Aphasia therapy software: research, development, and implementation
Cuperus, Pauline

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CHAPTER 6

GENERAL DISCUSSION

This thesis described research on the topic of digital aphasia therapy, focusing on describing literature on this topic and conducting a survey among researchers/developers and one among speech and language therapists. It also introduced a new therapy app that was subsequently piloted.

6.1 RESEARCH AIMS

The aims of the research presented in this dissertation were to:
1. Create an overview of aphasia therapy software described in the research literature and determine their current clinical availability.
2. Investigate the experiences of researchers and developers with regards to the development of aphasia therapy software, and gather advice from researchers/developers for those who are looking to develop such software.
3. Investigate the experiences and preferences of speech and language therapists with regards to using aphasia therapy apps.
4. Create a new aphasia therapy app that focuses on treating verb and sentence processing, following experiences and preferences of stakeholders.
5. Conduct a pilot treatment study to test the efficacy and usability of the newly developed therapy app.

I will now address each of these aims separately in relation to our findings and will also discuss suggestions for further research.
6.2 OVERVIEW OF APHASIA THERAPY SOFTWARE AND ITS CLINICAL AVAILABILITY

In Chapter 2, I presented a systematic literature search that aimed to create an overview of the aphasia therapy software that was described in the literature. We briefly summarised the resulting 126 publications, which encompassed a total of 63 software programmes. Through reading the available literature, online searches, and contacting authors, we were able to establish that 35% of these pieces of software were currently clinically available. The overwhelming majority of available software (95%) used an Indo-European language, an issue that prevails in aphasia research more generally (Beveridge & Bak, 2011). The language properties most frequently targeted by software were a range of language skills \( n = 10 \) and word retrieval \( n = 4 \) for available software and word retrieval \( n = 12 \) and a range of language skills \( n = 6 \) for non-available software.

Considering the large amounts of time, money, and effort that are invested in developing and researching software by researchers, clinicians, and people with aphasia alike, for only 35% to be clinically available is relatively low. This is true even if the actual percentage of software that is clinically available is potentially higher than that reported here, as, especially in the case of older software and non-English software, it was difficult to establish clinical availability. While we fully acknowledge that software commercialisation can be difficult and demanding, we do want to argue that making software available to the aphasia community should be a priority for those involved in development of aphasia software, especially given the previously reported shortage of evidence-based aphasia therapy software available on the market (Vaezipour et al., 2020).

6.3 SOFTWARE DEVELOPMENT: EXPERIENCES AND ADVICE FROM RESEARCHERS AND DEVELOPERS

Aiming to better understand their experiences and in order to gather advice for others (Research Aim 2), we reached out to 46 researchers/developers associated with the software that was found in our systematic literature search (Chapter 2). Participants answered questions related to 1) participant demographics (6 questions); 2) the software development process (6 questions); and 3) what had happened to the software since the initial publication as well as reflecting on the development process (6-10 questions depending on the availability of the software). We received responses from 35 people (response rate = 76.1%), which were analysed through descriptive statistics and thematic analysis (Braun & Clarke, 2006; Clarke & Braun, 2017).

Respondents’ motivations, goals, and experiences ranged widely, resulting in an extensive list of enablers and hurdles that were experienced during the software development process, as well as advice for those that are looking to develop aphasia therapy
software. While every participant’s experience was unique, we were able to identify some recurring themes from the data. The recurring themes that participants reported were: 1) software development can be expensive and insufficient funds are an important contributor to software not becoming clinically available; 2) commercialisation of software is often new and daunting to researchers but essential for making software available to a wider clinical audience; 3) clinicians and people with aphasia are a valuable source of feedback during the software development process; 4) working with software developers can be difficult and requires researchers and developers to come together; and 5) aphasia therapy software should combine both the evidence base and current clinical need, while being mindful of existing software.

Based on our participants’ responses, we can conclude that the development and subsequent dissemination of aphasia therapy software requires large amounts of time, energy, and funds. Still, these resources are worth spending on software development and commercialisation considering the frequently reported efficacy of many pieces of software (see e.g. Lavoie et al., 2017; Repetto et al., 2020; Zheng et al., 2016) for reviews), combined with the lack of evidence for the efficacy of many of those pieces of software that are available (Vaezipour et al., 2020). While our research has provided useful advice regarding software development, we believe that for future research it would be valuable to further examine ways that software commercialisation can be achieved, an aspect that we feel was not sufficiently addressed in our study. Many of our respondents indicated that commercialisation was a major part of their projects and one that came with many (unexpected) hurdles, yet it is an essential process in order to achieve clinical availability. I feel that for future research, a focus group setting, with more room for follow-up questions (similar to Swales et al., 2016) would be a more suitable way to fully understand each step in the process from initial idea to commercial release, rather than keeping to a fixed set of questions as we did in our approach. Describing these experiences in more detail would be beneficial for researchers who are looking to develop software and release it to a wider clinical audience.

Given that the translation from research to clinical practice of these pieces of software is so frequently reported as being a complex process by our respondents, it seems that there is a need for a bridge between the two: A potential expertise/resource centre that gathers and shares experiences and advice may be a larger-scale solution for the aphasia research and clinical communities. Such a centre could potentially also aid in facilitating introductions and communication between clinicians, developers, and researchers, from the conceptualisation stage until commercialisation. It is clear from our respondents’ feedback that the aphasia community has gathered much experience in this field and that there is much to learn from each other. Furthermore, our results highlight the generosity and collaborative spirit of the aphasia research community.
6.4 UNDERSTANDING USER NEEDS FOR APHASIA THERAPY SOFTWARE: EXPERIENCES AND PREFERENCES OF SPEECH AND LANGUAGE THERAPISTS

As discussed in Chapter 3, it is important to understand user needs when designing aphasia therapy software (see Bannon, 1986; Swales et al., 2016), especially since clinician acceptance has been reported to be a critical factor for software reaching clinical practice (Wade et al., 2014). While previous research has addressed this aim for aphasia software more generally (see Swales et al., 2016), this research was done some time ago (with focus groups conducted in 2013 and 2015), with rapid advancements in technological innovation having occurred since. In Chapter 3, we therefore explored the results of a survey that we conducted with speech and language therapists (SLTs) in Australia (n = 29) and the Netherlands (n = 35). The goal of this survey was to describe SLTs’ experiences and preferences with regards to aphasia therapy apps. Additionally, we investigated the potential influence of some demographic characteristics of our participants (age, country, therapist availability in the client’s hometown) on their attitudes towards aphasia therapy apps. The survey contained a total of 9 closed-ended and 3 open-ended questions, which were subsequently summarised and analysed, using thematic analysis for the open questions (Braun & Clarke, 2006; Clarke & Braun, 2017).

Participants were overwhelmingly positive about their experiences with aphasia therapy apps. A large proportion of respondents already used such apps and those who did not were generally open to using aphasia therapy apps in the future. This led us to believe that there was still room for growth in terms of app use among speech and language therapists. Participants also indicated that their clients were generally capable of using aphasia therapy apps independently. This is particularly relevant as increased therapy exposure could help meet the treatment recommendations by Brady et al. (2016) and in the light of increasingly reported waiting list for accessing speech and language therapy in countries such as Australia and The Netherlands (Commonwealth of Australia, 2014; Nederlandse Vereniging voor Logopedie en Foniatrie, 2019; Ruggero et al., 2012).

We did not find any consistently or strongly negative attitudes in any demographic group. Although more research is needed to confirm this given our relatively small sample size, these results may mean that SLTs are generally positive about aphasia therapy apps, which is important to ensure that therapy software reaches people with aphasia (see Wade et al., 2014).

Still, our participants identified several barriers to the use of aphasia therapy apps, as well as solutions to these barriers. While some of these barriers would be relatively easy for app developers to implement (e.g. customisable treatment content, tracking user’s performance), other are more difficult to tackle (e.g. how to make an app easy to use varies with user severity and impairment and is therefore potentially difficult to interpret for those unfamiliar with aphasia). Other issues would require a more systematic solution (e.g.
keeping apps financially accessible for people with aphasia and speech and language therapists). We argue in favour of an interdisciplinary approach: We need clinicians, people with aphasia, researchers, app developers, and funding bodies to work together in order to provide therapists, as well as their clients, with the best possible aphasia therapy software.

**6.5 DESCRIPTION OF THE ACTION! APP**

Chapter 4 described the development process and therapy content of the newly developed Action! app, which focuses on the treatment of verb/sentence processing. Verbs/sentences are relatively understudied in the context of aphasia therapy software, which is problematic since many people with aphasia particularly struggle with verbs (see e.g. Bastiaanse & Jonkers, 1998). There are, however, some promising results from the few studies that do address this topic (e.g. Furnas & Edmonds, 2014; Thompson et al., 2010). These pieces of software are, however, not currently commercially available (although software with a focus similar to Furnas & Edmonds is currently available, see Tactus Therapy Solutions Ltd., n.d.) and focus only on a subset of specific aspects of verb/sentence processing. We therefore identified a need for evidence-based therapy software, grounded in linguistic theory, that focused on all aspects of verb/sentence processing at varying levels of difficulty.

In this chapter, we described the design and development of a therapy app targeting verb and sentence processing that could be used independently by people with aphasia. The software design and development was guided by three principles: 1) To create a piece of software that was evidence based, using as a starting point four existing therapy programmes (ACTIE!, see e.g. Bastiaanse et al., 1997, 2016; de Aguiar et al., 2015), Mapping Therapy (see e.g. Byng, 1988; Mitchum et al., 2000; Schwartz et al., 1994), Verb Network Strengthening Treatment (VneST; see e.g. Furnas & Edmonds, 2014), and Treatment of Underlying Forms (TUF; see e.g. Thompson et al., 2010; Thompson & Shapiro, 2005); 2) To make Action! as functionally relevant and customisable as possible through incorporation of nine different treatment steps of varying difficulty, and customisable treatment items (as recommended by Van de Sandt-Koenderman (2011)); and 3) To prioritise user-friendliness by studying existing literature (e.g. Swales et al., 2016) and conducting a survey among one of our main user groups (see Chapter 3; Cuperus et al., 2022).

While Action! is currently in a relatively early stage of development, we believe we have accomplished some of these objectives. Nevertheless, a limitation that we must address here is that we were unable to implement all of the recommendations suggested by our respondents in Chapters 2 and 3 as we developed the Action! app. Most notably, we were unable to use a process of co-design involving people with aphasia. This was regrettable, considering the important role of user feedback that we have argued in favour of (in Chapters 2 and 3). Unfortunately, the start of our app development process coincided with the start of the COVID-19 pandemic. At the time, we saw no way to involve people with
aphasia in the design/development process. Retrospectively, there were ways to circumvent this issue (for example through videoconferencing, which has been successfully used with and by people with aphasia, albeit with occasional challenges; see e.g. Dekhtyar et al., 2020; Neate et al., 2022). Nevertheless, the app was considered user-friendly by two participants with aphasia (see Chapter 5). Still, we hope that future researchers/developers will follow our recommendations in terms of collaborative software design, rather than our example. Due to this limitation, more research is needed to further evaluate the app’s usability as well as to establish its efficacy, with some initial results presented in Chapter 5.

At the same time, Action! may already serve a clinical purpose in its current form, particularly as an addition to regular speech and language therapy. Homework exercises are an important feature of speech and language therapy, and Action! provides some features that are not available through traditional pen-and-paper exercises (e.g. using cues, SLT supervision of app use, recordings of users’ attempts). Even if all Action! steps have not currently been thoroughly tested, the fact that the app is based on existing therapy programmes means that it may already be useful in a clinical context. Of course, this would require Action! to be clinically available on a larger scale. In order to achieve this goal of clinical availability, we would have to address some of the issues mentioned by our participants in Chapter 2. Most notably, we would have to involve external experts to aid with issues like data protection and setting up a payment platform (which has previously been done successfully within the Groningen Center of Expertise for Language and Communication Disorders; see Bastiaanse et al., 2016; Bastiaanse et al., 2020) but requires substantial time, effort, and resources. Still, this may be worth it considering that there is currently no available aphasia therapy software that targets verb/sentence processing as extensively as Action!.

### 6.6 THE EFFICACY AND USABILITY OF ACTION!: A PILOT STUDY OF AN APHASIA THERAPY APP FOCUSING ON VERBS AND SENTENCES

Chapter 5 reports a pilot treatment study in which two people with aphasia used the Action! app for a two-week period. Our goal was to start to determine the app’s efficacy with regards to treatment of verb and sentence processing, as well as to report on its usability.

In terms of efficacy, the results of participant JOG (who had severe verb and sentence processing impairments and was treated on habitual present tense verbs) showed that Action! has the potential to induce immediate treatment-specific improvements after a relatively short bout of therapy. However, JOG’s improvements were not maintained at four weeks post-treatment, which may be the result of insufficient treatment dose and/or duration. This is in contrast with research by, for example, Links et al. (2010), which did find longer-term maintenance effects of treatment (possibly due to a higher dose and/or duration than in our study). Future research is necessary to better understand
the optimal treatment dose and duration of Action! treatment, although ideal dose and duration parameters are famously user-specific (with exact guidelines unlikely; see Best & Nickels, 2000) and in practice these factors will depend on clinician judgement and expertise. Contrary to JOG, participant DTR (who had relatively mild verb and sentence processing impairments and was treated on past/future tense) did not show significant improvements as a result of the treatment. Her marked pre-treatment improvement during the baseline made it difficult to demonstrate a greater rate of change during the treatment phase, even if her overall accuracy and lexical retrieval scores did increase over the course of the treatment. While we were aware of this issue when DTR commenced the treatment, it was decided to continue the treatment in order to collect her feedback on the app’s usability. JOG and DTR’s results highlight the importance of including participants with verb/sentence processing difficulties of varying types and degrees of severity in future research involving Action!, in order to further explore its efficacy across users with a range of impairments. Furthermore, it is also crucial to conduct studies focusing on each of the Action! treatment steps. Finally, future studies should look at whether Action! treatment leads to any improvements in functional communication, which may be facilitated by the fact that the Action! verbs were chosen based on their (high) frequency.

Both participants were positive about Action!’s usability. Post-treatment interviews indicated that while both participants experienced minor issues with the app (difficulty logging in and occasional app crashes), their overall experience was good, with both participants recommending the app to other people with aphasia. The data collected by the app showed that both participants used the app regularly and were able to access its functionality effectively (e.g. by using cues as appropriate). These results are particularly relevant considering the fact that our participants showed marked differences in their degree of impairment, suggesting that Action! could be suitable for independent use by people with a range of aphasia profiles. Importantly, however, both participants showed relatively unimpaired comprehension abilities, which may well be a requirement for successful independent use of Action! and would need to be explored in future research. The app’s accessibility was further highlighted by the fact that both participants had limited use of one hand, which is a frequently occurring issue for people with aphasia.

Future research could help us to further improve the app’s usability. Importantly, we have currently only piloted the app in one of our user groups (people with aphasia), but have not yet trialled it in the other main user group – speech and language therapists. Although we have attempted to keep their needs and preferences into account while developing the app (see e.g. the survey in Chapter 3), more research is needed to tailor the app more specifically to the needs of this user group. Ideally, such research would involve SLTs using the app with some of their clients for a period of time before reporting on their experiences (for example through focus groups (as in e.g. Swales et al., 2016). Similarly, it would be beneficial to collect user feedback from a larger and more varied group of people with aphasia (in terms of for example age and technical and linguistic abilities), in order
to make the app as user-friendly as possible. This is particularly important since we were unable to implement a co-design process involving people with aphasia in the app development stage.

To summarise, while the sample size of this pilot study was only small, it was sufficient for us to comment on the implications of these results for the future development of Action! and on its suitability for independent use by people with aphasia. Our results were in line with previous research, which found potential treatment effects as a result of interventions with aphasia therapy software and found this type of software to be well accepted by people with aphasia (see e.g. Adrián et al., 2011; Des Roches et al., 2015; Nef et al., 2018; Palmer et al., 2013; Ruiter et al., 2016; Weill-Chounlamountry et al., 2013).

6.7 CONCLUSION

This dissertation focused on the development and use of aphasia therapy software, which is a well-established, yet innovative, research field that is constantly changing. Considering the long-standing tradition of incorporating new technologies in the field of clinical aphasiology, combined with the fact that technological advances continue to be made, it seems reasonable to assume that the upwards trend of digital aphasia therapy use will continue for the foreseeable future. While the specific software and hardware that is used may continue to change, the underlying goals of aphasia therapy – whether digital or not – remain fundamentally consistent: “to optimize the communication between the person with aphasia and his or her environment” (Van de Sandt-Koenderman, 2011, p. 22). Therefore, regardless of the future changes and developments in technology, understanding how to best meet user needs when designing aphasia therapy software and how to smooth the software development process and subsequent commercialisation will remain essential for future clinical and research work in the field of digital aphasia therapy. I hope that this dissertation will contribute to these aims and will inspire others to continue on the same path.