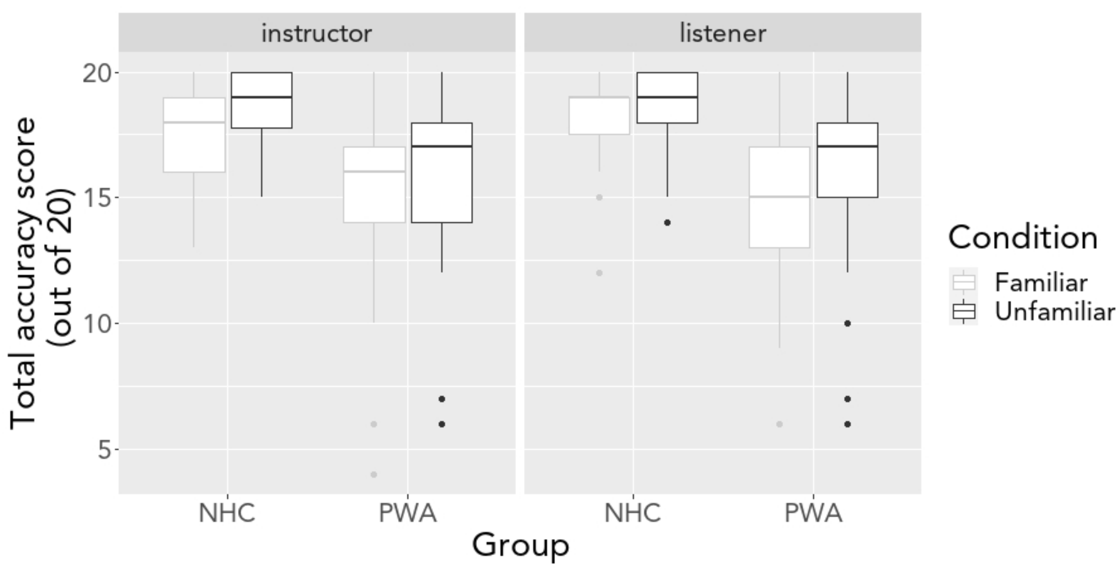


Figure 5. Boxplots showing total accuracy score (out of 20) by condition and group, for each role (instructor/listener).

Summary of results for accuracy

Overall, NHC always scored higher on task accuracy compared to PWA. When analysed as separate groups, accuracy scores were higher in the unfamiliar condition for both PWA and NHC.

[4]The main effect of condition was not significant based on the median analysis (estimated median difference = -0.67, p = .152). The difference in variance in both conditions could have affected the median less compared to the trimmed mean. In addition to this, a potential ceiling effect means that the median might not reflect the improvements in performance of NHC between conditions as reliably as the trimmed means. We will therefore rely on the trimmed mean analysis here.

Changes at the level of individual dyads

The changes in accuracy scores for each dyad are plotted in Figure 6. Data for PWA has been grouped according the severity of aphasia for the PWA participant. In general, the spread of data points is greater for PWA than for NHC. Based on aphasia severity, there doesn't seem to be a clear pattern of change in accuracy scores between condition: while the two participants with very severe aphasia have a higher accuracy score in the unfamiliar condition compared to the familiar condition, the opposite is true for the participant with severe aphasia. This is true in the listener and instructor role. The moderate and mild severity groups show a pattern that is more similar to the NHC group, with a tendency to show higher accuracy scores for the unfamiliar condition.

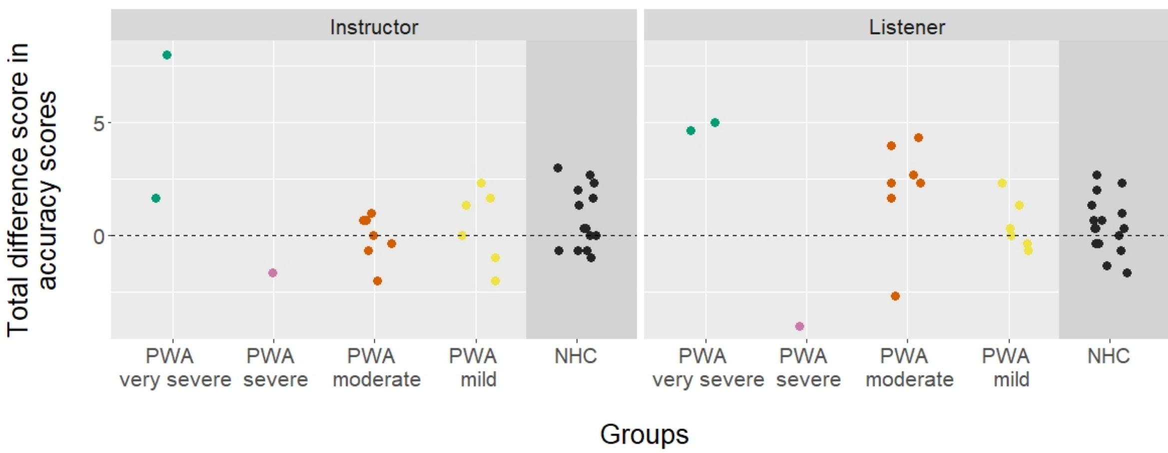


Figure 6. Plot showing individual data points for PWA for difference score between familiar and unfamiliar conditions, by role, categorised by WAB categorisation. Zero represents no change in accuracy scores between conditions, negative values indicate a lower accuracy score in the unfamiliar condition compared to the familiar condition.

Self-initiated repairs

Research question 1: An effect of role (instructor or listener).

Research question 2: An effect of CP familiarity for PWA.

PWA

The 2 (role: instructor/listener) x 2 (condition: familiar/unfamiliar) analysis showed a significant main effect of role (instructor vs listener; estimated median difference = 17, $p < .001$). The number of self-initiated repairs was higher in the instructor role (median = 13, CI = 1.17, 18) compared to the listener role (median = 2.08, CI = 0.17, 4.42). Planned pairwise comparisons on the effect of role show that the significant difference in number of self-initiated repairs was present in both the familiar ($p < .001$) and unfamiliar condition ($p < .001$). For PWA, the number of self-initiated repairs was higher when they were in the instructor role compared to the listener role. See Figure 7.

There was no significant effect of condition (estimated median difference = 0.5, p = .201) or of the interaction role*condition (estimated median difference = -0.17, p = .806).

NHC

There was a significant main effect of role (instructor vs listener; estimated median difference = 23, $p < .001$). The number of self-initiated repairs was higher in the instructor role (median = 15.25, CI = 13.17, 23.0) compared to the listener role (median = 5.75, CI = 2.5, 9.17). Planned pairwise comparisons on the effect of role show that for NHC the significant difference in number of self-initiated repairs was present in both the familiar (p = .007) and unfamiliar condition ($p < .001$). For NHC, the number of self-initiated repairs was higher when they were in the instructor role compared to the listener role. See Figure 7.

There were no significant effects of condition (estimated median difference = 0.33, p = .806) or interaction of role*condition (estimated median difference = -2.5, p = .173).

Research question 3: An effect of CP familiarity for PWA compared to NHC.

Instructor trials

The 2 (group: PWA/NHC) x 2 (condition: familiar/unfamiliar) showed no significant effects for group (estimated median difference = 2.25, p = .559), condition (estimated median difference = 0, p = 1) or the interaction group*condition (estimated median difference = -1, p = .539). In the instructor role, PWA and NHC self-initiated repairs a similar number of times. The rate of self-initiated repairs was the same in both conditions. See Figure 7.

Listener trials

The 2 (group: PWA/NHC) x 2 (condition: familiar/unfamiliar) analysis showed a main effect of group (PWA vs NHC; estimated median difference = 3.25 sec., p = .039), with a larger number of self-initiated repairs by NHC (median = 5.75, CI = 2.5, 9.17) compared to PWA (median = 2.08, CI = 0.17, 4.42). Planned pairwise comparisons show that the difference in number of self-initiated repairs is not significant in the familiar condition (p = .133) or the unfamiliar condition (p = .055)[5]. As shown in Figure 7, averaged across conditions, NHC show a larger number of self-initiated repairs compared to PWA. This effect disappears when this difference is assessed at the level of each condition (familiar and unfamiliar). The number of self-initiated repairs for PWA are almost at floor.

The effect of condition and the interaction were not significant (condition: estimated median difference = 0.33, p = .511, interaction: estimated median difference = 0.17, p = .934).

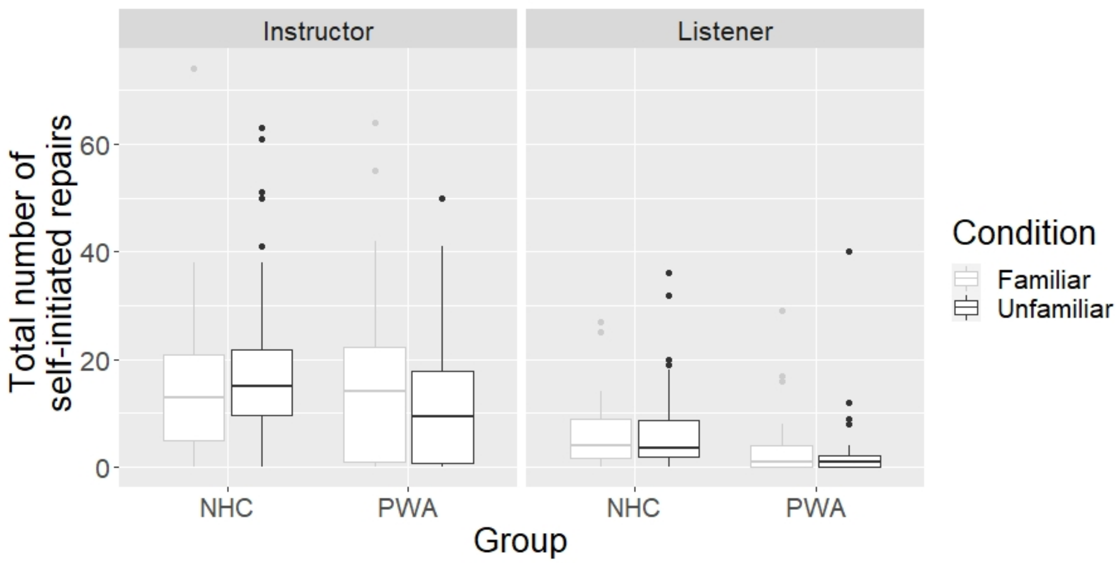


Figure 7. Boxplots showing total number of self-initiated repairs by condition and group, for each role (instructor/listener).

Summary of results for number of self-initiated repairs

The number of self-initiated repairs depended on the role participants fulfilled: in the instructor role, both PWA and NHC showed a higher number of self-initiated repairs compared to the listener trials. Compared to NHC, PWA produced a similar number of repairs in the instructor role. As listeners, PWA produced fewer self-initiated repairs compared to NHC.

Changes at the level of individual dyads

The changes in number of self-initiated repairs for each dyad is plotted in Figure 8. Data for PWA has been grouped according the severity of aphasia for the PWA participant. In general,

[5]In the unfamiliar condition, the difference in self-initiated repairs between groups was significant in the 20% trimmed means analysis (p = .031). The presence of a large number of outliers could have inflated the effect of the trimmed means analysis. We will therefore rely on the more conservative median analysis here.

the spread of data points for both groups (PWA and NHC) is greater for the instructor role. In the instructor role, there is a trend that as aphasia severity decreases (moving left to right along the x axis), the distribution of difference scores becomes more like the NHC group, with more dyads showing lower number of self-initiated repairs in the unfamiliar condition (negative values). Interestingly, PWA do not show the tendency to increase the number of self-initiated repairs to the extent that NHC do (positive values): PWA tend to show fewer self-initiated repairs in the unfamiliar condition compared to the familiar condition, while NHC show a slightly more equal distribution between decreases and increases in the number of self-initiated repairs. There is tentative evidence that for PWA who are less severe, the number of self-initiated repairs was likely to be smaller for the unfamiliar condition.

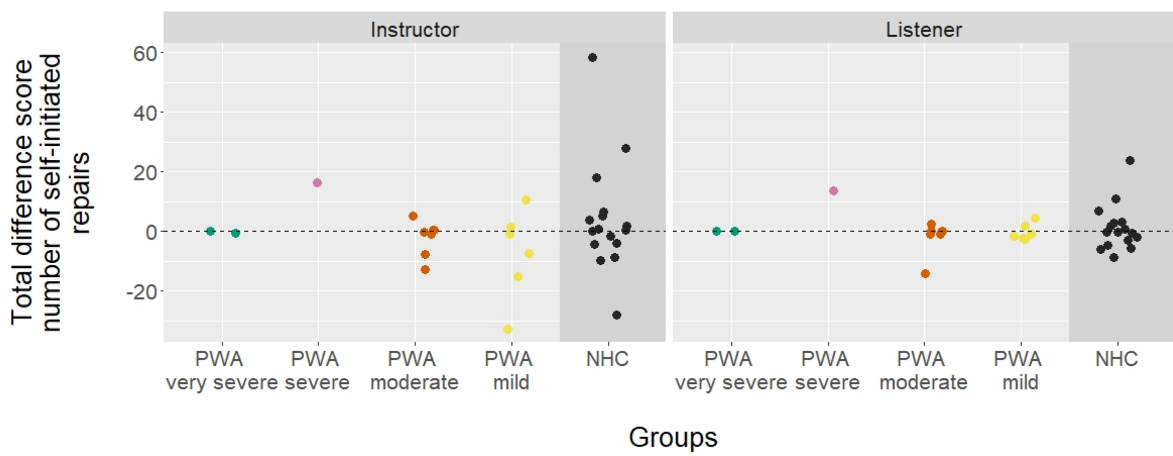


Figure 8. Plot showing individual data points for PWA for difference score between familiar and unfamiliar conditions, by role, categorised by WAB categorisation. Zero represents no change in self-initiated repairs between conditions, negative values indicate a smaller number of self-initiated repairs in the unfamiliar condition compared to the familiar condition.

Clarification requests

Research question 1: An effect of role (instructor or listener).

Research question 2: An effect of CP familiarity for PWA.

PWA

The 2 (role: instructor/listener) x 2 (condition: familiar/unfamiliar) analysis showed a significant main effect of role (instructor vs listener; estimated median difference = -10, $p < .001$) [6].

[6] The 20% trimmed means analysis did not show a significant effect of role (role: Q = -11.7, p = .064). The variance in the instructor role is close to zero. This will have made the analysis based on the 20% trimmed mean less reliable. We will therefore rely on the outcome of the median analysis here.

The number of clarification requests was higher when PWA took on the listener role (median = 6.17, CI = 3.0, 12.67) compared to the instructor role (median = 0.75, CI = 0.42, 1.33). Planned comparisons show that for PWA, the difference in number of clarification requests between instructor and listener role was significant in the familiar ($p < .001$) and the unfamiliar condition ($p < .001$). PWA showed a higher number of clarification requests in the listener role compared to the instructor role. See Figure 9.

The main effect of condition was significant (familiar vs unfamiliar; estimated median difference = 3.33, p = .010) [7], with higher number of clarification requests in the familiar condition (median = 4.42, CI = 2.0, 10.5) compared to the unfamiliar condition (median = 2.17, CI = 0.67, 3.25). Pairwise comparisons resulted in a significant difference between conditions for both the listener (p = .002) and instructor roles (p = .036). PWA showed a higher number of clarification requests in the familiar condition compared to the unfamiliar condition. See Figure 9.

The interaction of role*condition was also significant (estimated median difference = -2.17, p = .046) [8]. In the instructor role, there is no difference in number of clarification requests between the familiar and unfamiliar conditions. In the listener role, PWA produced a smaller number of clarification requests in the unfamiliar condition compared to the familiar condition. See Figure 9.

NHC

For NHC there was a significant main effect of role (instructor vs listener; estimated median difference = -34.5, $p < .001$), with more clarification requests produced in the listener role (median = 18.17, CI = 13.58, 28.17) compared to the instructor role (median = 0.75, CI = 0.5, 1.08). Planned pairwise comparisons for the effect of role show that the number of clarification requests between roles is significantly different in both the familiar ($p <.001$) and the unfamiliar condition ($p <.001$). NHC produced more clarification requests while in the listener role compared to when they were instructors. See Figure 9.

There were no significant effects of condition (estimated median difference = 5.33, p = .244) or interaction of role*condition (estimated median difference = -4.5, p = .388). For both roles, NHC produced similar numbers of clarification requests in the familiar and unfamiliar condi-

[7] The 20% trimmed means analysis did not show a significant main effect of condition (Q = 4.33, p = .159). The same reasoning applies as discussed in footnote 5.

[8] The 20% trimmed means analysis did not show a significant interaction of role*condition (Q = -2.67, p = .112). The same reasoning applies as discussed in footnote 5.

tions. See Figure 9.

Research question 3: An effect of CP familiarity for PWA compared to NHC.

Instructor trials

For the instructor trials the 2 (group: PWA/NHC) x 2 (condition: familiar/unfamiliar) showed no significant effects for group (estimated median difference = -0.17, p = .657), condition (estimated median difference = 0.33, p = .324) [9] or the interaction group*condition (estimated median difference = -0.33, p = .432). See Figure 9.

Listener trials

The 2 (group: PWA/NHC) x 2 (condition: familiar/unfamiliar) analysis showed a main effect of group (PWA vs NHC; estimated median difference = 12.5, p = .001), with NHC producing a larger number of clarification requests (median = 18.17, CI = 13.58, 28.17) compared to PWA (median = 6.17, CI = 3.0, 12.67). Planned pairwise comparisons indicated that a significant difference between the two groups existed in both conditions (familiar: p = .032[10], unfamiliar: p < .001). As listeners, NHC showed a higher number of clarification requests compared to PWA in both conditions. See Figure 9.

The effect of condition and the interaction were not significant (condition: estimated median difference = 3.33, p = .156, interaction: estimated median difference = 3.83, p = .454)[11].

[9] The main effect of condition was significant based on the 20% trimmed mean analysis (Q = 4.74, Qcrit = 4.38, p = .042). The variance for the groups will have been close to zero, which will have made the trimmed means analysis less reliable. We will therefore rely on the median analysis here.

[10] In the familiar condition, the trimmed mean analysis showed an insignificant difference between the two groups (p = .755). Again, the presence of multiple outliers will have inflated the trimmed mean for the PWA group, making the trimmed mean analysis less reliable.

[11] The main effect of condition was just significant based on the 20% trimmed mean analysis (Q = 4.29, Qcrit = 4.27, p = .049). As for the instructor trials, the presence of a large number of outliers will probably have inflated the trimmed mean analysis more than the median analysis. To be on the safe side, we will again rely on the more conservative median analysis.

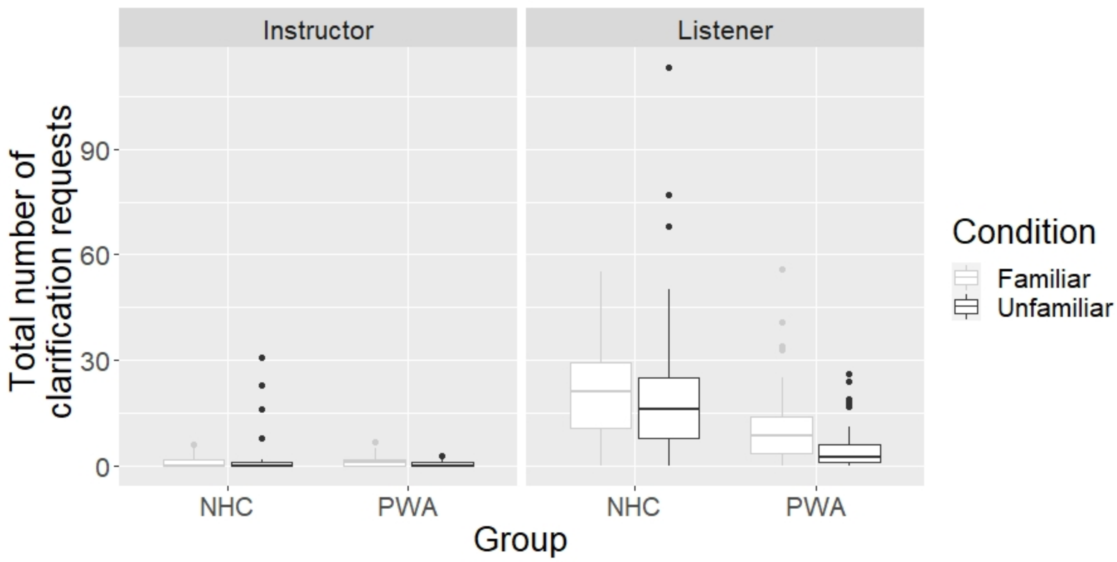


Figure 9. Boxplots showing total number of clarification requests by condition and group, for each role (instructor/listener).

Summary of results for number of clarification requests

The number of clarification requests depended on the role the participants took on: both PWA and NHC asked their conversation partner for clarification more often as listeners compared to when they were instructors. As listeners, PWA asked for clarification less often when working with their unfamiliar conversation partner compared to a familiar conversation partner. In the listener role, NHC did not show a change in number of clarification requests between conditions. Overall, PWA asked their conversation partner for clarification less often compared to NHC.

Changes at the level of individual dyads

The changes in number of clarification requests for each dyad are shown in Figure 10. Data for PWA has been grouped according the severity of aphasia for the PWA participant. For the instructor role, the change in number of clarification requests was minimal for both groups, and the pattern seems roughly the same across all aphasia severities and groups. In the listener role, there is a trend that as aphasia severity decreases, the distribution of difference scores increases with more dyads showing lower numbers of clarification requests in the unfamiliar condition (negative values). Overall, even the milder severities mostly show more variation in terms of reduction in clarification requests with the UFCP compared to the FCP. NHC show a slightly more equal distribution between decrease and increase in number of clarification requests. These effects are confounded by the uneven spread of data points across aphasia severities.

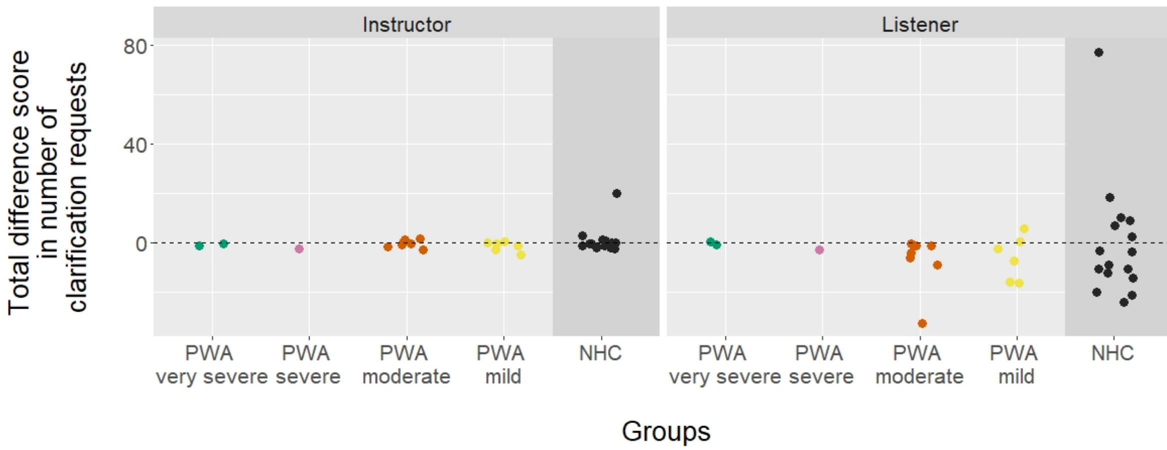


Figure 10. Plot showing individual data points for PWA for difference score between familiar and unfamiliar conditions, by role, categorised by WAB categorisation. Zero represents no change in the number of clarification requests between conditions, negative values indicate a smaller number of clarification requests in the unfamiliar condition compared to the familiar condition.

Discussion

This study examined the effect of conversation partner familiarity on goal-directed, face-to-face communication in aphasia, as part of the contextual component of a theoretical framework of real-world communication. We addressed three research questions.

Research question 1: Is there an effect of role (instructor or listener) during goal-directed communication on the collaborative communication task?

We hypothesized that the type of role (instructor/listener) would affect the outcome measure differently for each group. We predicted that role would have an impact on trial time and accuracy for PWA, but not for NHC. For both groups, we expected an effect of role on the number of self-initiated repairs and clarification requests, due to the nature of these communicative behaviours.

For total trial times, there was a significant effect of role for PWA: in the instructor role, PWA took longer to complete a trial compared to when they were in the listener role. For NHC, total trial time was stable across roles. Overall, NHC showed longer trial times compared to PWA as listeners, but not as instructors.

For both PWA and NHC, accuracy scores did not significantly differ by role. Planned comparisons on the main effect of condition did show a different pattern of change between the familiar and unfamiliar conditions across the two roles for PWA, which will be discussed in the next section. Overall, PWA obtained lower accuracy scores compared to NHC.

The number of self-initiated repairs showed the expected main effect of role: both groups initiated more self-repairs as instructors compared to when they were listeners. Overall, both groups showed equal numbers of self-initiated repairs in the instructor role, while PWA produced fewer repairs compared to NHC in the listener role.

The number of clarification requests also showed the expected main effect of role for both groups. These requests were more frequent in the listener role compared to the instructor role. As listeners, NHC produced more clarification requests compared to PWA.

Overall, these results show that the role participants take on during the task affected the process of goal-directed communication. For PWA, this is true on all measures except accuracy. In line with our expectations, role only impacted communication for NHC on the measures of self-initiated repairs and clarification requests.

Research question 2: Do PWA benefit from the familiarity of their conversation partner (personal common ground) during goal directed communication?

For each outcome measure, we tested the hypothesis that it would be easier for PWA to complete the collaborative task with a familiar CP than with an unfamiliar CP. Easier is characterised by the need for less time to complete the task, higher accuracy scores and requiring fewer self-initiated repairs and fewer requests for clarification to reach mutual understanding. Instead, we found contradictory results.

The results show that for both roles, PWA showed different communicative behaviour with the FCP compared to the UFCP. The differences between the familiar and unfamiliar condition went against our initial predictions (see Table 5). PWA showed shorter total trial times for the unfamiliar condition, higher accuracy for the unfamiliar condition (especially with PWA as listeners) and fewer clarification requests in the unfamiliar condition.

Despite the lack of a 'familiarity advantage', it is of interest to note that none of the outcome measures show a change in the 'negative' direction during communication with the UFCP (i.e. 'worse' communication as evidenced by longer trial times, lower accuracy scores, higher number of self-initiated repairs and clarification requests) as a result of the familiarity manipulation. This could be due to the lack of counterbalancing of conditions, as the unfamiliar condition always came second this meant that the familiar condition could act as a practice run. Thus, on a familiar, practised, concrete task, the communicative ability of PWA are not negatively affected by the lack of personal common ground with their CP during goal-directed communication.

Research question 3: Do PWA differ from NHC in how they respond to conversation partner familiarity?

Finally, we tested whether PWA differ from NHC in how they respond to CP familiarity during goal directed communication. We hypothesized that PWA and NHC would show an overall similar response to the familiarity manipulation on all outcome measures, but that the effect of the experimental manipulation would be greater for PWA compared to NHC, as evidenced by an interaction effect in the group*condition analysis. Results showed no significant interaction effects for any of the outcome measures. Interestingly, when each group was assessed separately for an effect of role and condition, a difference across the familiar and unfamiliar conditions did emerge (see Table 5).

A comparison of the two groups by role shows that for most outcome measures (five out of eight), PWA and NHC show a different directional response to the change in CP familiarity. NHC showed a stable profile of communicative behaviour across the two conditions, apart from an improvement in communicative performance (accuracy scores) as an instructor with an UFCP, which may have come from the practice effect of having the familiar CP condition first. NHC, therefore, generally did not show an effect of CP familiarity in their communicative behaviour.

In contrast to this, PWA showed a change in communicative behaviour between the two conditions as an instructor (time and number of clarification requests) and as a listener (number of clarification requests). As listeners, communicative performance (accuracy) is also affected. In short, PWA show a more widespread change in communicative behaviour and performance as a result of the familiarity manipulation compared to NHC. These differences are discussed in more detail below.

			RQ 2	RQ 3		
Outcome measure	**Description**	**Role**	**PWA**	**PWA vs NHC***	**Direction main effect of condition ** PWA**	** NHC**
Trial time	Faster times indicate 'better' communication	instructor	fam. > unfam.	NHC = PWA	fam. > unfam.	fam. = unfam.
		listener	fam. = unfam.		fam. = unfam.	fam. = unfam.
Task accuracy	Higher accuracy indicates 'better' communication	instructor	fam. = unfam.	NHC = PWA	fam. = unfam.	fam. < unfam.
		listener	fam. < unfam.		fam. < unfam.	fam. = unfam.
Self-initiated repairs	Fewer repairs indicate 'better' communication	instructor	fam. = unfam.	NHC = PWA	fam. = unfam.	fam. = unfam.
		listener	fam. = unfam.		fam. = unfam.	fam. = unfam.
Clarification requests	Fewer requests indicate 'better' communication	instructor	fam. > unfam.	NHC = PWA	fam. > unfam.	fam. = unfam.
		listener	fam. > unfam.		fam. > unfam.	fam. = unfam.

Table 5. Results for research questions 2 and 3 by outcome measure. Red indicates the outcome is different from the original hypothesis. * hypotheses were about the difference scores between the familiar and unfamiliar conditions. A larger difference score represents a bigger impact of the experimental manipulation. ** in these columns, red indicates a different directional effect in response to the experimental manipulation for PWA compared to NHC.

Familiarity effect in aphasia and NHC

Instructors

We found that as instructors, PWA showed a different pattern of behaviour when working with a FCP compared to an UFCP (shorter trial times, fewer clarification requests with the UFCP, and stable accuracy scores and self-initiated repairs). The stability of the number of self-initiated repairs is in line with previous studies that have suggested that certain aspects of communication might remain stable across different communicative settings and CPs (Gurland et al., 1982; Leaman & Edmonds, 2019; Lubinski et al., 1980). The higher number of clarification requests with the FCP is also in line with previous research with NHC (Boyle et al., 1994). As suggested by the authors, the unfamiliarity might have discouraged PWA from asking UFCPs for clarification more often. The stability of the accuracy scores across familiar and unfamiliar CPs, and the reduction in trial time with the UFCP compared to the FCP are surprising. As the two conditions were not counterbalanced, it is difficult to exclude a potential practice effect for the unfamiliar condition. The findings from the NHC group, however, can function as a reference in the discussion of what communicative behaviour would be expected in response to the experimental manipulation.

In light of this comparison, the changes in communicative behaviour and performance in the PWA group can be interpreted in the following way: it seems that with the UFCP, PWA were able to achieve the same result (i.e. stable accuracy scores), while putting in less 'effort' (i.e. time and number of clarification requests). Differently put, PWA might have been more 'efficient' at completing the task with the UFCP compared to the FCP. In contrast to this, NHC were shown to put in the same amount of effort (i.e. time, repairs and clarification requests) with both CPs, which gave a better result with the UFCP (i.e. higher accuracy scores).

There are a number of possible reasons for this difference in effort. Firstly, perhaps PWA felt more comfortable with their FCP compared to the UFCP, resulting in more time and effort spent with the FCP. In line with this, PWA might have felt more comfortable asking for clarification from the FCP compared to the UFCP. The results from our measure of comfort with the CP indicate that at least at the group level, this explanation doesn't hold, as PWA reported the same level of comfort with both CPs. Another possible explanation is that in the instructor role, PWA dyads reached a ceiling for accuracy. It is possible that on average, PWA were not able to communicate more detail on the task to their CP.

Finally, it is possible that as instructors, PWA and NHC differed (consciously or unconsciously) in the criterion they set for achieving mutual understanding. To communicate, interlocutors must continuously achieve mutual understanding together, i.e. they must understand what the other person is saying to continue the conversation (Clark, 1996; Clark & Brennan, 1991; Clark & Wilkes-Gibbs, 1986). Mutual understanding does not have to be perfect for conversation to work. Instead, interlocutors negotiate a criterion of mutual understanding "well enough for current purposes" (Clark, 1996, p. 221). NHC, unrestricted by any communication difficulties, might have set a higher criterion for mutual understanding on the current task (i.e. striving for a higher level of accuracy). This then resulted in similar amounts of effort made in an attempt to achieve higher accuracy scores, regardless of CP familiarity.

For PWA, this process might have unfolded differently. When confronted with the UFCP, PWA might have accepted the level of mutual understanding they had been able to achieve so far (with their FCP) as good enough for current purposes. This level of mutual understanding was already lower compared to controls in the familiar condition. This might have allowed PWA to strip away any communicative behaviours deemed unnecessary for current purposes (i.e. fewer clarification requests and less time). We can only speculate about the underlying reasons for such a shift. It could have been the desire to avoid unnecessary conversational difficulties (or: avoid 'losing face') with the UFCP, as evidenced by fewer clarification requests initiated by the PWA in the unfamiliar condition (Simmons-Mackie & Damico, 1995). It could also be that regardless of the CP, PWA tend to strive to minimize communicative (cognitive) effort in light of the good enough accuracy scores more generally.

Listeners

We found that as listeners, PWA also showed a different pattern of behaviour when working with a UFCP compared to an FCP. This pattern is different from that observed with PWA in the instructor role.

The changes in the number of self-initiated repairs and clarification requests were in line with previous research, as discussed for the instructor role. The increase in accuracy scores with the UFCP, and the stable trial times across CPs go against our predictions. Again, the findings from the NHC group will be used as a reference in the discussion the current findings.

It seems that as listeners, PWA put in the same amount of 'effort' in both conditions (as measured by total trial time), while achieving a better result with the UFCP (i.e. higher accuracy scores). NHC show the same pattern in trial time, but their accuracy scores remain stable. For NHC, this might reflect a ceiling effect rather than a strong behavioural pattern.

These results can be interpreted in two different ways: firstly, PWA could have benefitted from communicating with the UFCP while in the listener role, as evidenced by the higher accuracy scores in the unfamiliar condition. The second option is that PWA benefitted from repeated practice on the task, resulting in better performance on the second half of the trials. Completing the same task with the same set of stimuli a number of times might have created a physical and communicative context (i.e. things that have been discussed within the same conversation become part of common ground) that could have helped restrict the number of possible interpretations for PWA (Doedens & Meteyard, 2020; Skipper, 2014).

Interestingly, while PWA showed shorter trial times with the UFCP when they were instructors, this effect disappeared when they were in the listener role. A potential explanation for this is that those who take on the instructor role are more in control of the way the trial unfolds over time. This would explain why the reduced trial time when PWA are listeners disappears: their CP might have taken the lead, resulting in similar patterns of 'effort' as compared to the NHC group and no reduction in overall trial time. Further assessment of the CP role is needed to confirm this interpretation, however. An analysis as reported in this paper, conducted on data from the conversation partners of each PWA when they were in the instructor role, for example, could reveal whether they show a pattern of 'effort' across conditions that is similar to NHC or not. Furthermore, insight into the number of turns taken, or the duration of turns for each CP (PWA and their familiar and unfamiliar CPs) could provide more detailed insight into the efforts made by both parties during the task, and how this changed (or not) as a result of the familiarity manipulation.

Aphasia severity

The inspection of the difference scores on all outcome measures between the familiar and unfamiliar conditions allows us to draw tentative conclusions about the difference in behavioural patterns depending on aphasia severity. Visual inspection of the data shows the tendency for PWA with milder severity to show greater behavioural change as a result of CP familiarity. As might be expected, as aphasia severity decreases the behavioural pattern becomes more like that of the NHC group. Although more research is needed with a larger group of people with severe aphasia, an intuitive interpretation is that less flexibility in communicative behaviour is seen for PWA with more severe aphasia, as they have less scope for flexible communication in the first place. More research is needed with a larger group of PWA, divided equally across severities, to draw stronger conclusions about this.

Conclusions

The current study expands our current understanding of how PWA are affected by CP familiarity in face-to-face communication. When communicating about a concrete, familiar topic, PWA show different communicative behaviours with an unfamiliar conversation partner as compared to a familiar conversation partner. Based on the current findings, it seems PWA aim to reduce communicative efforts in order to achieve good enough information transfer. This seems specifically the case when PWA are in the 'speaker' role. As PWA still achieve at least the same level of communicative performance with an unfamiliar conversation partner, the current results go against a simple familiarity advantage, as such. In the listener role, it seems PWA might benefit from the repeated practice on the same task, i.e. building up of common ground within the task, as evidenced by their improved performance across conditions. In contrast to PWA, NHC show similar communicative behaviours across conversation partners. This group seems to strive for the most detailed information exchange, regardless of the familiarity of the CP. In the case of NHC, an improvement in performance suggests NHC might benefit from a building up of experience, or common ground, within the task, regardless of the familiarity of their conversation partner. More research is needed to evaluate the effect of conversation partner familiarity on communicative behaviours and performance in PWA on, for example, an unfamiliar task. In such a case, the tendency of PWA to minimise communicative efforts with the unfamiliar conversation partner, without having had any practice, could theoretically lead to lower performance scores.

Clinical implications

The findings from the current study have clinical implications for treatment and assessment in aphasia rehabilitation. The current study partly supports the existing assumption that speaker familiarity affects communication for PWA. Importantly, the outcome on the current task was not negatively affected by the presence of an unfamiliar CP, as shown by equal or improved communicative performance on the task with the unfamiliar conversation partner. We cannot rule out the effect of practice for PWA, as this was confounded with the familiarity manipulation. However, a positive effect of practice for PWA on a goal-directed communication task is something to be celebrated. This research shows that PWA can show different communicative behaviours and communicative purposes, depending on the conversation partner they are communicating with (Simmons-Mackie & Damico, 1995). These findings also have implications for the way communicative behaviours that have been trained in a clinical setting, might generalise (or not) to real-world settings. The results suggest that PWA with more severe aphasias might be less flexible in adapting to different communicative settings (and therefore might require training on a more generic set of communicative strategies, that work across communication settings and partners). Although the underlying reasons for the change in communicative behaviours between conversation partners remain unclear, this is important to keep in mind when profiling real-world communicative abilities for PWA.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

Conceptualisation: W.J.D., A.B., L.M.; Data collection: W.J.D.; Data coding: W.J.D., L.L., Writing: W.J.D.; Critical review: A.B., L.M.

Funding

The first author was supported by the Magdalen Vernon Studentship from the School of Psychology and Clinical Language Sciences, University of Reading. Recruitment was supported by the Aphasia Research Registry of the School of Clinical Language Sciences, University of Reading (British Academy Grant ARP scheme 190023).

Acknowledgments

The authors would like to thank Prof. Katherina Hilari at City University London for the use of the English version of the Scenario Test. We would also like to thank Odette Stoutjesdijk, aphasia therapist at the Utrecht Aphasia Centre in the Netherlands, for her support.

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Supplementary Materials

NHC					Conversation partner						
ID	Sex	Age	Education (yrs)	MOCA	ID	Sex	Age	Education (yrs)	MOCA	Partner type	Years knowing NHC
4	female	71	17	28	3	male	70	17	23	Partner	51
9	female	63	12	27	10	male	65	16	29	Partner	47
22	female	54	16	29	21	male	64	16	27	Partner	18.5
26	female	59	17	29	25	male	61	23	28	Partner	49
28	male	63	12	28	27	female	62	13	30	Partner	45
30	female	70	14	30	29	male	71	14	27	Partner	51
34	male	67	11	28	33	female	64	14	30	Partner	32
36	male	84	11	17	35	female	79	12	29	Partner	35
49	female	60	19	28	50	male	61	14	30	Partner	42
51	female	53	17	28	52	male	56	16	23	Partner	26
55	female	52	17.5	30	56	male	57	18	29	Partner	16
58	male	72	13	26	57	female	51	21	29	Partner	22
59	male	58	15	27	60	female	60	18	26	Partner	35
61	male	67	21	30	62	female	64	17	27	Partner	28
65	male	62	13	28	66	female	62	15.5	26	Partner	42
74	male	84	10	27	73	female	79	11	26	Partner	32

Table S1. Demographics of the NHC group and their conversation partners.

Item			MRC Psycholinguistics database				Subtlex-UK	N-Watch
		Animacy	Concreteness (100-700)	Familiarity (100-700)	Imageability (100-700)	Number of phonemes	LogFreqCBBC (Zipf) (0-6)	Frequency CELEX (spoken)
Sofa	Sofa	Inanimate					4.33	1.54
	Couch		578	521	536	4	3.76	3.08
Chair		Inanimate	606	617	610	3	4.61	12.31
Cat		Animate	615	582	617	3	5.22	8.46
Table		Inanimate	604	599	582	4	4.91	63.85
Woman		Animate	580	623	626	5	4.86	180.77
Man		Animate	618	623	567	3	5.73	533.08
Mean			604.28	589.85	590.71	3.71	4.78	114.72
SD			19.13	37.61	31.56	0.75	0.62	195.37

Table S2. Psycholinguistic features of target items taken, where available, from three different databases.

PWA 1									PWA 2								
Subj	type	Sex	Age	Ed.	WAB-AQ	ST	Knowing partner (years)	Relationship to PWA	Subj	type	Sex	Age	Ed.	WAB-AQ	ST	Knowing partner (years)	Relationship to PWA
1	PWA	M	64	11	90.8	53	26	Partner	11	PWA	M	66	17	83.8	53	22	Grandparent
2	FCP	F	58	18	-	-	26	Partner	12	FCP	M	22	13	-	-	22	Grandchild
5	PWA	M	72	16	61.6	41	25	Partner	19	PWA	M	65	13	56.8	44	40	Ex-partner
6	FCP	F	55	13	-	-	25	Partner	20	FCP	F	60	13	-	-	40	Ex-partner
7	PWA	F	51	16	90.1	54	10	Partner	67	PWA	F	65	16	93.3	55	47	Partner
8	FCP	M	63	14	-	-	10	Partner	68	FCP	M	66	18.5	-	-	47	Partner
13	PWA	M	63	18	94.2	51	42	Partner	53	PWA	M	67	19	89.4	53	33	Partner
14	FCP	F	60	18	-	-	42	Partner	54	FCP	F	72	14.5	-	-	33	Partner
41	PWA	M	45	11	62.5	37	20	Partner	43	PWA	M	57	12	18.3	45	30	Partner
42	FCP	F	41	13	-	-	20	Partner	44	FCP	F	56	13	-	-	30	Partner
45	PWA	F	42	19	58.2	50	10	Friend	37	PWA	F	68	17	62.5	48	50	Partner
46	FCP	F	43	13	-	-	10	Friend	38	FCP	M	69	17	-	-	50	Partner
47	PWA	F	70	10	72.2	50	49	Parent	78	PWA	F	51	15	74.1	47	23	Parent
48	FCP	F	49	15	-	-	49	Child	79	FCP	M	23	17	-	-	23	Child
69	PWA	M	72	10	11.6	45	54	Partner	15	PWA	F	57	19	27.6	20	40	Partner
70	FCP	F	69	11	-	-	54	Partner	16	FCP	M	60	17	-	-	40	Partner

Table S3. Demographics of PWA (PWA 1), their FCP (shown below PWA) and the pair to whom they were matched for the familiarity manipulation (PWA 2). PWA are matched on WAB-AQ and Scenario Test scores, where possible also on sex, age and years of education and conversation partner type. In the unfamiliar condition, conversation partners of each set of matched PWA were swapped. Ed. = years of education, ST = Scenario Test.

NHC 1							NHC 2						
Subj	type	Sex	Age	Ed.	Knowing partner (years)	Relationship to NHC	Subj	type	Sex	Age	Ed.	Knowing partner (years)	Relationship to NHC
3	NHC	male	70	17	51	Partner	29	NHC	male	71	14	51	Partner
4	FCP	female	71	17	51	Partner	30	FCP	female	70	14	51	Partner
10	NHC	male	65	16	47	Partner	21	NHC	male	64	16	18.5	Partner
9	FCP	female	63	12	47	Partner	22	FCP	female	54	16	18.5	Partner
23	NHC	female	71	18	50	Partner	31	NHC	female	73	17	55	Partner
24	FCP	male	70	17	50	Partner	32	FCP	male	73	18	55	Partner
25	NHC	male	61	23	49	Partner	50	NHC	male	61	14	42	Partner
26	FCP	female	59	17	49	Partner	49	FCP	female	60	19	42	Partner
33	NHC	female	64	14	32	Partner	27	NHC	female	62	13	45	Partner
34	FCP	male	67	11	32	Partner	28	FCP	male	63	12	45	Partner
35	NHC	female	79	12	35	Partner	73	NHC	female	79	11	32	Partner
36	FCP	male	84	11	35	Partner	74	FCP	male	84	10	32	Partner
52	NHC	male	56	16	26	Partner	56	NHC	male	57	18	16	Partner
51	FCP	female	53	17	26	Partner	55	FCP	female	52	17.5	16	Partner
60	NHC	female	60	18	35	Partner	66	NHC	female	62	15.5	42	Partner
59	FCP	male	58	15	35	Partner	65	FCP	male	62	13	42	Partner
62	NHC	female	64	17	28	Partner	57	NHC	female	51	21	22	Partner
61	FCP	male	67	21	28	Partner	58	FCP	male	72	13	22	Partner

Table S4. Demographics of NHC (NHC 1), their FCP (below) and the pair to whom they were matched for the familiarity manipulation (NHC 2). NHC are matched on sex, age and years of education. In the unfamiliar condition, FCP of each set of matched NHC were swapped. Ed. = years of education.

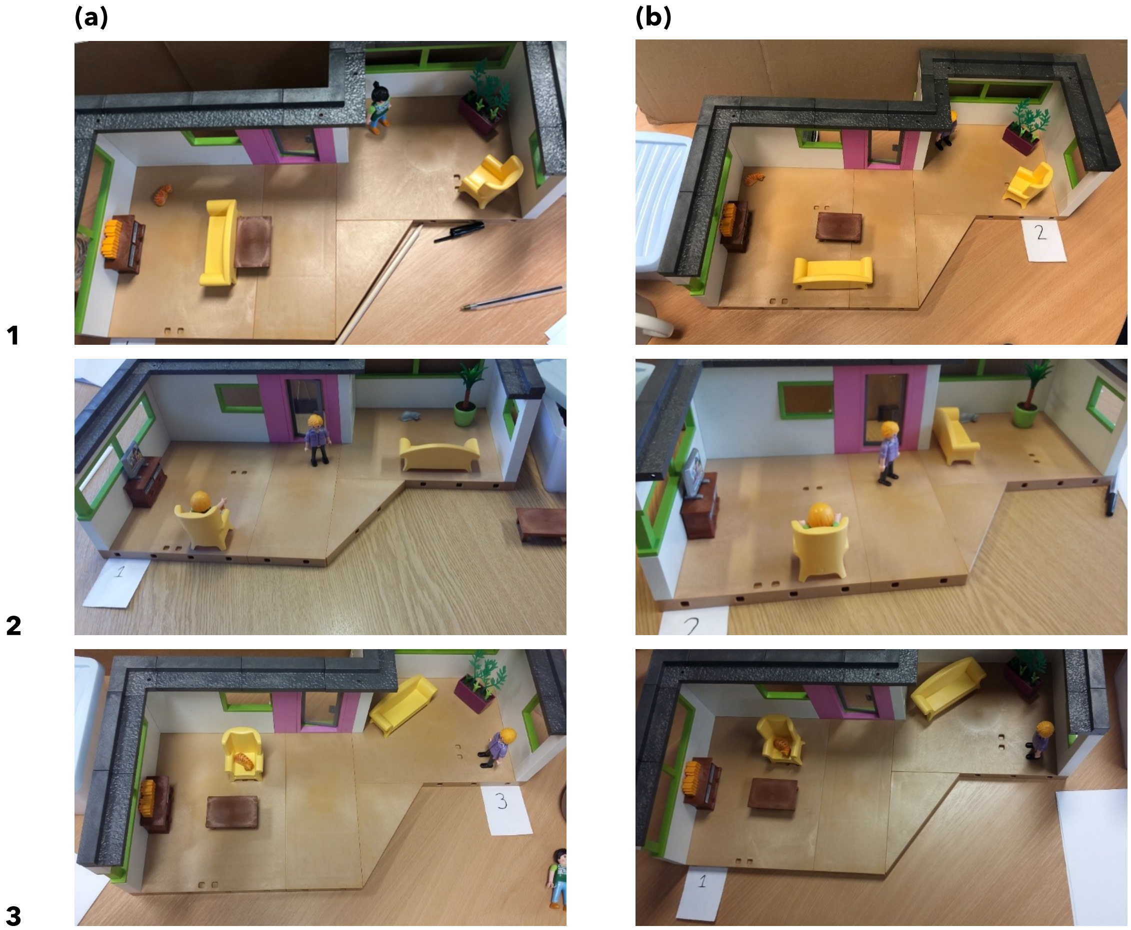


Figure S1. Examples of different accuracy scores. **(1): low score (a).** shows the instructor view, as it was set up by the experimenter. (b) shows the final listener view, resulting in a total score of 7 points. Adding to the baseline score of 4: the chair is in the right orientation (+1), the cat is in the correct orientation (+1), the arms of the person are correctly placed (+1). **(2) moderate score.** (a) shows the instructor view, as it was set up by the experimenter. (b) shows the final listener view, resulting in a total score of 15 points. Adding to the baseline score of 4: the lady and the chair are in the right position with the correct arm position (+6), the man is in the correct position with his arms in the correct position (+2), the cat is in the correct orientation (+1) and the table is correctly kept outside of the room (+2). **(3) high score.** (a) shows the instructor view, as it was set up by the experimenter. (b) shows the final listener view, resulting in a total score of 20 points. All 5 items are placed correctly in terms of location, orientation, action and arm placement.

Outcome measure	Percentile bootstrap with robust analysis on the median						Bootstrap-t with robust analysis on 20% trimmed means					
	Role (instructor/ listener)		Condition (familiar/unfamiliar)		Role*condition		Role (instructor/listener)		Condition (familiar/unfamiliar)		Role*condition	
	Est. median diff.	**p-value**	**Est. median diff.**	**p-value**	**Est. median diff.**	**p-value**	**Est. median diff.**	**p-value**	**Est. median diff.**	**p-value**	**Est. median diff.**	**p-value**
PWA												
Trial time	156.65 (87.58, 293.61)	< .001***	167.34 (87.77, 346.28)	< .001***	38.02 (-43.97, 65.84)	.457	177.26 (64.97, 289.55)	.012*	188.35 (56.40, 320.29)	.008**	30.28 (-43.58, 104.14)	.415
Task accuracy	0.67 (-1.33, -2)	.538	-1.67 (-3.67, 0)	.049*	1.83 (-1.67, 2.67)	.167	0.4 (-1.7, 2.5)	.649	-1.77 (-3.88, 0.35)	.092	1.2 (-1.78, 4.18)	.285
Self-initiated repairs	17 (2, -31.33)	< .001***	0.5 (-0.67, 8.67)	.201	-0.17 (-1.5, 3.33)	.806	18.2 (3.05, 33.35)	.03*	2.17 (-4.99, 9.32)	.309	0.33 (-2.58, 3.25)	.801
Clarification requests	-10 (-24.67, -4)	< .001***	3.33 (1, 10.33)	.010**	-2.17 (-7, -0.001)	.046*	-11.7 (-24.53, 1.13)	.064	4.33 (-2.19, 10.86)	.159	-2.67 (-6.47, 1.13)	.112
NHC												
Trial time	4.97 (-71.31, 139.01)	.75	75.75 (-134.08, 280.42)	.46	21.26 (-66.32, 154.98)	.76	32.69 (-83.74, 149.13)	.481	71.91 (-134.29, 278.11)	.462	32.68 (-99.07, 164.43)	.555
Task accuracy	-0.67 (-1.67, -0.33)	.173	-0.67 (-1.67, -3.55)	.015	-0.33 (-0.67, .67)	.338	-0.7 (-1.74, 0.34)	.158	0.18 (-2.12, 0.52)	.177	-0.2 (-0.89, 0.49)	.498
Self-initiated repairs	23 (12.33,26)	< .001***	0.33 (-5.67, 3.67)	.806	-2.5 (-7, 3.5)	.173	20.73 (14.22, 27.25)	.002**	-0.57 (-4.72, 3.59)	.816	-2.23 (-8.01, 3.54)	.454
Clarification requests	-34.5 (-53.33, -26.17)	< .001***	5.33 (-7, 11.33)	.244	-4.5 (-11.67 7)	.388	-38.17 (-54.12, -22.22)	.003**	3.97 (-7.47, 15.40)	.335	-3.8 (-12.39, 4.79)	.308

Table S5. Results of the within-by-within 2 (role: instructor/listener) x 2 (condition: familiar/unfamiliar) analysis on the median using percentile bootstrap and an analysis on the 20% trimmed mean using bootstrap-t . * p < .05, ** p < .01, *** p < .001.

Group (PWA/NHC)	Main effect comparison	At factor level	Percentile bootstrap with robust analysis on the median		Bootstrap-t with robust analysis on 20% trimmed means	
			Est. median diff. (CI)	p-value	Est. mean diff.	p-value
PWA	Role: instr. vs list.	Condition: fam.	107.58 (21.81, 190.92)	.015*	92.69 (14.22, 171.17)	.023*
	Role: instr. vs list.	Condition: unfam.	52.49 (4.37, 89.50)	.035*	61.75 (-28.34, 151.84)	.136
PWA	Condition: fam. vs unfam.	Role: instr.	87.24 (50.79, 143.50)	<.001***	128.9 (13.06, 244.74)	.035*
	Condition: fam. vs unfam.	Role: list.	77.83 (-17.56, 202.78)	.201	97.95 (-1.57, 197.47)	.053

Table S6. Results of the planned pairwise comparisons for the role*condition analysis on total trial time. * p < .05, ** p < .01, *** p < .001.

Group (PWA/NHC)	Main effect comparison	At factor level	Percentile bootstrap with robust analysis on the median		Bootstrap-t with robust analysis on 20% trimmed means	
			Est. median diff. (CI)	p-value	Est. mean diff.	p-value
PWA	Condition: fam. vs unfam.	Role: instr.	-0.33 (-1.33, 0.67)	.607	-0.13 (-1.02, 0.76)	.744
	Condition: fam. vs unfam.	Role: list.	-2 (-2.83, 0)	.062	-1.83 (-2.97, -0.69)	.007**
NHC	Condition: fam. vs unfam.	Role: instr.	-0.33 (-1.67, 0.17)	0.131	-1.03 (-2.02, -0.04)	.043*
	Condition: fam. vs unfam.	Role: list.	-0.33 (-1, 0.33)	0.182	-0.53 (-1.37, 0.3)	.189

Table S7. Results of the planned pairwise comparisons for the role*condition analysis on task accuracy. * $p < .05$, ** $p < .01$, *** $p < .001$.

Group (PWA/NHC)	Main effect comparison	At factor level	Percentile bootstrap with robust analysis on the median		Bootstrap-t with robust analysis on 20% trimmed means	
			Est. median diff. (CI)	p-value	Est. mean diff.	p-value
PWA	Role: instr. vs list.	Condition: fam.	9.17 (1, 18)	<.001***	10.5 (3.35, 17.65)	.009**
	Role: instr. vs list.	Condition: unfam.	7.17 (1.33, 13.33)	<.001***	8.1 (2.51, 13.69)	.018*
NHC	Role: instr. vs list.	Condition: fam.	8.83 (3.67, 14.17)	.007**	8.73 (2.45, 15.02)	.016*
	Role: instr. vs list.	Condition: unfam.	9.33 (6.67, 14.33)	<.001***	10.5 (5.24, 15.76)	.002**

Table S8. Results of the planned pairwise comparisons for the role*condition analysis on the number of self-initiated repairs. * $p < .05$, ** $p < .01$, *** $p < .001$.

Group (PWA/NHC)	Main effect comparison	At factor level	Percentile bootstrap with robust analysis on the median		Bootstrap-t with robust analysis on 20% trimmed means	
			Est. median diff. (CI)	p-value	Est. mean diff.	p-value
PWA	Role: instr. vs list.	Condition: fam.	-6.67 (-17, -3.5)	<.001***	-8.5 (-16.84, -0.16)	.047*
	Role: instr. vs list.	Condition: unfam.	-2.67 (-5.67, -0.67)	<.001***	-3.47 (-6.64, -0.29)	.041*
NHC	Role: instr. vs list.	Condition: fam.	-20 (-23.83, -15.33)	<.001***	-19.33 (-24.44, -14.22)	<.001***
	Role: instr. vs list.	Condition: unfam.	-15.5 (-28.33, -9.33)	<.001***	-16.63 (-26.92, -6.35)	.006**
PWA	Condition: fam. vs unfam.	Role: instr.	0.5 (0, 1.67)	.036*	0.83 (-0.3, 1.97)	.130
	Condition: fam. vs unfam.	Role: list.	2.5 (0.67, 7.33)	.002**	5.87 (-0.79, 12.53)	.068

Table S9. Results of the planned pairwise comparisons for the role*condition analysis on the number of clarification requests. * $p < .05$, ** $p < .01$, *** $p < .001$.

Outcome measure	Percentile bootstrap with robust analysis on the median						Bootstrap-t with robust analysis on 20% trimmed means					
	Group (PWA/NHC)		Condition (familiar/unfamiliar)		Group*condition		Group (PWA/NHC)		Condition (familiar/unfamiliar)		Group*condition	
	Est. median diff.	p-value	Est. median diff.	p-value	Est. median diff.	p-value	Q (Qcrit)	p-value	Q (Qcrit)	p-value	Q (Qcrit)	p-value
Trial time (instr.)	78.37	.199	68.09	.01**	-53.52	.253	0.89 (4.49)	.359	3.44 (4.16)	.074	1.34 (4.12)	.259
Trial time (list.)	144	.008**	60.4	.08	-53.52	.399	6.23 (4.55)	.024*	1.62 (4.34)	.205	2.23 (4.30)	.142
Task accuracy (instr.)	2	.004**	-0.33	.407	<.001	.950	15.57 (4.05)	.001***	3.78 (3.99)	.056	2.25 (4.01)	.133
Task accuracy (list.)	2.83	<.001***	-0.67	.152	1.67	.093	23.26 (5.07)	<.001***	14.09 (4.36)	.002**	4.25 (4.48)	.055
Self-initiated repairs (instr.)	2.25	.559	0	1	-1	.539	0.94 (5.19)	.348	0.001 (3.71)	.970	1.30 (4.23)	.264
Self-initiated repairs (list.)	3.25	.039*	0.33	.511	0.17	.934	6.02 (4.87)	.031*	0.07 (4.69)	.791	0.26 (4.47)	.629
Clarification requests (instr.)	-0.17	.657	0.33	.324	-0.33	.432	0.03 (4.37)	.858	4.74 (4.38)	.042*	0.13 (4.57)	.731
Clarification requests (list.)	12.5	.001***	3.33	.156	3.83	.454	13.24 (4.46)	.001***	4.29 (4.27)	.049*	0.34 (4.77)	.567

Table S10. Results of the between-by-within 2 (group: PWA/NHC) x 2 (condition: familiar/unfamiliar) analysis on the median using the percentile bootstrap and a robust analysis of the 20% trimmed mean using bootstrap-t. * $p < .05$, ** $p < .01$, *** $p < .001$.

Group (PWA/NHC)	Main effect comparison	At factor level	Percentile bootstrap with robust analysis on the median		Bootstrap-t with robust analysis on 20% trimmed means	
			Est. median diff. (CI)	p-value	Est. mean diff.	p-value
Instructors	Condition: fam. vs unfam.	Group: PWA	87.24 (50.79, 143.50)	<.001***	128.9 (13.06, 244.74)	.035*
	Condition: fam. vs unfam.	Group: NHC	33.72 (-17.38, 169.23)	.203	29.71 (-121.89, 181.32)	.691
Listeners	Group: PWA vs NHC	Condition: fam.	67.01 (-49.08, 215.04)	.158	71.39 (-32.46, 196.53)	.173
	Group: PWA vs NHC	Condition: unfam.	221.08 (49.02, 308.84)	.009**	177.13 (51.49, 281.92)	.004**

Table S11. Results of the planned pairwise comparisons for the group*condition analysis on total trial time. * $p < .05$, ** $p < .01$, *** $p < .001$.

Group (PWA/NHC)	Main effect comparison	At factor level	Percentile bootstrap with robust analysis on the median		Bootstrap-t with robust analysis on 20% trimmed means	
			Est. median diff. (CI)	p-value	Est. mean diff.	p-value
Instructors	Group: PWA vs NHC	Condition: fam.	1.5 (0.17, 3.17)	.022*	1.7 (0.57, 3.4)	.0032**
	Group: PWA vs NHC	Condition: unfam.	-2.5 (-4.33, -1.33)	.002**	-2.6 (-3.93, -1.27)	<.001***
Listeners	Group: PWA vs NHC	Condition: fam.	3.83 (1.33, 5.17)	<.001***	3.33 (1.87, 4.93)	<.001***
	Group: PWA vs NHC	Condition: unfam.	-1.83 (-3.17, -1)	<.001***	-2.03 (-3.4, -1.13)	<.001***
Listeners	Condition: fam. vs unfam.	Group: PWA	-2 (-2.83, 0)	.062	-1.83 (-2.97, -0.69)	.007**
	Condition: fam. vs unfam.	Group: NHC	-0.33 (-1, 0.33)	.182	-0.53 (-1.37, 0.30)	.189

Table S12. Results of the planned pairwise comparisons for the group*condition analysis on task accuracy scores. * $p < .05$, ** $p < .01$, *** $p < .001$.

Group (PWA/NHC)	Main effect comparison	At factor level	Percentile bootstrap with robust analysis on the median		Bootstrap-t with robust analysis on 20% trimmed means	
			Est. median diff. (CI)	p-value	Est. mean diff.	p-value
Instructors	Group: PWA vs NHC	Condition: fam.	3.5 (-0.67, 6.67)	.133	2.83 (-0.13, 6.4)	.06
	Group: PWA vs NHC	Condition: unfam.	3 (-4.44, 8.33)	.055	3.7 (0.37, 7.4)	.031*

Table S13. Results of the planned pairwise comparisons for the group*condition analysis on the number of self-initiated repairs. * $p < .05$, ** $p < .01$, *** $p < .001$.

Group (PWA/NHC)	Main effect comparison	At factor level	Percentile bootstrap with robust analysis on the median		Bootstrap-t with robust analysis on 20% trimmed means	
			Est. median diff. (CI)	p-value	Est. mean diff.	p-value
Instructors	Group: PWA vs NHC	Condition: fam.	-12.33 (-18.67, -1.5)	.032*	-0.17 (-1.23, 0.83)	.755
	Group: PWA vs NHC	Condition: unfam.	12.67 (5, 25)	<.001***	13.23 (6.2, 22.3)	<.001***

Table S14. Results of the planned pairwise comparisons for the group*condition analysis on the number of clarification requests. * $p < .05$, ** $p < .01$, *** $p < .001$.

Chapter 6 | Measuring task-based functional communication in post-stroke aphasia: an evaluation of construct validity.

Doedens, W.J., Bose, A. & Meteyard, L. (to be submitted).

Abstract

Introduction. The multifactorial nature of functional communication makes it a particularly difficult behaviour to study in the lab, where increased experimental control is assumed to negatively affects the ecological validity of the behaviour of interest. This study examined the potential of using an experimental, collaborative communication task in the investigation of real-world communication in post- stroke aphasia.

Aims. The current study assessed the construct validity of an experimental task for measuring functional communication in post-stroke aphasia.

Methods. The relationship between performance on the experimental task and well-established standardised measures of linguistic impairment (WAB-R, Kertesz, 2009) and functional communication (the Scenario Test, van der Meulen et al., 2010) was tested. Sixteen people with aphasia (PWA; very severe – mild impairments) completed the standardised tests. Each PWA completed the collaborative communication task with a self-selected familiar conversation partner. Performance on the task was correlated to the standardised linguistic and functional communication scores to examine the strength of the relationship between these measures. The strength of these correlations was compared.

Results. Results showed a moderate correlation between performance on the experimental task and the standardised measures of linguistic and functional communication. Both standardised measures explained roughly 40% of the variance on the experimental task. The strength of the correlations did not differ significantly.

Conclusion. These findings indicate that the experimental task captures part of both the linguistic and the communicative impairment as measured on the WAB-AQ and Scenario Test, providing support for the construct validity of the experimental task. These results also echo earlier claims that both standardised tests represent only part of the skillset that is required for communication as it is conducted in a less constrained, interactive, multimodal and contextualised setting. The current study provides support for the use of the collaborative communication task in the investigation of real-world communication in aphasia. Suggestions for follow-up research are made.

KEYWORDS: Aaphasia, stroke, linguistic processing, referential communication task, functional communication.

Introduction

Aphasia is an impairment of linguistic processing (Goodglass & Kaplan, 1972). Deficits in the ability to produce and comprehend words, grammatical structures and their meaning lie at the root of the problems that are experienced in everyday communication (Bastiaanse & Prins, 1994). Functional communication, or the ability to communicate effectively in everyday life, is a key concept in aphasia rehabilitation. For people with post-stroke aphasia (PWA), optimising their functional communication is often a long-term goal of language rehabilitation (Wallace et al., 2017; Worrall et al., 2011). A thorough understanding of the linguistic impairments have proved insufficient, however, in predicting functional communication impairments in PWA (Holland, 1982; Sarno, 1969). This is unsurprising, given the fact that communication requires more than the production and comprehension of spoken and written information.

Communication as it is conducted in the real world includes the use and integration of multiple modalities for information exchange (e.g. speech, gesture, prosody, facial expressions, etc), the continuous adaptation to a conversation partner and to what has already been said, the monitoring of longer stretches of conversation and the reliance on the physical space that one is communicating in (Doedens and Meteyard, 2020; Schumacher et al., 2020; chapter 2 of this thesis). Functional communication, in short, is a multifactorial and dynamic construct that goes beyond linguistic processing. Research has shown that cognitive functions, required for functional communication, can also be impaired in aphasia, such as impairments in cognitive flexibility (Spitzer et al., 2019), memory (Salis et al., 2017), attention (Ferstl et al., 2005; Murray, 1999, 2012) and executive functioning (El Hachioui et al., 2014; Fridriksson et al., 2006; Helm-Estabrooks, 2002; Olsson et al., 2019; Purdy, 2002). Despite decades of research on functional communication, knowledge on which internal and external factors influence communication for PWA remains relatively limited. This has had its knock-on effects in terms of assessment (Brady et al., 2016; chapter 3 of this thesis) and treatment (Dipper et al., 2020; Simmons-Mackie et al., 2014). It is therefore crucial for the field of aphasia that well-controlled experimental research is conducted to extend current knowledge on functional communication in post-stroke aphasia.

Research on functional communication is challenged, however, by the multi-factorial nature of the behaviour. Numerous attempts have been made in the field to strike the right balance between having experimental control, which allows for drawing causal conclusions, and eliciting a language sample that is sufficiently naturalistic to ensure generalisability of the findings. For example, studies using Conversation Analysis have mostly relied on observations of spontaneous conversations to study characteristics of interaction (e.g. Wilkinson et al., 2011). While this maximises the ecological validity of the data, the lack of control restricts the type of questions that can be answered based on the data (Prins & Bastiaanse, 2004). Lab-based experiments that have focused on language use above the level of a single sentence have often relied on tasks that provide the researcher with more control, at the cost of the ecological validity of the data. For example, complex picture descriptions have been used in abundance in the aphasia literature, even though there are reasons to believe the degree to which findings from such tasks can be generalised to communication in the real world is low (Armstrong et al., 2013; Brady et al., 2016; Doedens and Meteyard, 2020, chapter 2 of this thesis). While there is a need for more research on functional communication in aphasia, this research should aim to utilise empirical methods that maximise the generalisability of its findings to improve existing knowledge on functional communication in post-stroke aphasia.

Collaborative communication tasks (also referred to as referential communication tasks or barrier tasks; Krauss and Glucksberg, 1969) strike an optimal balance between the level of experimental control and the spontaneous nature of the communication that is elicited. These tasks have often been used to study aspects of typical everyday communication (e.g. attention and memory processes, common ground, conversation partner familiarity, online-feedback, etc. Boyle et al., 1994; Brown-Schmidt and Tanenhaus, 2008; Keysar et al., 2003), but have seen limited application in the aphasia literature (e.g. Hengst, 2003). Collaborative communication tasks incorporate all necessary components of real-world communication (i.e. interactive, multimodal, embedded in context; Doedens and Meteyard, 2020, chapter 2 of this thesis), strengthening the content validity. The task offers experimenters a high level of control, as all aspects of communication are pre-determined, and can be manipulated. While offering a high level of control, the task elicits unstructured conversation from the participants as they complete the task. This increases the naturalness of the exchange that is elicited. While the widespread application of this paradigm in the control literature and the content validity of the method are promising, more work is needed to establish the reliability, validity and generalisability of this method to ensure its usefulness to the field of aphasiology.

The aim of the current study was to examine the construct validity of performance of people with post-stroke aphasia (PWA) on a collaborative communication task. Given the key role of linguistic processing in functional communication in aphasia (Fucetola et al., 2006; Irwin et al., 2002; Meier et al., 2017), convergent validity was assessed by examining the relationship between performance on the experimental task and a standardised measure of linguistic impairment (WAB-AQ, Kertesz, 2009). The Scenario Test (Hilari & Dipper, 2020; van der Meulen et al., 2010) was used to examine the relationship between performance on the task and a standardised measure of functional communication impairment. In line with previous studies, it was hypothesized that the linguistic impairment would correlate positively with performance on the collaborative communication task (directional hypothesis). The more severe the linguistic impairment (i.e. as WAB-AQ score decreases), the lower performance on the experimental task was expected to be (Fucetola et al., 2006; Irwin et al., 2002; Meier et al., 2017). Because communication involves more than the verbal channel (Schumacher et al., 2020, chapter 2 of this thesis), the relationship between the linguistic impairment and performance on the experimental task was not expected to be very strong, however. The Scenario Test, on the other hand, was developed to capture functional communication. It was therefore hypothesized that this measure would show a positive correlation with performance on the experimental task (directional hypothesis). However, as PWA with a less severe aphasia are known to show ceiling effects on the Scenario Test, the correlation is predicted to depend on the relative number of PWA with a severe impairment that are included in the study.

Finally, the current study aimed to compare the strength of the two correlations. It was difficult to hypothesize the outcome of this comparison. Measures of linguistic impairment have consistently shown a positive moderate-strong relationship with measures of functional communication, though the strength varies depending on the type of measures that are used (Fucetola et al., 2006; Irwin et al., 2002; Meier et al., 2017). The Scenario Test aims to capture functional communication specifically, which would suggest that its score should correlate more strongly with an experimental measure of functional communication. Given the limitations of the test in terms of capturing communicative ability for PWA with less severe linguistic impairments and the existing criticism of this test more generally (Doedens and Meteyard, 2020; chapter 3 of this thesis), however, the Scenario Test might *not* correlate strongly with performance on the task. It is therefore hypothesized that there will be no difference between the correlations of the two standardised scores with task-based performance.

Ethics

The current paper is part of a larger study on goal-directed communication in aphasia, and the influence of different conversation partners on communication. Ethical clearance was provided by the School of Psychology and Clinical Language Sciences, University of Reading (Ref: 2018-093-LM). Participants provided informed consent prior to taking part in the study and all forms (consent and information packs) were adapted to aphasia friendly format for the participants with aphasia.

Participants

Sixteen participants with post-stroke aphasia (PWA, 42-72 years, M = 60.94, SD = 9.41, male = 9) were recruited through the Aphasia Research Registry of the School of Clinical Language Sciences, University of Reading (British Academy Grant ARP scheme 190023) and local stroke groups. PWA were at least one-year post-stroke (1-14 years, M = 7.04, SD = 3.85) and were native speakers of English. Exclusion criteria were an inability to provide consent due to severe comprehension or cognitive difficulties and any coexisting neurological diagnoses such as dementia. All subjects reported normal or corrected-to-normal vision and hearing. See Table 1.

Thirteen out of sixteen PWA had some degree of weakness (hemiparesis) on the right-hand side due to the stroke. All PWA were mobile enough to attend the experiment at the University clinic and used their unaffected arm and hand effectively. One PWA attended the clinic in a wheelchair.

Procedure

The participants were invited to take part in a study about conversation in aphasia. For PWA, background tests were administered either at the School of Clinical Language Sciences, University of Reading or at the participant's home. For the experimental session, all participants visited the Speech and Language Therapy Clinic at the University of Reading.

PWA											Conversation partner					
								Scenario Test								
ID	Sex	Age	Ed.	Time post stroke (months)	WAB-AQ	Severity	Type	Rawscore	Perc.	Classification*	ID	Sex	Age	Ed.	Partner type	Years knowing PWA
69	M	72	10	71	11.6	very severe	Global	35.94	34	Limited	70	F	69	11	Partner	54
43	M	57	12	58	18.3	very severe	Broca/Global	42.4	46	Okay	44	F	56	13	Partner	30
15	F	57	19	56	27.6	severe	Wernicke	20.25	14	Almost none	16	M	60	17	Partner	40
19	M	65	13	177	56.8	moderate	Broca	44.47	49	Okay	20	F	60	13	Partner	40
45	F	42	19	12	58.2	moderate	Broca	48	63	Okay-Good	46	F	43	13	Friend	10
5	M	72	16	123	61.6	moderate	Broca	41.63	42	Okay	6	F	55	13	Ex-partner	25
41	M	45	11	75	62.5	moderate	Broca	37	34	Limited	42	F	41	13	Partner	20
37	F	68	17	136	69.5	moderate	Conduction	48	63	Okay	38	M	69	17	Partner	50
47	F	70	10	116	72.2	moderate	Broca	49	68	Okay-Good	48	F	49	15	Child	49
78	F	51	15	20	74.1	moderate	Anomic	47.47	60	Okay	79	M	23	17	Child	23
11	M	66	17	56	83.8	mild	Conduction	53	93	Good	12	M	22	13	Grandchild	22
53	M	67	19	42	89.4	mild	Anomic/Transc. sensory	53	93	Good	54	F	72	14.5	Partner	33
7	F	51	16	55	90.1	mild	Anomic	54	100	Good	8	M	63	14	Partner	10
1	M	64	11	133	90.8	mild	Anomic	53	93	Good	2	F	58	18	Partner	26
67	F	65	16	110	93.3	mild	Anomic	53	93	Good	68	M	66	18.5	Partner	47
13	M	63	18	111	94.2	mild*	Transc. sensory	51	78	Good	14	F	60	18	Partner	42

Table 1. Descriptives for PWA and their familiar conversation partners, ordered by WAB-AQ score (lowest to highest; 0-25 is very severe, 26-50 is severe, 51-75 is moderate, and 76–above is mild, *93.8 is the cut-off for an aphasic score). Scenario Test classification is based on the percentiles of the Dutch norm group, solely used her to provide a descriptive classification. *Classification refers to the communicative ability of the PWA: "almost no communicative ability", "seriously limited communicative ability", "okay communicative ability in simple situations" and "good communicative ability in simple situations". Ed. = Education in years.

Measures

Linguistic impairment (standardised)

The Western Aphasia Battery – Revised (WAB-R; Kertesz, 2009) is a widely used standardised test of linguistic impairment. The test examines the ability of PWA to produce and comprehend linguistic content across five different subscales (spontaneous speech, auditory verbal comprehension, repetition, naming and word finding, reading and writing). For the current correlation analysis, the composite aphasia quotient score (AQ) was used. The WAB-AQ represents the (weighed) sum of all subscales that relate to *spoken* language ability (comprehension and production). The composite score is used to classify the level of severity of the aphasia, ranging from very severe to mild. WAB-AQ scores of the participants ranged from 11.60-94.2 (M = 65.88, SD = 26.59), with severities ranging from very severe to mild (see Table 1).

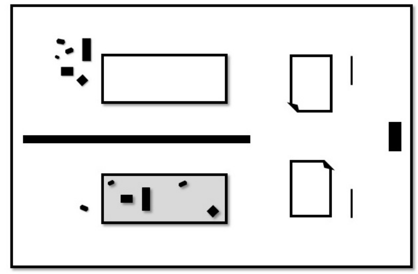
Functional communication (standardised)

The Scenario Test UK (Hilari & Dipper, 2020; van der Meulen et al., 2010) was used as a standardised measure of functional communication. This test was specifically developed to test the ability of PWA with more severe linguistic impairments to communicate using different modalities (i.e. verbal and non-verbal channels for communication). The Scenario Test evaluates the ability of PWA to effectively transmit a message across a number of different scenarios that are presented to the PWA through role-play with the clinician. The Scenario Test was selected as the instrument with the best content validity, i.e. that most comprehensively incorporates the theoretical description of real-world communication (Doedens and Meteyard, 2020; chapter 3 of this thesis). Scores ranged from 20.25-54 (maximum score = 54, M = 45.58, SD = 8.87; details shown in Table 1).

Collaborative communication task

PWA completed six trials of a collaborative, referential communication task (Clark & Krych, 2004; Krauss & Glucksberg, 1969) with a self-nominated familiar conversation partner (aged 22-72 years, M = 54.12, SD = 15.12), see Table 1 for more details. The task was presented to the participants as a game in which pairs have to work and communicate together to succeed (the experimental procedure is described in more detail in chapters 3 and 4 of this thesis). Each dyad was asked to sit across from each other, at either end of a table (as shown in Figure 1). Both participants faced identical playmobile rooms. A low barrier was placed between the par-

(a)



(b)

Figure 1. Schematic overview of the experimental setup. **View A** shows a side-view: two participants sitting across from each other with a low barrier between them to only block the view of the other person's workspace. **View B** shows the table from above: two identical room layouts. Participant A has five items placed in the room, plus one distractor object on the side. For participant B, all six items are placed outside of the room. Pen and paper are placed to the left-hand side for the PWA (in case of neglect, hemianopia or hemiparesis), and is provided for both participants. A button at the far end of the table (again to the left of the PWA) is used to indicate completion of the task.

ticipants to obstruct the view of the other's room. On each trial, five items were placed in one participant's room, according to a pre-determined setup. One item, a distractor, was placed outside of the playmobile room and the participant was instructed to ignore that item. For the other participant, six items were placed on the side of the room. Pairs were asked to recreate the setup of the instructor's room in the listener's room as best as possible, by communicating as they normally would. Pairs were specifically reminded that they could use any means to communicate (i.e. speak, gesture, point, write, drawn or use a communication aid). Pen and paper were provided for both participants, on one side of the table where the barrier did not block interactions between the two participants. Participants were instructed not to pick up an item and show it to their CP, and not to look over the barrier at the other room.

Aphasia friendly images were used to visually support the instruction for all participants. After questions were answered, the experimenter left the room for the duration of the task. Pairs pressed a button when they felt they had completed the task. The participants were shown the results of their efforts with a picture of both sides that the experimenter made. Participants were free to discuss the outcome of the task, while the experimenter set up the next trial of the experiment.

Each pair completed the game six times: for each trial, roles (instructor/follower) were swapped, resulting in three instructor trials and three follower trials for each participant. The starting role was counterbalanced across participants. A different setup of items was used for each trial, the order of which was randomized for each pair.

Functional communication was measured as accuracy achieved by each PWA dyad on the task. Accuracy was assumed to be the most direct reflection of the degree of understanding that was achieved between the two interlocutors on the task (Ramsberger & Rende, 2002). Task accuracy was defined as the correct placement of the items in the follower's room as compared to the instructor's room as set up by the experimenter. The pictures of the instructor and follower's rooms at the end of the trial were scored by two independent judges on accuracy (correct/incorrect) of two aspects of the item: its location (in the room and in relation to other objects) and its orientation. For the people, two additional aspects were coded: the action that was undertaken (i.e standing, sitting, etc.) and the positioning of the arms. For all other objects, the action was always coded as correct, resulting in a maximum score of 3 per item, and 4 per person (a maximum score of 20 and a minimum score of 4). In case of doubt due to different angles of the pictures, a grid was superimposed on the floor of each image using Kinovea software (Charmant, 2006-2011). Dyad accuracy scores were averaged across trials for the familiar partners (and therefore, across roles) into a single accuracy score on the task (ranging between 4-20).

Statistical analysis

All variables showed deviations from normality based on visual inspection of the QQ plots and the results of the Shapiro-Wilkes test (task accuracy: $p = .03$; scenario test score: $p = .001$; WAB-AQ: $p = .03$). Given the existence of tied values in a number of the outcome measures, correlations were conducted using the non-parametric Kendal's Tau rank-based test. Statistical analyses were conducted in R version 3.6.3 (RStudio Team, 2020).

The strength of the correlations was compared according to procedures outlined by Diedenhofen and Munch (2015), using the cocor package (overlapping, dependent groups) in R version 3.6.3 (RStudio Team, 2020).

Results

The relationship between the linguistic impairment and communicative success on the collaborative communication task

There was a significant, positive relationship between a person's overall linguistic impairment and performance on the collaborative communication task , $\tau = .67$, $p < .001$ (directional hypothesis). As linguistic scores increase, so do the task-based functional communication scores (see Figure 2). For the current group of participants, 44.45% of their performance on the collaborative communication task was explained by their standardised linguistic scores on the WAB-AQ ($r^2 = .44$).

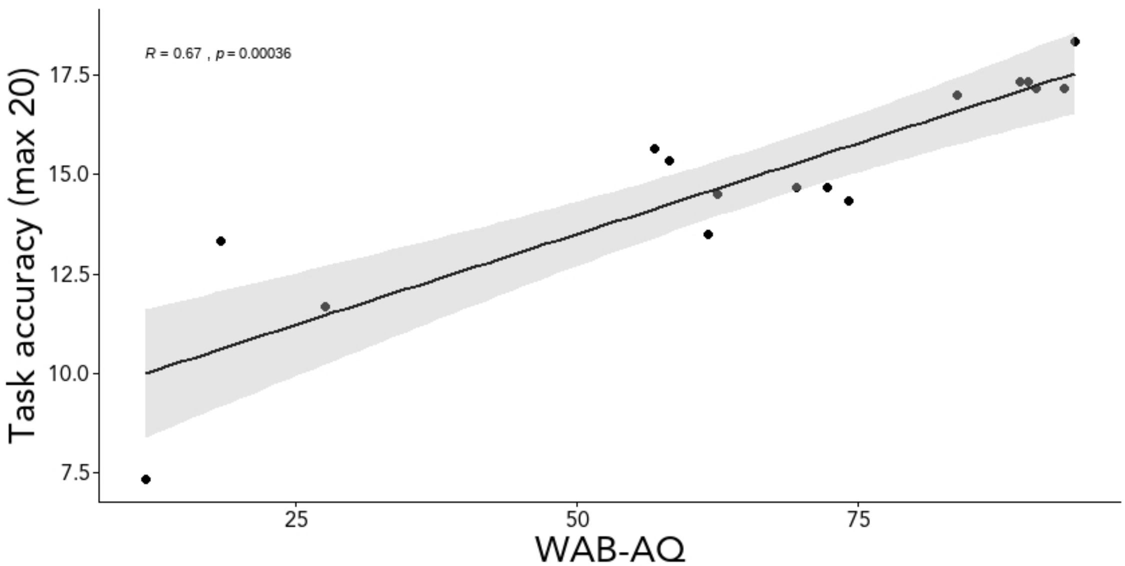


Figure 2. Kendall's τ rank-based correlation between linguistic impairment (WAB-AQ) and task accuracy scores on the collaborative communication task.

The relationship between standardised functional communication and performance on the collaborative communication task

Functional communication as measured on the Scenario Test was significantly correlated with accuracy on the collaborative communication task, $\tau = .70$, $p < .001$ (directional hypothesis). As performance on the Scenario Test improved, so did their performance on the collaborative communication task (see Figure 3). For these participants, 49.62% of their performance on the experimental task was explained by their standardised communication scores on the Scenario Test ($r^2 = .49$).

Visual inspection of the correlation (Figure 3) shows that one datapoint very clearly deviates from the overall regression line: participant 69 (with a very severe linguistic impairment) obtained a much lower score on the collaborative communication task than would be expected based on their Scenario Test score.

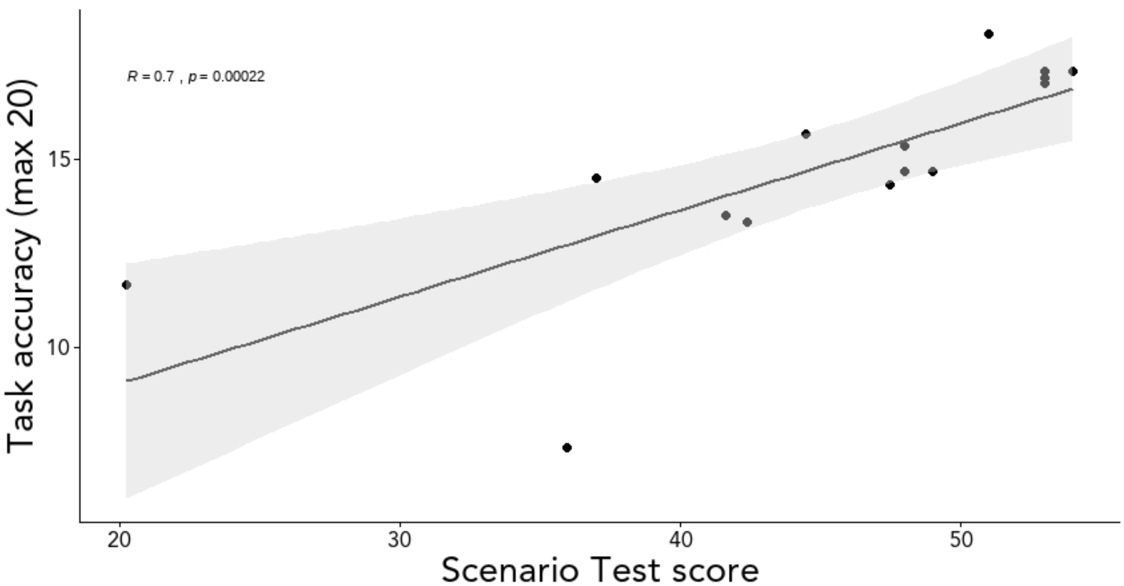


Figure 3. Kendall's τ rank-based correlation between communication impairment (Scenario Test raw score) and task accuracy scores on the collaborative communication task.

Comparing correlations of communication vs linguistic impairment scores with performance on the collaborative communication task

To compare the two correlations (1: WAB-AQ x experimental task performance; 2: Scenario Test x experimental task performance), the relationship between the linguistic score (WAB-AQ) and the communication score (Scenario Test) was first assessed. These two measures showed a significant, positive relationship , $\tau = .64$, $p < .001$ (see Figure 4). A comparison between the two correlations (1: WAB-AQ x experimental task performance; 2: Scenario Test x experimental task performance) showed that the correlations were not significantly different ($n = 16$, $z = -.21$, $p = .83$), indicating that the strength of the relationship of experimental task performance is similar for the WAB-AQ score and the Scenario Test score.

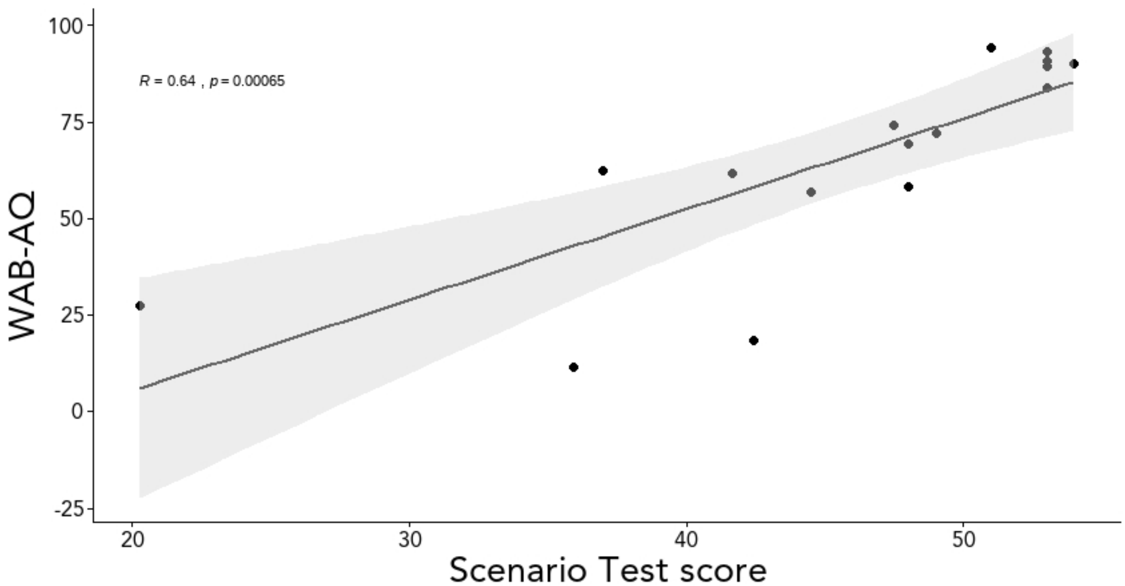


Figure 4. Kendall's τ rank-based correlation between communication impairment (Scenario Test raw score) and linguistic impairment (WAB-AQ).

Discussion

The current study examined the relationship between standardised measures of linguistic impairment and functional communication impairment with communicative performance on an experimental, collaborative communication task in a group of people with post-stroke aphasia. The aim was to investigate the construct validity of the task by evaluating the degree to which the lab-based task was able to capture skills that are said to be involved in functional communication, as measured by the well-established standardised WAB-R and Scenario Test. A second aim was to assess whether the strength of the relationship differed for the two standardised scores.

Both the standardised scores show a moderate correlation with accuracy scores on the collaborative communication task. The standardised linguistic score and the standardised communication score explained 44% and 49% of performance on the collaborative communication task, respectively. Statistical comparison of these correlations indicated that strength of the correlation was the same for both measures.

The collaborative communication task represents an unscripted, interactive, multimodal and contextualised communication challenge, in many ways, representing a communication setting as one might encounter in the real world. The current findings show that performance on this experimental task is able to capture elements of both the linguistic as well as the communicative impairment as measured on standardised tests, thereby providing support for the lab-based task's construct validity. Furthermore, the results indicate that the experimental task also taps into a skillset that is not captured by the existing tests, as will be discussed in more detail below.

The findings show that linguistic processing is an important contributing factor to communication on the experimental task specifically, as 44% of variance is explained by the linguistic impairment. This finding is in line with existing research that has consistently found a moderate-strong, positive relationship between measures of linguistic impairment and functional communication (Fridriksson et al., 2006; Fucetola & Connor, 2015; Irwin et al., 2002; Lomas et al., 1989; Meier et al., 2017). This finding also underscores the fact that success on the collaborative communication task required more than just linguistic processing, in line with theoretical descriptions of real-world communication (Doedens and Meteyard, 2020, chapters 2 and 3 of this thesis). For example, non-verbal modalities are an important part of naturalistic communication, and often deemed essential for PWA (de Ruiter, 2000; Hogrefe et al., 2013; van Nispen et al., 2017). Cognitive functions such as cognitive flexibility (Beckley et al., 2013; Spitzer et al., 2019) and executive functions have been associated with successful functional communication (El Hachioui et al., 2014; Frankel et al., 2007; Fridriksson et al., 2006; Murray, 2012; Olsson et al., 2019; Purdy & Koch, 2006; Ramsberger, 2005). These aspects of communication are not captured by the WAB-R. Existing research suggests that the linguistic impairment plays less of a role in the ability of those with a severe linguistic impairment to communicate successfully (Schumacher et al., 2020). For these PWA non-linguistic factors such as cognitive flexibility are likely to be more indicative of success on the task and their ability to communicate in the real world (Olsson et al., 2019). This might, for example, be partly due to the fact that PWA with severe aphasia are constantly required to find alternative ways to communicate (Nicholas et al., 2011).

The relatively low explanatory power of the Scenario Test is perhaps, at first reading, more surprising. The Scenario Test was specifically designed to capture the ability of PWA to communicate in a real-world setting. Theoretically, therefore, the Scenario Test might be expected to correlate more strongly with performance on the experimental task than a standardised linguistic measure such as the WAB-AQ. However, there are a number of ways in which the current finding can be explained. First, the Scenario Test was specifically designed to capture multimodal communication for PWA with a severe aphasia. The majority of PWA in the current sample were moderately-mildly impaired, suggesting that those whose communicative abilities would be best captured by the standardised test, only made up a small portion of the dataset. Furthermore, the Scenario Test represents a highly structured and helpful interactive environment that is provided by the clinician/conversation partner (Hilari & Dipper, 2020), which includes a highly standardised, helpful conversation partner (Olsson et al., 2019). In the collaborative communication task, the structure provided by and helpfulness of the conversation partner was not controlled for, meaning that these external factors very likely had a bigger effect on the dyad's communicative success on the task than on the score of the Scenario Test (Hengst, 2003). This could have made the lab-based task more challenging and demanding for PWA. On the other hand, the familiar conversation partners might have been able to provide help more readily than is scripted in the Scenario Test, which would have mediated that effect. In short, the experimental task very likely included more variability in terms of task demands and complexity, compared to the Scenario Test. Finally, these results reflect how measures of functional communication (in this case, the experimental task and the Scenario Test) vary in the way they capture functional communication, depending on the way in which measurement is designed, either as a highly standardised test, an experimental task or, for example, ratings of communication in everyday life. Previous research has also found correlations of varying strengths between different measures of functional communication (Hilari & Dipper, 2020; Olsson et al., 2019; Schumacher et al., 2020; van der Meulen et al., 2010). While the Scenario Test was shown to have the greatest content validity compared to a large number of other clinical instruments (Doedens and Meteyard, 2020, chapter 3 of this thesis), its ability to reliably capture real-world communication in its current form is very likely still limited, especially given the group of PWA included in the current study (Olsson et al., 2019; Schumacher et al., 2020). More research is therefore needed to determine exactly how performance on the experimental task and performance on the Scenario Test translate to observations of naturalistic interactions in real life. Fundamental research should be conducted to identify which factors significantly affect communication for PWA in the real world, thereby making it possible to determine exactly which factors need to be considered, or standardised, in an assessment of functional communication (as discussed in chapter 2 of this thesis).

Finally, the current findings are encouraging in terms of the construct validity of the accuracy measure on the current task. While previous experimental work with a collaborative communication task has shown mixed results in terms of the usefulness of an accuracy score in quantifying functional communication, the current findings suggest that the accuracy score reported in this study can provide a sensible reflection of the overall impairment of communication on the task (e.g. Hengst, 2003; Meuse and Marquardt, 1985, chapter 3 of this thesis). More research is needed, however, to establish the reliability and informativeness of this measure across different experimental manipulations. It is also expected that different measures taken from the current task (e.g. time taken to complete the task, number of turns, etc.) will show a different correlation with the standardised measures, as such variability has been shown across measures of functional communication in previous research (Hilari & Dipper, 2020; Olsson et al., 2019; Schumacher et al., 2020; van der Meulen et al., 2010).

A limitation of the current study is the unequal representation of different aphasia severities in the dataset. A few participants with severe and very severe aphasia were included. These groups were too small, however, to examine the relationship of performance on the experimental task to the standardised measures in terms of aphasia severity. Future research should include a larger sample of PWA to further test the relationship between performance on the experimental task and these standardised measures. A larger sample of participants across the range of aphasia severities would also make it possible to investigate the degree to which the two standardised tests are complimentary in their ability to explain the variance in task-based performance and how their explanatory power varies across different aphasia severities.

Conclusion

The current analysis shows that performance by people with post-stroke aphasia on an interactive, multimodal, and contextualised, lab-based communication task correlates moderately with standardised measures of linguistic and communication impairments. The strength of the correlations of the Scenario Test and the WAB-AQ score with performance on the experimental task did not differ significantly. These findings provide support for the construct validity of the lab-based task in capturing functional communication. Furthermore, these findings are in line with the idea that these standardised measures of linguistic and communicative impairment in their current form are limited in their ability to explain the variance of communicative ability (Frattali et al., 1995; Holland, 1982). A better understanding of the internal (e.g. cognitive functions, linguistic impairment) and external (e.g. ability of the conversation partner to provide support, the structure provided and the complexity of the collaborative communication task) factors that influence functional communication for PWA will inform further developments of reliable assessment tools.

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Chapter 7 | General Discussion

The ability to communicate in the real world is a behaviour that is of central importance to aphasia rehabilitation. It represents one of the main long-term goals of speech and language therapy for PWA and those closest to them (Wallace et al., 2017; Worrall et al., 2011). It is also the behaviour that underpins many of the social and societal participation difficulties experienced by people with post-stroke aphasia, such as maintaining work, friendships, a sense of independence and overall quality of life (Cruice et al., 2006; Hilari, 2011; Hilari & Northcott, 2016; Northcott et al., 2016; Worrall et al., 2011).

Despite the growing body of research on functional communication in aphasia, the field has struggled to bring these findings together into a coherent understanding of real-world communication for PWA (Brady et al., 2016). At the root of this lies the lack of a unified definition of what real-world communication encompasses, and what it does not. The main objective of this thesis was to address the lack of a coherent theoretical foundation by proposing a systematic, empirical, and cognitive-behavioural approach to the investigation of real-world communication in post-stroke aphasia. To this end, we aimed to answer the following research questions:

1. How can we define real-world communication in aphasiology?
2. How can we measure functional communication in an ecologically valid manner, given the theoretical framework?
3. How can we investigate communication experimentally in post-stroke aphasia, given the theoretical framework?
4. How does conversation partner familiarity influence communication for PWA, as measured on a collaborative, communicative experimental task?

In this final chapter, the main findings from the preceding six chapters will be integrated and the implications of these findings will be discussed. Limitations of the studies will be addressed, and recommendations for future empirical and clinical work will be made. The chapter will end with an overall conclusion.

Discussion of the current findings

A theoretical understanding of real-world communication

The first research question of the thesis directly touches on a fundamental issue in the field of aphasiology, namely the lack of a clear conceptualisation of functional communication in aphasia rehabilitation (Armstrong, 2000; Brady et al., 2016; Linnik et al., 2016). The theoretical framework that is introduced in chapter 2 addresses this research question by breaking down the concept of real-world communication into a number of necessary sub-components. The framework thereby attempts to provide the field with a more specific vocabulary by which to define the concept of functional communication. Such specification represents a necessary step for a more unified and productive approach to the study, assessment, and treatment of communication in aphasia (Armstrong, 2000). A number of important implications follow from the theoretical framework of real-world communication, as will be discussed below.

Firstly, the current findings provide theoretical and empirical support for the original claim that there is a difference between language processing (i.e. single words and sentences) in a highly controlled lab- or clinic-based setting and real-world communication (Figure 1; Holland, 1982). The findings from the literature review in chapter 2, therefore, emphasize the need for the field to acknowledge the limitations of data from highly controlled, traditional language-based research when it comes to understanding real-world communication. It is crucial that studies focus more on how findings from highly controlled environments relate to linguistic processing in higher, more functional levels of language use. This research is necessary in terms of assessment (how well do scores on tests such as the WAB-R (Kertesz, 2009) and CAT (Howard et al., 2004) inform our understanding of a person's communicative abilities in the real world?), treatment (i.e. how does impairment-based treatment affect communication outside the clinic?) and generalisation of treatment effects (i.e. how can we facilitate the translation of therapy gains achieved in clinic to behaviour outside of the clinic?).

Secondly, the findings from chapter 2 also differentiate between levels of language use that exist between the processing of single linguistic elements such as words and sentences, and language use in the real world. As was discussed in the introduction, the continuum presented

level of language use	word	sentence ←——————→ everyday communication

Table 1. Visual representation of the distinction between isolated language use and language as it is used in the real world.

in Table 2 clearly reflects the overlap in terminologies that, in the literature, are all used to refer to *functional communication* (as discussed in chapter 2, i.e. connected speech, discourse, monologue, dialogue and everyday communication).

level of language use	word	sentence	connected speech			
			picture description	discourse		
				monologue	dialogue / everyday communication	
Elicitation methods	* Picture naming	* Constrained phrase or sentence production tests	* Complex picture description * Sentence production tests	* Narrative, e.g. story retell * Personal narrative, e.g. recount * Procedural narrative * Expositions, e.g. opinions	* Conversation (more or less naturalistic sampling) * Role-playing	* Elicited production of everyday scenarios * Rating scales

Table 2. Continuum of levels of language use, illustrating the terminologies that have been used to refer to functional communication in the aphasia literature, based on the continuum by Webster et al (2015).

The theoretical framework that is presented in the current thesis can be used to differentiate between these different levels of language use and specify which levels represent language use in the real world and which do not. For example, the framework identifies *everyday communication* and *dialogue* (both at the far right on the continuum) as most representative samples of communication as it is used in the real world (Armstrong, 2000). These are most likely to be interactive, multimodal and embedded in some degree of context (i.e. a physical space and the context of a conversation). While *monologue* and *complex picture description* represent higher levels of language use compared to word- and sentence level processing, each lack critical characteristics that make up the dynamics of real-world communication, according to the framework (e.g. neither are interactive). Theoretically, therefore, there is reason to believe that *monologues* and *complex picture descriptions* tap into skills that might be required for communication but are elicited under circumstances that are inherently different from those placed on a person during the most common form of communication in the real-world. In that sense, the continuum could indeed be viewed as a continuum of *complexity of language use*. The further one moves to the right on the continuum, the larger the number of variables that come into play and that increase the overall demands of the task.

The findings from the literature review in chapter 2 also provide empirical support for the idea that samples from different levels of language use (i.e. monologue, dialogue) will show different patterns of language use as a result of the changes in task demands (e.g. a difference in gesture use; Sekine and Rose, 2013; a difference in linguistic forms and complexity, Bryant et al., 2016). The theoretical framework therefore stresses the need for more research that specifically examines functional communication, or *dialogue*, in aphasia. It is also critical that more research is conducted to better understand which patterns of language use are stable across samples of language use, and which are not (e.g. measures of syntactic and semantic aspects of discourse; Armstrong et al., 2011; Armstrong et al., 2013; Bryant et al., 2016; Li et al., 1995; Ulatowska et al., 1990; Williams et al., 1994). Insight into the patterns of language use that overlap across levels of language use will allow researchers to reliably generalise findings from lower levels of language use (i.e. monologue) to higher levels (i.e. dialogue).

It is worth mentioning that the original continuum as presented by Webster et al. (2015) focused specifically on the generalisation of language production skills across different levels of linguistic processing. In the current discussion of different levels of language *use*, it is imperative to consider the differences in processing demands both in terms of production as well as comprehension, both of which are inherently part of communication in the real world.

Finally, both the theoretical framework and the literature review showcase the multifactorial nature of real-world communication. The framework therefore underscores the critical role of factors beyond linguistic skills in everyday communication and highlights the need to consider these factors in judgements of communicative ability (e.g. non-verbal communication and non-linguistic cognitive impairments such as executive functions, memory, attention and cognitive flexibility, e.g. El Hachioui et al., 2014; Frankel et al., 2007; Fridriksson et al., 2006; Meier et al., 2017; Olsson et al., 2019; Schumacher et al., 2020). As was argued for linguistic processing, there is a need for more research that investigates the involvement and interaction of these factors in the dynamics of dialogue, specifically, to fully understand the challenges that PWA face when communicating in the real world. The theoretical framework provides a structured approach to understanding the link between non-linguistic cognitive impairments (i.e. internal factors) and specific components of functional communication. Greater insights into these challenges and opportunities is necessary in terms of assessment (e.g. which skills need to be assessed to understand a person's ability to communicate in the real world?), treatment (e.g. which behaviours can be targeted in treatment to optimise communication in the real world, either through relearning or compensation?) and generalisation of treatment effects (e.g. which factors can facilitate or impede the generalisation of what is trained inside the clinic to effective use outside of the clinic?). The influence of one external factor, namely the conversation partner, was examined in chapter 5 of this thesis, as will be discussed later on in this chapter.

The findings from chapter 2, therefore, emphasize the importance of using a *specific* vocabulary when discussing language use at different levels (i.e. complex picture descriptions, monologue, or dialogue). It also emphasizes the need for a more *restrictive* use of the term *functional communication*, *everyday communication*, or *real-world communication* (i.e. not to be used interchangeably with monologue or complex picture description). Furthermore, the theoretical framework underscores the relatively uninformative nature of terms such as *discourse* and *connected speech* to describe a specific level of language use. Both discourse and connected speech represent umbrella terms that include multiple different levels of language use (e.g. discourse refers to both monologue and dialogue), and therefore automatically lack the differentiation and specification that is needed in the discussion of functional communication in aphasia rehabilitation. If applied systematically, these endeavours can help generate more targeted and productive research and can facilitate future meta-analyses and cross-study comparisons (Armstrong, 2000). Finally, the findings from chapter 2 emphasize the need to consider functional communication as a multi-factorial behaviour that requires the consideration of a profile of different skills, one of which is linguistic processing. While these ideas are not by any means new, more work is needed to realise a specific and comprehensive approach to functional communication in the field of aphasia rehabilitation.

Clinically, the hope is that the theoretical framework can provide speech and language therapists with a structure to guide their considerations of a client's functional communicative abilities. We expect that the lack of theoretical conceptualisations of the term functional communication in the field of aphasia will very likely have had a significant impact upon the way clinicians are able to plan interventions targeted at communication, and on the way clinicians are able to discuss and explain the potential impact of post-stroke aphasia on communication in the real-world with clients. The hope is that the current theoretical framework will provide clinicians with a preliminary structure that will begin to demystify the multi-factorial nature of functional communication.

The cross-disciplinary nature of chapter 2 presents a particular strength of the paper. However, mention of a specific limitation is warranted. The narrative nature of the selection of the framework, as well as the scoping nature of the literature review may have restricted the number of existing frameworks or models identified and reviewed. Due to the multi-factorial nature of the review, the current approach was deemed most suitable to give a sense of the breadth and complexity of the concept of real-world communication. However, this approach will have necessarily limited the number of relevant papers that were included. A systematic review (or rather, multiple reviews) with specific search terms for each component of the framework and specifically for models/frameworks of communication could be used to address this limitation.

Clinical assessment of real-world communication

Chapter 3 addressed the second research question of the thesis, namely which assessment instrument was most ecologically valid, given the newly proposed theoretical framework. The critical evaluation in chapter 3 therefore represents a practical application of the narrow definition of real-world communication as prescribed by the theoretical framework. By evaluating existing assessment instruments on their conceptualisation of functional communication, this chapter addressed an existing problem surrounding the lack of consensus in the assessment of functional communication in research (i.e. use of heterogeneous instruments that impedes the synthesis of data and thereby hampers cumulative progress in research; Brady et al., 2016; Wallace et al., 2014) and clinical practice (i.e. low reported rates of functional assessment compared to impairment-based tests; Katz et al., 2000; Verna et al., 2009). To the knowledge of the author, this is the first attempt to evaluate the content validity of these measures with an empirically founded definition of functional communication. The usefulness of the theoretical framework in addressing some of these existing issues has already been evidenced by the fact that the pre-print of chapter 2 and 3 (Doedens & Meteyard, 2018) was used by a consortium of internationally renowned aphasia researchers to support the selection process of an instrument to measure communication as part of the ROMA COS (Research Outcome Measurement in Aphasia: Core Outcome Set) for post-stroke aphasia treatment studies in 2018 (personal communication, 2018; 2019). The evaluation in chapter 3 represents a critical step in the development of comprehensive, meaningful assessments of functional communication in aphasia, both in the clinic and in research. The results have a number of important implications.

Theoretically, the results from chapter 3 illustrate the usefulness of a more systematic, theoretically founded approach to the assessment of functional communication in aphasia. The variable way instruments were shown to assess functional communication supports the claim that such a theoretically founded approach had previously not been applied to the study of functional communication. Furthermore, the current evaluation revealed that an explicit statement regarding the theoretical assumptions with regards to functional communication was often missing. To facilitate the evaluation of the construct validity of new instruments, and to facilitate the selection of an instrument for assessment of functional communication, future studies are therefore encouraged to make the assumptions surrounding the conceptualisation of functional communication explicit.

Empirically, the evaluation and resulting recommendations described in chapter 3 provide insight into the inherent complexity of the assessment of real-world communication. The recommendation of a single existing instrument is a practical solution for researchers and clinicians who need a standardised test right now. However, the existence of a wide range of vastly different assessment instruments (i.e. standardised tests, observational profiles, linguistic and sociological methods of analysis) and the different criticisms of these instruments reflect the diverse ways in which functional communication can be studied and the challenges that need to be addressed when attempting to capture this behaviour. A number of key challenges facing the assessment and investigation of functional communication are discussed below.

A criterion of successful communication

A challenge in the assessment of real-world communication lies in its inherent variability. There is not one way of communicating something, and successful communication therefore does not have a clear-cut criterion to measure performance against. This raises the question of how good or effective communication should be operationalised (i.e. what is a meaningful criterion of performance for real-world communication? Prins and Bastiaanse, 2004). This challenge is reflected in the various ways in which this criterion is operationalised across the different instruments (e.g. the amount of information transfer, judgement of 'correct' use of particular speech acts, the correct use of particular linguistic constructions, etc). The Scenario

Test quantifies successful communication as the ability to express one or two key 'propositions' or 'concepts' of a number of non-complex messages (i.e. 'children', 'okay?', expressed in any kind of modality, represents a successful transmission of information for the scenario in which someone is required to inquire after a friend's children). This criterion has proven useful in differentiating between people with severe linguistic impairments (Hilari & Dipper, 2020; van der Meulen et al., 2010). Existing criticism of the Scenario Test (i.e. the ceiling effect for PWA with milder impairments) suggests that its criterion of successful communication is not suitable to differentiate between PWA with milder impairments. The findings from the experimental work of the current thesis (i.e. chapters 4, 5 and 6) suggest that the linguistic impairment might play a bigger role in functional communication for PWA with milder impairments compared to those with more severe impairments. This would warrant a more detailed analysis of information transfer, particularly through the verbal channel, to differentiate between PWA with milder impairments, than is currently included in the Scenario Test. Indeed, Nicholas and Brookshire (1995) stated that a judgment of successful communication for people with a mild impairment might depend more on the form of a message (i.e. grammatical complexity, cohesion, etc) than for people with a severe impairment. In fact, it's been suggested that the number of main concepts communicated on a story-retell task will not necessarily differentiate PWA with mild-moderate impairments from controls. Rather, a more fine-grained analysis of the completeness and accuracy of these main concepts is needed to differentiate between these groups (Nicholas & Brookshire, 1995). This is in line with the findings from the experimental work of the current thesis that a measure of information exchange should be sufficiently detailed in order to capture differences between mild, moderate and more severe impairments of communication (chapter 4; Schumacher et al., 2020). An example of an assessment instrument that focuses on the spoken functional communication in more detail is the ANELT/ANELT-CU (Blomert et al., 1995; Ruiter et al., 2011). This instrument has been shown to differentiate between PWA with milder impairments, while it is less capable of distinguishing between PWA with more severe impairments, who rely less on the verbal channel for communication. A criticism of the ANELT is that it does not consider the use of other modalities, and therefore is likely to miss the full extent of the communicative abilities of PWA (chapter 3 of this thesis). An integration of the approaches in the Scenario Test and ANELT might provide insight into the overall, multimodal communicative effectiveness, and the unique contribution of the verbal channel to this ability. This would provide the clinician with insights into the way the existing verbal resources are utilised and the effectiveness of other modalities in real-world communication. Crucially, an integrated approach to the assessment of functional communication across the full range of aphasia severities with a single test would facilitate comparisons across studies and PWA with different levels of severities. Future research will have to explore whether it is possible to integrate two different approaches to describing functional communication into one test.

A more detailed scoring manual for the Scenario Test has been developed by a team in Germany, to better account for PWA with less severe impairments (Nobis-Bosch et al., in press, as reported by Schumacher et al., 2020). Details of the content of this coding scheme are unknown to the author at the time of submission of this thesis.

Capturing the variability of communication in the real world

The inherent variability of communicative behaviour as it is used in the real world across the different settings, communicative purposes and roles people take on presents a particular challenge to the development of any assessment of functional communication. There are different ways in which this variability of communication in the real world can be approached by a particular assessment instrument. This is evidenced by the large number of heterogeneous instruments that were reviewed in chapter 3. Most observational profiles seem to be based on the premise that a judgment of functional communication should rely on an overall impression of ability across different settings, roles and purposes, rather than focusing on a single, one-off observation. This premise is similar to the approach in discourse analysis, where it is generally recommended that multiple samples of language use are used to provide a comprehensive overview of a person's overall communicative ability (Armstrong, 2000; Bryant et al., 2016; Olness, 2006). Clinically, such an approach is difficult given the time-consuming nature of the collection and analysis of such data (Prins & Bastiaanse, 2004). The observational profiles, in turn, are criticised for being subjective and indirect measures of communication (Blomert et al., 1987; van der Meulen et al., 2010), and not specific enough to provide detailed information on the communicative behaviour (Doedens and Meteyard, 2020, chapter 3 of this thesis). In contrast, the premise of standardised tests such as the Scenario Test is that a single, controlled measure of communication can capture a person's basic set of underlying, fundamental communication skills. This premise is in line with the theoretical framework described in chapter 2, which assumes that an assessment of face-to-face communicative ability can be used to make assumptions about the way communicative behaviour might vary depending on the challenges that are encountered in the real world (i.e. speaking on the phone, rather than face-to-face). The question then arises as to what kind of baseline measure would be most useful in forming an understanding of a person's communication skills in the real world, given its inherent variability. One option is to measure communication in the most optimal and supportive setting, thereby capturing a PWA's maximum capacity to communicate. Alternatively, a test can aim to standardise variations of the key challenges that PWA might face in the real world (e.g. more and less helpful conversation partners) and test their performance on each of these variations. The generalisability of both types of standardised scores to the variability of the real world ultimately depends on a thorough understanding of the key factors that affect functional communication in post-stroke aphasia, a good understanding of the circumstances in which communication is elicited on the test and the way in which the operationalisation of functional communication of the test translates to different communication challenges in the real-world. For example, communication on the Scenario Test is elicited in a highly structured and supportive environment (Hilari & Dipper, 2020), in which the amount of cueing provided by the conversation partner is varied. This raises the question whether the scores on the test provide a sufficiently realistic insight into the communication skills of PWA as they communicate in the real world, in which less structure is often provided (Hengst, 2003). The generalisability of the standardised scores will, in the end, depend on the extent to which the circumstances of the test are described in detail, and the knowledge that exists on how this relates to real-world communication. While the Scenario Test has shown moderate to good correlations with observational measures of functional communication (e.g. Hilari and Dipper, 2020; Schumacher et al., 2020; van der Meulen et al., 2010), more research is needed to evaluate the degree to which scores from the Scenario Test are generalisable to real-world communication and which factors might limit its generalisability, such as for example, variability across conversation partners. Future studies should therefore aim to better understand the relationship between standardised scores such as the Scenario Test and real-life communication, through a combination of systematic observations of naturalistic communication in the real world and experimental investigations of functional communication. A first step in this approach was taken in chapter 6 of this thesis. Furthermore, studies should conduct a thorough inventory of the factors that make up circumstances under which language is elicited on the Scenario Test in its current form (similar to the approach in chapter 3) and how this relates to the different situations, communicative goals and roles that PWA have to take on in real life.

The subjective experience of real-world communication

While the current thesis focuses on the objective assessment and investigation of functional communication, the existence of a large number of observational profiles that are based on the judgments of PWA or their proxies, and often deemed *subjective* in nature, highlights the value of these experiences in the assessment of functional communication. While an objective instrument such as the Scenario Test can provide insight into the communication skills of PWA in a controlled manner, a targeted and specific observational profile can provide complimentary insights into those aspects of the communication impairment that are actually experienced as problematic by the PWA or those closest to them, as well as providing insight into the way in which the objectively measured communication skills are, or are not, utilised across different settings in the real world (Simmons-mackie, 1998). Discrepancies between objectively measured communicative ability and real-world use could highlight the need for the clinician to explore underlying reasons for this, such as avoidance of communicative situations to save face (Simmons-Mackie & Damico, 1995), an under- or overestimation of a person's objective communication skills (Schumacher et al., 2020), or a lack of ability to adapt the communication skills to various challenges that are not addressed in the standardised tests administered in the clinic. Furthermore, the subjective experience of PWA can help determine their individual criterion of communicative success, i.e. what to them represents successful communication, regardless of their objective communicative ability. This, in turn, can inform collaborative goal setting in speech and language therapy (Hersh et al., 2012). The existence of measures of objective and subjective functional communication underscores the value of both perspectives, and the complimentary role for both to optimally inform a therapy plan that is tailored to the client's specific needs. Future research should explore the relationship between objectively quantified communicative abilities and the subjective experience of communication in the real world, and how this might affect the experience of the impact of the communication difficulties, and quality of life more generally.

Clinically, the results from chapter 3 have a very clear, practical implication, namely a recommendation of the Scenario Test (van der Meulen et al., 2010) as the instrument that incorporated the components of the theoretical framework most comprehensively, while also giving insight into the way these components affect communication for PWA. With good psychometric properties, standardised norms and standardised administration procedures, it represents a highly useful clinical tool. This particular instrument is available both in Dutch (van der Meulen et al., 2010), English (UK version: Hilari and Dipper, 2020) and is in the process of being adapted for German (Krzok & Plum, 2016). Along with the recommendations from the ROMA COS initiative, the evaluation from chapter 3 provides clinicians and researchers with a theoretical argument for selecting the Scenario Test from the long list of possible instruments as a measure of functional communication, as well as a structure to select a different instrument based on the specific needs of the project.

Empirical investigations of real-world communication in post-stroke aphasia

Chapters 4, 5 and 6 were used to answer the third research question of the thesis: how can we investigate functional communication experimentally, given the theoretical framework? The chapters contribute to a growing body of research on communication in aphasia in a number of different ways. Methodologically speaking, the studies described in chapters 4, 5 and 6 directly address the need for research on dialogue or everyday communication as described in the theoretical framework. The ecological validity of the data was established by utilising an experimental setup that included all aspects of real-world communication as defined by the theoretical framework from chapter 2 (i.e. interactive, multimodal and embedded in context). By doing so, it was possible to create a communicative setting which presented the participants with task demands that were, in many ways, similar to those experienced during real-world communication. The preliminary construct validity of this experimental measure of functional communication was established in chapter 6. While similar experimental setups have been used to a limited degree in aphasia research in the past, its systematic application to gain a better understanding of communication (or dialogue) in PWA, as it is presented in the current thesis, is novel. The findings from the empirical chapters of this thesis have a number of theoretical, empirical and clinical implications that will be discussed below. The implications of these chapters will be discussed in a general sense, followed by a discussion of the implications of the main findings.

Empirically, the findings from the experimental investigations in chapters 4, 5 and 6 contribute to existing knowledge of functional communication in aphasia by identifying behavioural markers that characterise and differentiate aphasic communication from that of a group of controls. Identification of such markers provides insight into the type of behaviours that are relevant for the assessment and treatment of functional communication in aphasia rehabilitation. The experimental work in this thesis also provides insight into the degree to which aphasia severity (i.e. the linguistic impairment) is a mechanism driving functional communication for PWA, and the opportunity that this experimental paradigm provides in gaining insight into learning mechanisms that support communication. Both these findings will be discussed later on in this chapter.

Clinically, this experimental approach highlights the potential ways in which the use (i.e. production and comprehension) of isolated language elements that are targeted in traditional impairment-based approaches (e.g. lexical retrieval and sentence production exercises) can be trained in more dynamic, interactive settings in the clinic, in an attempt to support generalisation from impairment-based therapies to real-world language use (as discussed in chapter 4).

Characterisation of functional communication in aphasia

Behavioural markers of aphasic communication

The findings described in chapter 4 show that communication in post-stroke aphasia can be characterised in two ways. One, in terms of a reduction in the amount of information that is exchanged (i.e. communicative success) and two, in terms of the modalities that are used to communicate (i.e. multimodal communication strategies). These findings imply that in an assessment of real-world communication it would be meaningful to describe, as a minimum, how much information PWA are able to communicate and how communication is achieved (i.e. which modalities are relied upon during communication). While the former can give an indication of the severity of the communication impairment (similar to the overall score on the WAB-R or the Scenario Test), the latter can provide insight into the arsenal of tools a person has readily available to support communication. The Scenario Test describes exactly these aspects of communication. The degree of overall impairment is reflected in the overall communicative score on the Scenario Test, while multimodal communication is described qualitatively according to the type of modalities used, their frequency of use, the effectiveness in communication and the ease with which a PWA can switch between modalities (i.e. the degree of help needed for this from the conversation partner in terms of prompting; Hilari and Dipper, 2020). These experimental findings, therefore, provide further support for the usefulness of the way the Scenario Test approaches the assessment of functional communication in aphasia.

Interestingly, the current experiment employed a coding scheme for accuracy that deviated from traditional referential communication tasks, in the sense that accuracy was coded on a continuum, rather than a binary (correct/incorrect) scale. While previous studies using this experimental paradigm did not find differences between PWA and controls on a binary measure of accuracy (Hengst, 2003; Meuse & Marquardt, 1985), the continuous accuracy scale employed in the current thesis provided more detailed insight into the degree to which communication was effective for a dyad. It seems, therefore, that accuracy can be informative of communicative performance, as long as it is considered in sufficient detail. As discussed in the previous section ("A criterion of successful communication"), the degree of detail with which communicative success is considered on the Scenario Test, combined with its low level of complexity, very likely reduces its ability to differentiate between people with moderate-mild linguistic impairments (Nicholas & Brookshire, 1995). The definition of successful communication as successful transmission of a minimum amount of information required during an exchange (Blomert, 1990) might lack a differentiation between responses that include the bare essentials (i.e. rough placement of an object) and those that go beyond that and include more detailed information (i.e. a specific angle or an object's location in relation to another object). Future research will have to examine whether a more detailed scoring scheme of communicative success, combined with the addition of more complex communicative scenarios, might lead to a more informative application of the Scenario Test to a wider group of PWA. An integrated approach such as the combination of the approach in the ANELT and Scenario Test, might provide insight into the communicative abilities of a wider range of PWA. As was mentioned before, a more detailed scoring scheme of the Scenario Test will reportedly be published for the German translation of the test (Nobis-Bosch et al., in press, as reported by Schumacher et al., 2020).

A limitation of the current empirical work is that it does not assess the individual contributions of each modality in terms of their communicative value. The time spent relying on the different modalities (i.e. time spent gesturing, time spent drawing, number of words produced) probably does not directly reflect the communicative value of each modality. An analysis of the role each modality played in transmitting information (i.e. whether they carry essential information, or compliment information expressed through another modality) can provide greater insight into the role each modality played in achieving communicative success.

The influence of conversation partner familiarity on communication in aphasia

The fourth and final research question, regarding the influence of conversation partner familiarity on functional communication for PWA, was addressed in chapter 5. This chapter therefore represents the first manipulation within the current experimental paradigm of an external factor from the theoretical framework. The experimental findings reported in chapter 5 expand existing knowledge on the way external factors influence functional communication in aphasia. The results show that in communication, or dialogue, the degree to which PWA are personally familiar with their conversation partner has a significant impact on the way people with post-stroke aphasia communicate. More specifically, PWA were shown to invest less (i.e. time and requests for clarification) in the conversation with the unfamiliar conversation partner compared to the familiar conversation partner. When PWA were most in control of the conversation (i.e. when they were 'instructors' on the task), accuracy remained stable across conversation partners. This effect exists, even when knowledge of aphasia and experience in communicating with someone with aphasia is controlled for. Critically, chapter 5 shows that the patterns of language use across conversation partners is different for PWA compared to people without neurological impairments (who showed stable measures of time and clarification requests across conversation partners, but an increase in accuracy on the task). These findings have a number of important implications for the study and assessment of functional communication in aphasia rehabilitation.

Theoretically, the findings support the relevance of the *interactive* component in the theoretical framework. They also illustrate that research based on typical communication cannot directly be transposed onto the case of communication in post-stroke aphasia. Instead, research with PWA needs to be conducted to gain insight into the unique ways in which functional communication is affected in aphasia. At an empirical level, these results highlight the need to predict how well PWA will be able to adapt to challenging conversation partners they might encounter in the real world. If research can shed light onto the factors that determine this adaptive ability, it might become possible to target this adaptability through intervention, thereby improving functional communication for PWA as a whole.

Methodologically, these findings highlight a particular challenge to the study of functional communication in aphasia. In order to better understand the individual performance of PWA within this joint action, it is necessary to control or account for the role of the conversation partner in that process. This is a challenging endeavour, and it is exactly the challenging nature of studying dialogue that has been raised as a reason for the predominant use of monologues in studying functional communication in aphasia research (Bryant et al., 2016). As is argued throughout the current thesis, however, it is imperative that the individual behaviour is investigated within the dynamics of dialogue. This is needed in order to better understand real-world communication and to understand the way patterns of language use in dialogue relate to other levels of language use. To facilitate research in dialogue, it is therefore crucial to gain greater insight into the different ways in which the conversation partner can affect functional communication for PWA, and which internal factors of the PWA mediate this effect. Such knowledge will make it easier to control for the influence of the conversation partner in different communicative settings. One way in which the influence of the conversation partner can be explored includes the use of a confederate to manipulate the degree of help provided by the conversation partner (as in Busch et al., 1988 and Cubelli et al., 1991), or to compare the influence of different conversation partners across conditions, as was done in the current thesis (and, for example in Kistner, 2017). Furthermore, the way in which the role of the conversation partner can best be standardised in research and assessment practices should be explored. For example, rapid developments in the application of virtual reality in language research and healthcare might make it possible to standardise variations of different conversation partners in communicative settings (Bryant et al., 2019; Cherney & Halper, 2008; Peeters, 2019). This also ties in with earlier statements regarding the need to explore how factors such as the conversation partner can best be standardised, either by testing performance in an optimal setting or by testing performance across varied expressions of these factors.

More specifically, in the Scenario Test, the role of the conversation partner is controlled for by way of a script that the conversation partner follows, similar to the use of a confederate in an experimental setting. This approach attempts to standardise the behaviour on the side of the conversation partner across all PWA tested and facilitates comparison across different PWA. It is worth wondering, given the impact of the conversation partner on the communicative behaviour of the PWA, and the variability of the potential conversation partners a PWA can come across in day-to-day life, whether the generally supportive attitude of the conversation partner in the Scenario Test is informative enough of a PWA's ability to deal with various kinds of conversation partners. As discussed previously, the generalisability of scores from the Scenario Test depends on a thorough understanding of the different ways in which functional communication will vary, depending on the PWA's individual profile of impairment.

Clinically, the results highlight the importance of considering the different ways in which conversation partners can influence communication for PWA, even when the communicative challenge is relatively familiar to the PWA. In terms of current assessment procedures, this means that it is important to get a sense of the fluctuations a specific client shows in their communicative behaviour with different conversation partners, either through observations (i.e. with different family members or friends, or while interacting with other clinicians), self-report or observations of proxies. In terms of treatment of the PWA's communication skills, it might be possible to train a PWA to communicate with different people by involving different conversation partners in the communication interventions. More research is needed to evaluate whether this would indeed lead to more flexibility in the real world. In terms of the communicative environment, there is of course a large body of research that supports the training of specific conversation partners or dyads in their ability to enable PWA to communicate (e.g. Beckley et al., 2017; Simmons-Mackie et al., 2010).

A number of possible explanations for the difference in communicative behaviours between familiar and unfamiliar conversation partners are discussed in chapter 5, such as a ceiling effect in accuracy scores for PWA, or a (conscious or unconscious) difference in criteria of 'good enough' performance, with PWA aiming for a different interpretation of 'good enough' performance with unfamiliar conversation partners compared to controls. The available data does not, however, make it possible to test these hypotheses. It therefore remains unclear whether the observed behavioural change (i.e. reduction in time spent on the task and in number of requests for clarification with the unfamiliar conversation partner, as well as the stability of the accuracy scores) was due to a limited ability, a conscious strategic compensation, a conscious adaptation to optimise performance or an unconscious response to a challenging situation. More research is needed to provide insight into why and how communicative behaviour might vary for PWA in real life. An example is the use of qualitative interviews with PWA on their experience in communicating with various types of conversation partners. These could be conducted after completing a task such as the one reported in this thesis or independently, focusing on PWA's personal insights on barriers and facilitators in communication with different conversation partners, as well as their conscious (strategic) approach to dealing with such communicative challenges (similar to Dalemans et al., 2010; Davidson et al., 2008; Harmon, 2020). Insights could shed light on potential avenues for therapeutic intervention aimed at optimising functional communication, and potentially understanding discrepancies between what PWA can do as compared to communicative behaviours that are observed.

It is important to discuss a number of critical limitations to the current experimental design. A key limitation is that the main manipulation, conversation partner familiarity, was not counterbalanced for order. This reduced the strength of the conclusions that we can draw from the current data. Future studies should explore whether the current findings can be replicated when conversation partner familiarity is properly counterbalanced. This will help rule out alternative explanations for the difference found, such as fatigue on the part of PWA, practice effects for both groups and any potential ceiling effects for PWA on task accuracy. Another limitation of this study is that the role and involvement of the conversation partner themselves was not taken into account. An analysis of the degree to which the familiar and unfamiliar conversation partners differed in providing help and structure to the exchange, can provide further insight into the *individual* role and actions of the PWA within the exchange.

Furthermore, a serious limitation of the experiment is that while the findings from chapter 3 identify multimodal communication as an important behavioural marker of functional communication in aphasia, the influence of the conversation partner is not explored on this aspect of communication in chapter 4. An analysis of whether the unfamiliar conversation partner affected the use of different modalities (e.g. number of words, time spent gesturing and drawing/writing) for communication by PWA would provide further insight into the communicative behaviours and efforts of PWA across conversation partners.

Finally, chapter 5 reports the investigation of one aspect of functional communication in aphasia, which is part of the contextual component of the theoretical framework described in chapter 2 (i.e. the shared personal knowledge, experiences and beliefs as part of common ground). The findings from this chapter are encouraging in terms of the possibility of manipulating and investigating the impact of such external and internal factors systematically in an experimental setting. Future research should aim to address the significant gaps in research (as discussed in chapter 2) through experimental work to better understand the effect of other factors on functional communication in aphasia. Examples are the influence and use of the physical environment during communication (i.e. reliance on physical objects to communicate information, and the ability to discuss objects and events in the here-and-now compared to displaced reference in time and space), and the influence of memory or attention processes on functional communication (Ferstl et al., 2005; Murray, 2012; Zwaan, 2014).

The influence of aphasia severity on functional communication

The results from chapters 4, 5 and 6 also examined the relationship between aphasia severity and functional communication.

In terms of communicative success, the results reported in chapter 4 show that the ability to communicate effectively is negatively related to the severity of the linguistic impairment, meaning that as the severity of the linguistic impairment increases, the amount of information that is exchanged effectively is reduced. Overall, chapter 6 shows that the majority of variance in communicative performance on the experimental task was not explained by a composite measure of linguistic impairment (i.e. 44% of the variance explained). Previous research suggests that the influence of the linguistic impairment might be different for PWA with a mild compared to a more severe impairment. Both the way in which communication is achieved (i.e. the use of different modalities for communication) and the impact of the unfamiliar conversation partner did not show a clear relationship to the severity of the linguistic impairment. These findings suggest that factors beyond the internal variability of the linguistic impairment play an important role in determining how communicative success is achieved in aphasia with a familiar conversation partner.

Theoretically, these findings provide support for the framework proposed in chapter 2, which stipulates that verbal processing is a sub-component of a complex interplay between multiple factors that are involved in real-world communication. Consequently, these findings emphasize the importance of taking a broad perspective of functional communication, in which verbal processing is one of multiple skills that are required. Both linguistic processing, non-verbal communication and non-linguistic cognitive functions are involved in achieving communicative success and can all be impaired in PWA (El Hachioui et al., 2014; Olsson et al., 2019). Empirically, these findings highlight the need for more research on functional communication in aphasia, to better understand the way in which different factors influence communicative success and the way in which communication is achieved under different circumstances. More specifically, there is a need for research to explore how the interaction of different internal and external factors determines functional communication. This could lead to greater insight into the way in which variations in a *profile* of impairment might predict successful or impaired communication outcomes for PWA across the full range of aphasia severities. As discussed throughout this thesis, the use of any single measure of functional communication will very likely be uninformative. Future studies are therefore encouraged to quantify functional communication in terms of linguistic, communicative and cognitive factors. Furthermore, it will be critical for these future endeavours to evaluate the way in which functional communication is operationalised, as differences in the relationship between a linguistic impairment and functional communication have been found to vary depending on the standardised tests that are used to measure functional communication, such as the CADL-2 (Fucetola et al., 2006), the ASHA-FACS (Meier et al., 2017), the ANELT and the Scenario Test (Hilari & Dipper, 2020; Schumacher et al., 2020; van der Meulen et al., 2010). Part of these inconsistencies are likely due to the different conceptualisations of functional communication (as discussed in chapter 3 and 6). For empirical research on functional communication, the task used in the current thesis might provide a more direct, objective measure of the behaviour of interest, which will allow researchers to move beyond correlational analyses with single measures (although, as suggested elsewhere in the General Discussion, more work is needed to establish the generalisability of functional communication as measured on the experimental task). Insights from empirical research will ultimately feed into the development of intervention plans that address the key mechanisms that underpin functional communication at a linguistic, and (non-linguistic) cognitive level.

Clinically, these findings emphasize the need to compose a *profile* of impairment to gain insight into the potential a PWA has for communicating in the real world. This profile of impairment will include (at least) a measure of linguistic impairment, multimodal communication use and cognitive impairments that affect real-world communication (e.g. Frankel et al., 2007). Given the breadth and multi-faceted nature of real-world communication, a multi-disciplinary approach to the assessment and treatment of communication in aphasia involving speech and language therapists, occupational therapists, and clinical psychologists both in clinic and in research is recommended.

A relatively large group of PWA, spanning the full range of aphasia severities, was included in the current study. A key limitation that was already mentioned in chapter 4, 5 and 6, however, is the unequal distribution of PWA across the different levels of impairment. The severe impairments are particularly underrepresented in the current sample, which means only tentative conclusions can be drawn on the basis of the data. More research is needed with a larger group of PWA that is equally distributed across the full range of aphasia severities to corroborate the current findings specifically in relation to the measures used in the current experiment. Furthermore, a limitation lies in the sole reliance on composite scores such as the WAB-R for the correlation analysis. A larger sample may have allowed a breakdown of the composite scores to gain greater insight into the elements of linguistic impairment that drive the observed correlation.

Learning in functional communication

The experimental work reported in chapter 4 also showed that mechanisms of learning, as part of the dynamic communicative setting, can be explored within the proposed experimental paradigm. Learning is believed to be critical for treatment responsiveness and generalisation of therapy effects (Ferguson, 1999; Kelly & Armstrong, 2009; Rohter, 2014; Vallila-Rohter & Kiran, 2013). The call of the current thesis for more investigations, better assessment, and a greater focus of treatment at the level of functional communication also requires greater insight into learning mechanisms as they occur at this level of functioning. A better understanding of the type of learning mechanisms that PWA can rely on during functional communication can help clinicians tailor clinical interventions to the abilities of individual PWA. This might also reveal whether these can be targeted directly as part of aphasia rehabilitation.

The findings in chapter 4 indicate that as a group, PWA dyads showed learning on the communicative task as a result of repeated practice, without active intervention from the experimenter. Crucially, not all PWA dyads showed effects of learning across trials. More research is therefore needed to gain insight into the factors that determine whether learning will occur on a communicative task. Of particular interest is the question whether learning as measured on an experimental task such as the current one relates to more standardised measures of generalised learning (Kendrick, 2019; Vallila-Rohter & Kiran, 2013), and whether it can be used to better understand adaptiveness in functional communication, or generalisation of treatment effects. Because aphasia severity did not show a clear relationship with learning on the task, more research should be conducted to explore whether other cognitive factors such as executive functioning predict learning (Keil & Kaszniak, 2002; Lesniak et al., 2008; Purdy & Koch, 2006).

Empirically and clinically, these findings emphasize the importance of considering learning mechanisms in the context of treatment, generalisation of treatment effects to functional communication and predictions of recovery in aphasia rehabilitation.

Conclusion

This thesis set out to investigate the theoretical foundations of functional communication for aphasia rehabilitation, and the application of these foundations in clinical assessment and experimental investigations of functional communication. By doing so, the studies presented in this thesis have addressed a number of critical issues that have fragmented the field of functional communication in post-stroke aphasia, such as the lack of conceptualisation of functional communication, the heterogeneity of the measurement of communication and the limited generalisability of experimental and clinical findings. This thesis has provided greater insight into the cognitive-behavioural profile of functional communication in post-stroke aphasia, which has led to a number of important implications for the clinical setting and future research. The findings emphasize the complex and multi-factorial nature of functional communication, and the challenge that aphasiology is faced with in investigating this concept. The hope is that the current thesis helps the field move a small step closer to understanding functional communication and targeting this behaviour in clinical interventions.

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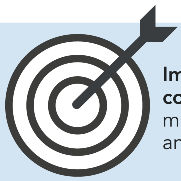
Aphasia-friendly summary

EVERYDAY COMMUNICATION IN POST STROKE APHASIA



Improving real-world communication is the main **goal** of speech and language **therapy**

There is no clear definition of real-world communication. As a result:

- There is **no agreement** on **how to measure** real-world communication
- **Different definitions** of communication are **used in research**
- There is **limited understanding** of **how aphasia affects** communication

Q1 HOW CAN WE DEFINE REAL-WORLD COMMUNICATION?

Traditional **language experiments** are **not** interactive or multimodal and do not take account of context.

Q2 HOW CAN WE MEASURE REAL-WORLD COMMUNICATION IN CLINIC?

We found 19 existing tests of real-world communication

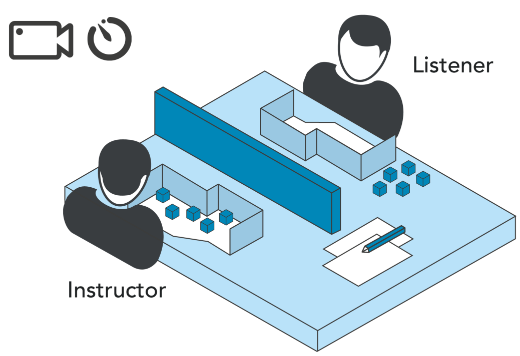
For each test, we checked the definition of communication

Only one test was interactive, multimodal and took account of context

Q3 HOW CAN WE INVESTIGATE REAL-WORLD COMMUNICATION IN THE LAB?

THE GAME:

- Two people **solve a task** by communicating **together**
- The **listener** has to **position five items** in a Playmobil room
- The **instructor explains** where the five items should go
- The pair can **communicate freely** (speech, gesture, drawing, writing)



WHAT IS BEING MEASURED?

Accuracy: how similar are the two set ups?

Time: how much time is needed for the task?

Collaboration: how does the pair communicate together?

Multimodal communication: how do people communicate?

A EXPERIMENT A "APHASIA VS CONTROLS"

How do people with aphasia compare to the control group?

Both groups asked their partner for clarification

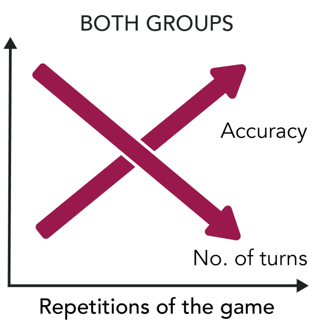
Both groups gave their partner feedback

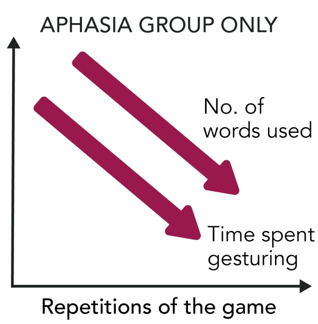
FINDINGS

- People with aphasia were **less accurate** and used **different modalities** to communicate compared to the controls

B EXPERIMENT B "PRACTISE, PRACTISE, PRACTISE"

Does practise make perfect?



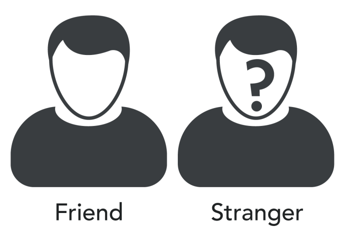


FINDINGS

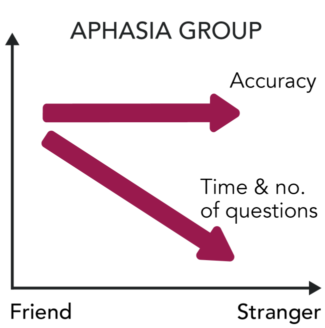
- People with aphasia **get better** at the game **with practice**
- People with aphasia get **more efficient** (less effort) on the game **with practice**

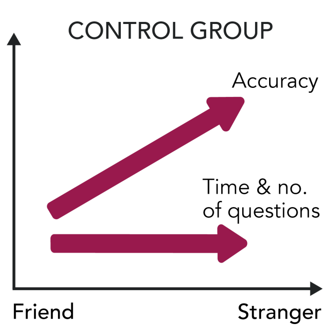
C EXPERIMENT C "FRIEND VS STRANGER"

Do friends and strangers affect communication differently?



When the game was completed with a stranger...





FINDINGS

- People with aphasia **communicate differently with a stranger** compared to the control group
- We **do not know why** this happens

Acknowledgements

C: This is it, Joel. It's going to be gone soon. J: I know. C: What do we do? J: Enjoy it.
— Eternal Sushine of the Spotless Mind

I have thoroughly enjoyed the past three years. For this, I have quite a few people to thank.

Lotte, I have left every single meeting we've had over the past three years feeling (even more) excited about this work than when I entered. Your enthusiasm, your support and guidance, your ability to put the work and academic life in perspective, and your complete trust in my abilities have enabled me to enjoy these past three years far more than I had dared to hope. I could not have wished for a better supervisor.

Arpita, thank you for your support as second supervisor. Your enthusiasm and eye for detail has been incredibly helpful throughout this process. Your insightful guidance into the world of academia has helped prepare me for life beyond the PhD.

To all the participants: Data collection can be a stressful time. Your involvement, your jokes, your insights and your questions about the project have made this period a particularly special time for me. Thank you for welcoming me into your homes and for offering me endless cups of tea and biscuits. Thank you for sharing your stories with me and thank you for your incredible hard work on this project.

Thanks to the School of Psychology and Clinical Language Sciences for offering me a studentship, which enabled me to conduct this research. Thanks to Lucy Letzer for her brilliant work on the infographic. Thanks to Lydia Lambert for all the hours of data coding.

To the ladies who I was lucky enough to be placed in office 215 with. Back in October 2017, we embarked on this PhD journey together and we've since survived quite a number of ups and downs together. I'm going to miss having you ladies around. A special shout-out to Emma and Michal, who did not live in office 215, but who helped make Reading feel like home. Thanks also to my lovely flatmate Jo, who didn't think she'd end up in this thesis.

I've been very lucky to meet many aphasia researchers over the past three years. Thanks to all of you, who welcomed me into this wonderful research community. Your work inspires me and your questions have kept me on my toes. I cannot wait to continue the work. A special thank you also goes out to my fellow British Aphasiology Society committee members, I've thoroughly enjoyed working alongside you all over the past years.

To those who inspired this work long before the opportunity at Reading came along: I am forever indebted to my colleagues and the clients at the Aphasia Centre in Utrecht, Amersfoort and Veenendaal. My interest in functional communication will always be linked to our work there. Your dedication, enthusiasm, creativity and brilliant teamwork still inspire me to this day. Elise de Bree, thank you for the many cups of coffee, cakes and chats. I wouldn't have considered myself capable of achieving this if it hadn't been for you.

To my wonderful friends and family in the Netherlands and those scattered across the globe: despite the physical distance your letters, surprise packages, postcards, messages, phone-/video calls and visits have made it feel like you were never far away. Life happened and we continued to share it.

Completing a thesis during a COVID-19 lockdown is not an easy feat. A special thank-you therefore goes out to the wonderful Babette, Nadine and Marjolein. Our daily quarantine-tea chats over dubious internet connections in Ireland, England and the Netherlands kept me sane during the final six months of thesis-writing. I hope we'll still be oversharing when we're grey and old.

Finally, thanks to my parents for always supporting me, no matter where my next plan takes me.

[1]

To all **the participants**:

Data collection can be a **stressful time**.

Your **involvement**,
your **jokes**,
your **insights**,
and **your questions** about the project
have made this period **a particularly special time** for me.

Thank you for **welcoming me** into **your homes**.

Thank you for the endless cups of **tea** and **biscuits**.

Thank you for **sharing your stories** with me.

Thank you for **your** incredibly **hard work** on this project.

[1]Created by Gan Khoon Lay from the Noun Project

Situated language use in post-stroke aphasia: a systematic exploration of functional communication.

PhD thesis. School for Psychology and Clinical Language Sciences, University of Reading, Reading, England.

Author: Willemijn Doedens

Layout: Anne Urai, https://anneurai.net/

Infographic: Lucy Letzer

The studies presented in this thesis were funded by Magdalen Vernon Studentship from the School for Psychology and Clinical Language Sciences, University of Reading.