Entertainment Computing 5 (2014) 401–412

Contents lists available at ScienceDirect

Entertainment Computing

journal homepage: ees.elsevier.com/entcom

# Talking to Teo: Video game supported speech therapy ☆

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ARTICLE INFO

*Article history:*
Received 31 March 2014
Revised 27 August 2014
Accepted 10 October 2014
Available online 1 November 2014

*Keywords:*
Speech therapy
Educational games
Voice
User interfaces

ABSTRACT

Children with hearing loss diagnosed before they are 2 years old are capable of developing abilities that range from elementary production such as single sounds, or vowels, to those which are more complex, such as spontaneous production of meaningful words and phrases, assuming that they have been treated correctly and opportunely. Speech production skills depend on language and auditory input, and therapy is usually guided by a therapist in personalised sessions. Some children find mechanisation sessions boring or stressful, while others cannot afford such sessions. In contrast, video games have been shown to motivate youngsters. We introduce Talking to Teo, a video game developed and based on verbal therapy and educational objectives, aimed at the rehabilitation of children with early diagnosed hearing disability, and who use aids such as cochlear implants. The software integrates speech recognition for user interaction and benefits from visual feedback. We performed a set of tests with therapists and patients where video game entertainment has evidenced favouring the repetitive approach required during speech mechanisation sessions.

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## 1. Introduction

### 1.1. Hearing

Hearing is the most important sense for the development of oral communication, making possible the perception of sounds and feedback of a persons own production. Children with auditory deficiency who are diagnosed to early age, have a suitable hearing aid (e.g., cochlear implants) and begin their therapy process with the help of speech therapists. Normally, these therapy sessions take place once a week guided by a speech therapist. Some therapy sessions are laborious and maintaining motivation of patients is difficult, particularly mechanisation of speech production process sessions [1]. Moreover, speech therapy is not easily accessible due to cost and demand (in terms of time) [1].

### 1.2. Rehabilitation

Speech therapy software is usually aimed at people with hearing impairment, which implies the need to exercise some speech production abilities. Such abilities depend on language and auditory input. Some efforts have been made in the development of therapy software since automatic speech recognition software became popular, and is mainly in Spanish. Vocaliza, from the University of Zaragoza [2] is a notable example, aimed at people with speech disorders, not necessarily children with hearing impairment. For the learning of language in deaf children, there are some similar developments in languages such as Mandarin [3] and English [4]. Speech therapy and speech learning software development has been a relevant research field with interesting results, such as auditory-verbal therapy [5], which states a clear sequence for an auditory-verbal program, from basic sounds to more complex and spontaneous production in people with hearing disabilities with a prosthetic aid (e.g., cochlear implant) Tan et al. [1] review a number of systems for providing speech pathologists and patients with mathematical graphs and animation of speech to provide feedback of vocal performance that is complicated for the user and requires expert interpretation. Also, they explain the functioning of Speech Viewer [6], where correct pronunciation of vowels cause a monkey to climb up in a tree, and state that this system produce a positive outcome.

### 1.3. Video games

Games are important for child development. In particular, computer games offer benefits such as motivation, engagement, learning, problem solving and skills development [7,8]. Additionally,

☆ This paper has been recommended for acceptance by Christos Gatzidis, Ph.D.

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http://dx.doi.org/10.1016/j.entcom.2014.10.005
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it is well known that speech can be used to control different devices [9,10]. Some computer games relate to sound or voice interaction, or to language skills, for example, Tomilson et al. [11] proposed a system to control graphical characters, while the character retains a high level of autonomy. Here, the user takes the place of a wolf and starts barking, howling, growling or whining. The wolves use sound processing to listen to the user, and a computational representation of emotion mixed with artificial intelligence and computer graphics to define the users wolf behaviour. Another system shows how an interactive graphical environment can be controlled by sound but is limited to non verbal interactions, which has shown to be significantly faster for discrete input generation in comparison to existing speech and keyboard input methods [12] but is not aimed at speech learning. Gurkok [13] proposes a speech controlled video game. Here, The player herds a flock of sheep by commanding a group of dogs. Speech is acquired by a microphone. The acquired acoustic data is recorded, processed and analysed. Three word level unigrams represent dog names which form a language model that is incorporated in a search graph. The dog whose name matches the decoding result is selected by the game. However, the usage of speech is limited to modality changes within the game using basic dog names. Connolly et al. [7] propose a game aided by alternate reality to support learning of foreign languages for secondary school children aged between 11 and 18 in Europe. However, the game is limited to older children with no hearing impairment, and with mastery of their own language. Tan et al. [1] propose a Pac-Man-like game which incorporates vocalisation of words generated from a pool used in clinical speech therapy sessions. It provides real-time feedback on the vocalisation performance of patients and evidences the possibilities of using familiar game play, instead of building one from scratch, while improving engagement. In this game the player gains power to attack a particular ghost by saying its name, which is a word that appears over the ghosts head and is selected from a set provided by a speech pathologist. However, this system does not select many correct vocalisations, probably due to differing accents (which should be trained). Additionally, the game showed evidence of slight lags in speech recognition which contrasted with the fast game mechanics, causing some frustration in children. Finally, the speech recognition engine needs improvement and further validation to find out if the game environment improves patient's engagement and the therapy process.

### 1.4. Our approach

We present a tool using speech recognition technologies which takes advantage of the graphic interaction and the narrative provided by video games. Video games provide an easier and more engaging interaction, different from the complex systems described by Tan et al. [1]. The challenges of our kind of game level is similar to that described by Speech Viewer [6] but our game levels are integrated in a more elaborated narrative. The use of simple levels with a slower mechanics deals with time lag problems [1]. Additionally, Talking to Teo is designed for Colombian Spanish. It aids unassisted speech therapy (i.e., without the presence of a qualified therapist), based principally on the theory developed by Daniel Ling et al. [5], thus making this kind of therapy more affordable and useful in the inclusion of the hearing impaired children. Our tests with therapists and patients show that video game entertainment favour the repetitive approach required during speech mechanisation sessions and is a step towards long-term engagement.

## 2. Speech therapy

In Ling et al. [5], some progressive levels of sound acquisition are stated as the basis for the speech rehabilitation therapy used in the "Instituto para Niños Ciegos y Sordos del Valle del Cauca" (INCSVC), as seen in Fig. 1. Here, the stages are shown as steps, starting with the basic one of free vocalisation at phonetic level, and ending in the more complex combination of words, with natural speech patterns. Levels 4 and 5, corresponding to consonant production, are approached through a series of exercises, focused on different types of articulation (place and manner), in combination with the vowels. Such levels are evaluated, also according to Ling et al. [5], using a series of stages, as stated in Table 1.

The stages are ordered according to the difficulty of articulation, and each is comprised of a series of exercises. In our video game, stage II of consonant learning, covering consonants d, t, n, s and l, is implemented in the application. Each stage consists of a series of sub-skills, which guide the type of evaluation to be made, and, in

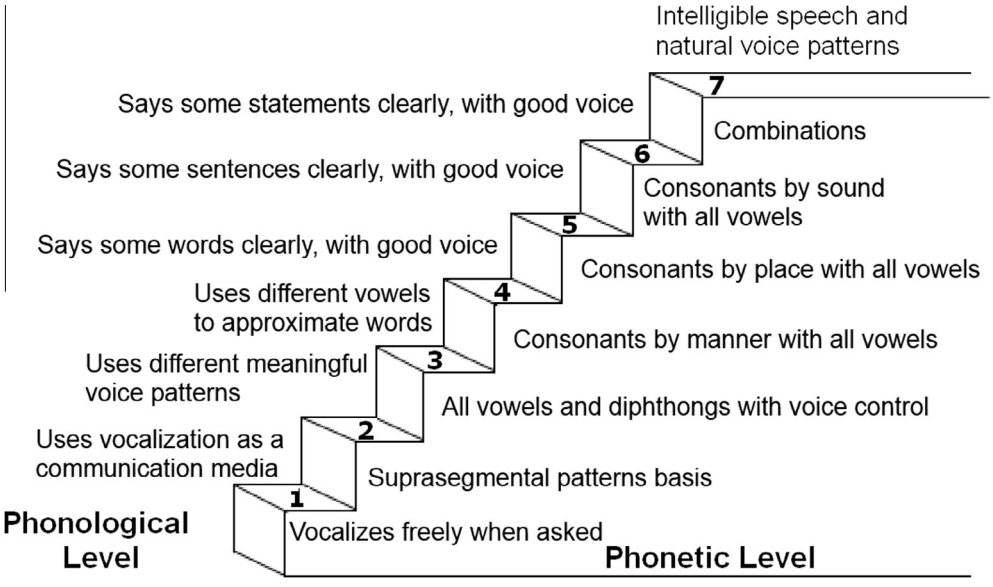


**Fig. 1.** Natural order of acquisition of sounds, according to [5].

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