

## Game Technologies to Assist Learning of Communication Skills in Dialogic Settings for Persons with Aphasia

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**Abstract**—Persons with aphasia suffer from a loss of communication ability as a consequence of a brain injury. A small strand of research indicates effectiveness of dialogic interventions for communication development for persons with aphasia, but a vast amount of research studies shows its effectiveness for other target groups. In this paper, we describe the main parts of the hitherto technological development of an application named Dialogica that is (i) aimed at facilitating increased communicative participation in dialogic settings for persons with aphasia and other communication disorders, (ii) based on computer game technology as well as on theory in dialogic education and argumentation theory, and (iii) designed for mobile devices with larger screens.

**Keywords**—Aphasia, communication development, computer games, philosophical dialogues, unity

### 1 Introduction

Acquired brain injuries (ABIs) are brain injuries obtained after birth, caused by, for instance, car accidents, strokes, or infections. It is a global problem [1] – millions of people around the world every year acquire a brain injury [2]. All age groups are subjected to it [1], where, for instance, ABIs are the leading cause of disability among young adults [3]. The consequences for the individuals are diverse and different for different individuals, but common reported effects are in the communicative, cognitive, social, emotional, and vocational domains [4, 2, 5, 6, 7, 8]. Aphasia, a communication disorder involving often grave difficulties with expressing thoughts to others, is one of the negative effects in the communicative domain. It is often the case that a person with aphasia has led a life full of communication and active, verbal, and social participation, just as people not subjected to it. This contrasts severely to the very limited social exchange that many persons with aphasia experience after a sudden ABI. The communication may then become limited to responding questions concerning basic daily routines and questions, such as “Was the food good?” or “Isn’t it really fine weather?”, which may be important but do not leave room for engaging in more personally meaningful or advanced topics. Overall, the impact of aphasia on the potential for communicative participation is oftentimes severe.

The effects of dialogic education on communication development have been well elaborated theoretically (see e.g. [9, 10, 11, 12]) and studied empirically (see e.g. [13]). Among research based dialogic frameworks, the Philosophy for Children (“P4C”) program [14] stands out as one of the frameworks where implementation has shown positive effects in several of the domains described as negatively affected by ABIs. For instance, positive impact on students’ communicative, cognitive, social, and emotional development have been reported [10, 15, 16, 17, 18, 19, 20]. The program has evolved and been adapted to different cultural contexts as well as to different age groups, and this broader scope is reflected in the expression “philosophical dialogues”. Prior research in the area of philosophical dialogues for persons with ABI and aphasia is yet very rare, but indicates that philosophical dialogues have a substantive positive impact [21]. Groups of persons with more severe ABIs and aphasia saw smaller positive changes, with a larger need for facilitator support [21]. The researchers tested using iPads and whiteboards, and hypothesized that a mobile application specifically aimed at providing support based on argumentation theory could be of great value for persons with aphasia in communicating in dialogic settings, and specified main functionalities from an educational and argumentation theoretic standpoint, and initially tested a crude prototype of some of the main functionalities [22].

At this background, we considered the possibility to develop and provide a technological tool assisting persons with aphasia during dialogues about deeper and personally relevant topics, in order to increase active communicative participation in the target group. In this paper, we describe main parts of the technological development so far, including some main elements of the application Dialogica – an application that is

- i. Aimed at facilitating increased communicative participation for persons with aphasia and other communication disorders
- ii. Based on computer game technology as well as on theory in dialogic education and argumentation theory, and (iii) designed for mobile devices with larger screens.

## **2 Background**

### **2.1 Philosophical dialogues in education**

Dialogic education is characterized by authentic questions and that the participants engage actively, influence the flow of the discussion, and build upon each other’s contributions through, asking for clarifications, supporting positions, or providing criticism [23, 24], etc. This contrasts to the IRE (i.e., initiation, response, and evaluation) pattern of traditional monologic teaching characterized by a more authoritarian structure where the teacher asks closed test questions, with short replies by the students, and where the students have very limited influence over content and form of the verbal exchange [25]. Precisely pinning down what it means for a dialogue to qualify as “philosophical” is a difficult philosophical task in itself, but we will here take it to mean at least that the participants should inquire together upon philosophical

content using philosophical procedure. What these expressions mean, too, is a philosophical question, but we will take philosophical content to be, for instance, ethical (e.g., “Is right/wrong?”) or ontological (e.g., “Do exist?”), and philosophical methods to include argumentation and rational deliberation. The questions inquired upon are often described as “contestable” [12, p. 51], which shortly could be described as open questions with argumentation potential. The dialogues, which are characterized by an emotionally supportive climate [26, 18], are led by a facilitator that probes for increased participation, listening skills development, and high-quality argumentation through so-called “talk moves”. Such talk moves include ‘If someone disagreed with you, what would [s/he] say to argue against you?’, ‘How are you using the word?’ and ‘How does this relate to what [s/he] said?’ [23, pp. 186–188].

The reflection and argumentation centred form of the dialogues resembles commonly used procedures in analytic philosophy (see, for instance [27], which provide tools for improvement and awareness of thinking processes. The dialogues do not only involve thinking about the subject matter, but also thinking about the procedures by which we think about the subject matter [28], something that underscores the metacognitive nature of the dialogues.

It is furthermore an inquiry-based educational method, in which philosophical questions are collaboratively inquired upon by the participants. A core idea is to convert the classroom into a “community of inquiry” in which students “listen to one another with respect, build on one another’s ideas, challenge one another to supply reasons for otherwise unsupported opinions, assist each other in drawing inferences from what has been said, and seek to identify one another’s assumptions” [28, p. 20].

While the form of a philosophical dialogue may vary between sessions and context, Trickey and Topping [18, p. 369] provide a summary of a ‘routine classroom philosophical enquiry’ in the following nine steps:

- “Getting started—begin with a relaxation exercise, agree rules of interaction
- Sharing a stimulus to prompt enquiry
- Pause for thought
- Questioning—the pupils think of interesting or puzzling questions
- Connections—making links between the questions
- Choosing a question to begin an enquiry
- Building on each other’s ideas—during which the teacher has to strike a balance between encouraging the children to follow on from each other’s ideas and allowing related lines of enquiry to open up
- Recording the discussion—e.g., by graphic mapping
- Review and closure—summarizing, reflecting on the process itself, whether minds were changed, etc.”

The educational method of P4C is considered to be ‘substantiated by a record of published, peer-reviewed research’ [10, p. 760] where its “quality and quantity of evidence bears favourable comparison with that on many other methods in education” [18, p. 374]. Meta-analyses critically review research on the effectiveness of the method and support effectiveness with regard to students’ development in several areas relevant for increased and improved communicative participation, such as great-

er amount and improved quality of student talk, reasoning, and argumentation [15, 10, 18, 20]. Considering the reported effects of dialogic education in general (see e.g. [13]), and the reported positive learning outcomes for students of, for instance, implemented metacognitive strategies [29, 30], the reported positive effects are not very surprising, but map in several respects well to certain needs of persons with ABIs and aphasia.

## **2.2 ABI, aphasia and communication development**

ABIs have recently been considered the leading cause of disability among young adults [3]. ABIs are usually divided into traumatic brain injuries (TBIs), caused by external forces (such as traffic accidents or falls), and non-traumatic ones, caused by internal forces (such as strokes or infections). TBIs have been estimated to be the third largest cause of the global disease burden [2] and cause disabilities for all age groups in all countries [1]. Worldwide, more than 10 million people annually acquire a TBI [2]. Add non-traumatic injuries, and the numbers would be significantly higher. There were, for instance, “13.7 million ... new stroke cases in 2016” [31, p. 439].

According to Brady et al. [32], about a third of the persons that suffer a stroke develop aphasia, which is often defined as “a loss or impairment of verbal communication, which occurs as a consequence of brain dysfunction” (e.g. [33, p. 79]) or, in more detail, as “[t]he loss (complete or partial) of verbal language as a result of some brain condition with preservation of the primary inputs (like auditory, visual or somatosensory projections) and outputs (like motor projections)” [34, p. 4]. More broadly, Brady et al. [32, p. 1] define it as “an acquired language impairment following brain damage that affects some or all language modalities: expression and understanding of speech, reading, and writing.” According to Lanyon, Rose, and Worrall [35], the often-permanent onset of aphasia brings about long-term communicative changes and has grave influence over engagement in activities and maintenance of relationships. They argue that it is important to support “adaptation to changed communication circumstances” and to provide “pathways to re-establishing access to the community” [35, p. 359]. This supports that research about the development and re-gaining of communication abilities and dispositions for persons with aphasia is an important undertaking.

Lanyon, Rose, and Worrall [35] conducted a meta study examining the evidence for “community and outpatient aphasia groups”, meaning groups of “two or more people meeting outside the inpatient hospital setting and involving people with aphasia as a consequence of acquired or traumatic brain injury” (pp. 360–361). Plenty of the found studies were conducted about the effects of specific and highly structured language training methods for persons with aphasia, where a speech-language pathologist manipulated a given set of stimuli (for instance, a set of nouns for naming), but the amount of studies examining interventions that were aimed at improving communication, where the participants rather were engaged with overall communication and participation as well as interaction between participants, were considerably fewer [35]. There is, however, a strand of research focusing on the effects of socially oriented and community-based conversation groups (hereafter “conversation groups”)

for persons with aphasia – environments that share some characteristics with philosophical dialogues – and the results are promising. According to researchers in the field [36, 37], the value for persons with aphasia of participating in conversation groups is widely recognized. Previous studies support positive impact on communication skills for persons with aphasia that participate in conversation groups [36, 37].

Conversation groups tend to resemble authentic communication in everyday social life [37]. However, according to Lanyon, Worrall, and Rose [36, p. 526], “[m]ulti-person interactions are inherently complex for people with aphasia” and unsuccessful conversation groups can produce negative experiences, such as disconnectedness, stress, frustration, and perceived marginalization [36]. According to Lanyon, Worrall, and Rose [36], persons with aphasia strive to become active contributors but wish for varying levels of support in order to express thoughts and opinions, participate meaningfully, and demonstrate competence. Lee and Azios [37] studied the impact of different facilitator behaviours on the active participation of persons with aphasia. They found that facilitator behaviours with positive influence were continuous feedback and acknowledgement of the contributions of the participants, explicating conversation rules, standards or guidelines, promoting interactional symmetry, directing attention towards joint efforts to find lost words, using humour for different purposes, and communicating multi-modally through both verbal and visual expressions (for instance, spoken words, written keywords, gestures and pictures). Behaviours found to have negative impact included asking plenty of recycled questions (that is, approximately, repeated questions without connection to previous participants’ contributions), a lot of closed questions with predetermined answer alternatives, test questions (following the IRE pattern) that signal power asymmetry, and exposing errors of the participants [37]. In line with several of these results, Lanyon, Worrall, and Rose [36] found that persons with aphasia themselves underlined the importance of promoting non-hierarchical interactions and equal opportunities for participation in conversation groups, where the “democratic feel” (p. 528) of the conversation is present and the responsibilities for the group process are distributed among the participants. The authors also emphasize the importance of whole-group usage of multimodal resources in order to normalize non-verbal communication [36].

### **2.3 Philosophical dialogues for persons with aphasia**

While, as shown above, philosophical dialogues as a pedagogical method for advancing students’ learning has been developed and studied for decades, and has been found to have multiple prominent benefits (compared to “traditional pedagogy” as well as several other interventions), very little work has been done with philosophical dialogues for persons with ABIs, and even less for persons with aphasia.

During 2015, a small research intervention based on philosophical dialogues in Sweden was conducted with persons with ABIs, including persons with aphasia [21]. The aim of the exploratory study was to examine the effects of philosophical dialogues on abilities and skills relevant for active societal participation, such as communication skills. The results were very positive, especially for the group of participants with less severe ABIs, with large learning outcomes in the communicative and

cognitive domains. For the group of participants with more severe ABIs, which included persons with aphasia, the positive results were still large, but a comparatively high degree of responsibility rested on the facilitator for encouraging active participation of the participants with aphasia. They were, for example, asked relatively many probing questions with the purposes of eliciting their views and making possible that their contributions influenced the discussion to a sufficient extent. One of the conclusions of the research project concerned the importance of developing a specified technological tool assisting communication for persons with aphasia.

### **3 The Design of Dialogica**

This section presents game engines and the Dialogica application.

#### **3.1 Application development using game development engines**

Engines for game development (“game engines”), include both a development and a runtime part. The latter is being used when the final game is actually used while the former is used when designing, implementing and testing the game. Using these game development engines, the developers can combine graphics, sound, animations, lighting, etc. to realize their creative vision, and provide a multiuser system that contributes to game interactivity [38].

There are several different tools publicly available for game development, each with its own benefits and drawbacks. The various tools differ in, for instance, what operating systems they can be used on, whether they are for 2D- and/or 3D-development, the size of their developer base, availability of help material, their supported programming language, whether they are free or at a cost, etc. The development tools also differ in how the games look and feel at runtime. There are also several proprietary game development tools primarily used by larger game companies for their own games.

Two of the most common game development engines are Unity [39] and Unreal [40]. These game engines differ in various ways where Unity is usually seen as easier to get started with and has more available help material online. Programming in Unity is done using C# and in Unreal either by graphical programming via Blueprint or C++.

For the development of Dialogica, Unity was chosen due to earlier experience and available graphical material.

#### **3.2 Dialogica and its overall usage**

Dialogica is an application designed for mobile devices with larger screens (iPads and larger phones). It is intended to provide opportunities for the target group to participate actively in conversations about contestable questions and assist the participants in expressing themselves in different virtual environments through personal

avatars, animations and chats. The main usage of the application is when the users are in the same physical room.

The application can be compared to the startup-part of many multiuser games where the users select avatars to represent them, choose from various environments to play in, and decide whom to play with; friends or others assigned by game matching. Each user selects a personal representation through an avatar.

The Dialogica application builds on this idea but without actually going into a game. The selected avatar can be used to express thoughts via both predefined chat messages and physical expressions through animations.

The setting of the application is to help with discussion in a dialogue; in a group conversation or between two people, in a more organized setting (e.g., a medical facility, an activity centre or educational setting) or more informal one (e.g. at home). In each situation, the Dialogica application is intended to support the communication.

As the application is not a real game, but rather a helper application, it is important that the users can get started quickly. Just by starting the Dialogica application they can be in the same virtual room within a few seconds and there see each other.

### **3.3 The overall look and feel of the application**

The application builds on the design principle that it should be fun to use but at the same time not too childish. The graphical style of the application is a so called “low-polygon” style meaning that graphical 3D-elements in the application are somewhere between realistic and cartoonish. This allows users to express themselves in a playful manner but also be serious.

At the same time, effort has been put into that the overall graphical feeling should feel attractive to the users. As described below, the application contains several different graphical environments, but they all share the same graphical style to give a feeling of coherence. The graphical elements used were not developed within the research project, as that takes a lot of time, but rather bought from the Unity Asset Store, a store for game components connected to Unity. To give a positive mood to the usage of the application, the light in the scenes is bright and shiny but the game development engine gives us the possibility to add various effects like fog, time of day, rain, clouds etc., something that might be added in future versions. See figure 1.



Fig. 1. Example of one avatar in the city environment.

### 3.4 Environments

In the application the users can choose which graphical environments they want to be in. The available environments have been selected based on several criteria to try to match the user's preferences, and they include several different views, for instance a city, a medieval Japan, a pirate island, snowy mountains, sci-fi etc. See figure 2.



Fig. 2. Example of three avatars in different environments.

The users can all select and switch speaking environments as part of expressing themselves and are currently not limited in the application and instead rely on social protocols. This is a trade-off between openness and control.

In the initial version of the application there is one predefined view available in each environment, but this will be extended with a 3D-walkabout mode where the users can select their own view (see "Future work").

### 3.5 Animations

For the users to be able to represent their feelings, several different animations are available. See figure 3 for a few examples. The Unity game development environment allows easy import of animations from, for instance, the free service Mixamo [41], providing hundreds of animations to choose from.

In the Dialogica application an initial selection was done based on foreseen usage of the application. More animations can easily be added later. The initial animations include activities such as getting attention (waving one or two arms), showing a thumbs up, or sitting, but also dancing and rallying.



Fig. 3. Example of three users' animation chat messages and different poses.

### 3.6 A multiuser application

The Dialogica application is a networked multiuser application where users share a common view and can see each other through a common 3D-interface. In games it is common to have many different virtual rooms to choose from, but as the purpose of Dialogica is to help people in the same physical room to communicate, the application automatically searches for local servers, and if none is found it creates one. All users on the same local network will then connect to this server running on one of the users' devices. This makes it easier for the users to find each other and get started with the augmented conversation. All actions in the application are mirrored between clients where applicable, meaning that everybody sees the same thing.

### 3.7 Conversation tree

A central piece of the philosophical dialogues is the conversation tree. A facilitator builds up a visual representation of the conversation which can be seen as a tree structure. Each proargument and counterargument is represented as a sentence in a bubble so that users can easily get an overview of the ongoing conversation and at the same time easily refer back to earlier parts of the conversation. The different parts of the conversation tree (i.e., the bubbles) are connected with one of several connectors that mean different things.

As chat conversations can be time dependent, the chat messages are also saved during the conversation as a timeline for each participant. This allows for the users to go back and see who chatted what at what time.

### 3.8 Chat messages

Chat messages are sent in two ways in the application. The first alternative is so called “animation messages” which are connected to the animations themselves where chat messages correspond to a specific animation button. See figure 3.

The second alternative is through a chat-dialogue window where messages are built up from three bases: need something, give something or other such as yes, no, etc. See figure 4.



Fig. 4. Example of chat windows.

### 3.9 Text to speech

Dialogica also supports text-to-speech where chat messages are read out loud via a synthetic voice. The user can choose from various voices to represent them. The current implementation is based on the built-in speech synthesis in Apple iOS, where the number of available voices differs between languages. For instance, in Swedish there are only three voices (two female and one male) available, while in US English there are nine voices available.

The user can choose if both local and/or remote messages should be spoken. This is useful in different situations. For example, if all users are situated in the same room, then only local messages should be read out loud to signify who is currently speaking.

The spoken messages are also buffered, meaning that they are played after each other instead of being played on top of each other (compare to humans speaking at the same time). The messages connected to the animations are only buffered on time per user. Hence, if a user changes her animation and animation message then the latest animation message will only be played.

### 3.10 Recording and playback

The conversation can, if the users so choose, be recorded and later played back. This can either be as full length recording where the original conversation can be played back as it happened live or it can be just stored as a final state and then loaded as that state, e.g., to continue the conversation at a later time.

The recording and playback feature helps users with limited cognitive abilities to better get an understanding of the conversation they were or are part of.

## 4 Discussion and Future Work

### 4.1 Discussion

As described by, for instance, Lanyon, Rose, and Worrall [35], it is important to support persons with aphasia in adapting to their changed communication abilities and circumstances, and help them establish their role in their communities. As noted by several authors, this concerns both the workplace (cf. [6]) and leisure time (cf. [5]). While very few studies have been carried out so far, there are indications of that philosophical dialogues can contribute to this [21]. But even more so, philosophical dialogues supported by modern technology, such as computer game technology on an iPad, may be able to contribute to this further, by very well meeting the above-mentioned requirements. Hence, an approach such as that taken with *Dialogica* seems promising, and it is of importance to carry out empirical studies about the effectiveness of such an approach.

Although several studies have noted positive effects of group conversation for persons with aphasia, many of these studies (see e.g. [35]) have been concerned with a form of communication that mostly resembles monologic education (cf. [25]), also known as traditional education. But we know from general educational science that monologic teaching has several drawbacks when compared to dialogic education [42]. In fact, a well-developed dialogic education in many ways far exceeds monologic education. Several decades of research into philosophical dialogues with children show significant effects in different important areas, such as the development of higher order thinking skills, communication abilities, mathematical abilities, etc., while it simultaneously has positive socio-emotional effects on participating children [15, 16, 17, 18, 19, 20]. At this background, there is a need for more research concerning persons with aphasia to focus on high quality dialogic education.

The usage of visual resources is considered positive for promoting communication and participation for persons with aphasia, but when the facilitator's attention is directed towards the participants with more severe aphasia and their usage of visual resources as communication support, participants with milder aphasia are easily shown less attention and are then more likely to disengage from the conversation [37]. Hence, an application that is aimed at supporting users with aphasia in group dialogues has to be either trained separately, or easy enough so that it can support the users with aphasia while not obstructing the dialogue or demand frequent or prolonged support from the facilitator. *Dialogica* is designed with this in mind, in several ways. For example, the use of game technology, and a game mechanics, where the user can unlock more advanced features as the user gets more skilled with the basic operations, is meant to accomplish continuous and non-obtrusive training. Second, by being developed on the basis of argumentation theory and tested methodology for dialogic education, and thereby specifically designed to give the user a comprehensive

and specialized set of communication tools specifically useful in group dialogues, the application can be powerful yet simple enough to offer a supportive tool for persons with aphasia.

## 4.2 Future work

By using a 3D-game environment such as Unity for the development of *Dialogica*, the application can easily be extended with new functionality. The authors plan to investigate how 3D-environments can be further used to allow for interaction between users. According to Ruzaman and Rosli [43], there is a great demand among both educators and researchers for technological advancements specifically aimed at assisting inquiry-based classroom activities. At this background, an extension of *Dialogica* for use also in, for instance, elementary school would likely be useful.

The recording and playback functionality allows for e.g. pre-recording of presentations which can be later played back. This is useful in a learning context where students need assistance in order to express themselves.

Another area of interest is how real-time translation between several languages of chat messages can be used to help users of various backgrounds to both communicate better and learn a new language easier.

The 3D-game environment also allows for easier access to other platforms than Apple handheld devices. In fact, all development is done in a desktop computer setting.

As noted above, research into the effects of a high-quality dialogic communication and education methodology, such as P4C, shows great promise for this methodology as a means to support persons with aphasia in the learning and development of communicative skills and abilities. Furthermore, it is especially important to study the effects of supporting communication with modern technological tools, such as is attempted with an application such as *Dialogica*, in learning environments for persons with aphasia, but also in other settings as well.

## 5 Conclusion

In this paper, we have presented and discussed how a modern mobile application, *Dialogica*, developed in a game engine environment, may help users to learn better via the method of philosophical dialogues. We suggest that, since there is a body of research showing the general effectiveness of a dialogic education method like philosophical dialogues on the learning of several key skills, abilities and dispositions of participating children, and since prior research suggests that group conversation is a good means for supporting the learning of communication skills for persons with aphasia, an application like *Dialogica* can be of great value. Because *Dialogica* meets several criteria for facilitating a successful learning environment for persons with aphasia, the application may be of value first and foremost for persons with aphasia and people in their immediate surrounding, and in the long run, for society as a whole.

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