PERFORMANCE EVALUATION OF SONIFICATION CONCEPT FOR DYSLEXIA

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DECLARATION

I hereby to declare that the material in this thesis is my own except for quotations, excepts, equations, summaries and references, which have been duly acknowledged.

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I also hope that this research will provide mutual benefits, to other researchers and could provide a new dimension in sonification and dyslexia research fields.

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ABSTRACT

Sonification is merely a new research field. It is defined as the representation of data or information using non-speech sound. Dyslexia is a specific learning difficulty that causes a person who has dyslexia to have problems in reading, writing, spelling or manipulating numbers even though they have normal intelligence and were exposed to sufficient education and training. This research aims to find out whether sonification concept can be used in the design of assistive tools for dyslexic students. Before any sonification based assistive tools can be designed, it is important to understand the fundamental issues, which are the listening performances of dyslexic peoples. Based on the tasks used in measuring usability properties of sonification applications, a listening test experimental design was developed and the performance results were analyzed. The overall results show that people who have dyslexia can be concluded as equivalent to normal people in performing general tasks in sonification concepts. However, there are some interesting results that might need to be taken into consideration for future research enhancements.

ABSTRAK

PENILAIAN PRESTASI KONSEP SONIFIKASI UNTUK DISLEXIA

Sonifikasi merupakan satu bidang yang agak baru. Ianya didefinisikan sebagai persembahan data atau maklumat dengan menggunakan bunyi bukan percakapan. Dislexia pula merupakan masalah yang berkaitan dengan pembelajaran yang menyebabkan seseorang yang mempunyai dislexia menghadapi masalah untuk membaca, menulis, mengeja atau memanuipulasi nombor walaupun mereka mempunyai kebijaksanaan yang normal dan didedahkan dengan kaedah pendidikan yang normal. Penyelidikan ini bertujuan untuk mengkaji samada konsep sonifikasi boleh digunakan sebagai alat untuk membantu masalah mereka. Walaubagaimana pun, sebelum sebarang alat bantuan berasaskan sonifikasi direka, adalah penting untuk memahami isu-isu asas yang berkaitan dengan kebolehan mendengar bagi mereka yang mengalami dislexia ini. Berdasarkan kepada kerja dan ujian yang pernah digunakan sebelum ini untuk mengukur elemen-elemen kebolehgunaan suatu aplikasi sonfikasi, ujian mendengar telah direkabentuk dan dijalankan dan keputusan telah dianalysis. Secara keseluruhan, keputusan analisis menunjukkan bahawa mereka yang mempunyai dislexia ini telah menunjukan prestasi yang lebih kurang sama dengan orang normal dalam melaksanakan tugas-tugas umum dalam konsep sonifikasi. Walaubagaimana pun, terdapat juga keputusan yang menarik yang perlu diberikan pertimbangan untuk dijadikan penyelidikan baru dimasa hadapan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOS

LIST OF EQUATIONS

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter gives overview about sonification, assistive tools and dyslexia.

1.2 Sonification

Based on NSF report (Kramer et al., 1999) by the International Community for Auditory Display (ICAD), sonification is defined as the process of using non-verbal sound to convey information. For instance, auditory icons (Hermann, 2002) are used for display sound information through an automatic process that adopts commonly held meaning for everyday sounds. Let's consider the sound of a bottle filling up, which can be used to indicate a progressing file download in the environment where the filling up is taking place.

Sonification concept is a branch of auditory display. Auditory display can generally be defined as any form of display that makes use of non-verbal sounds to communicate information. Sonification is a type of auditory display that adopts non-speech audio to represent information. Kramer et al. (1999) further broadened the concept by elaborating that sonification as the conversion of data relations into perceived relations in a non-speech sound signal to help facilitate communication or interpretation. Thus, the main objective of sonification is to translate the relationship in a data into non-speech sound(s), and make use of human beings auditory perceptual abilities to make the data relationship comprehensible.

There are several exsiting sonification techniques that currently available e.g., audification (Dombois, 2001), parameter mapping (Kramer, 1994), model based sonification (Hermann, 2002), earcons, auditory icons etc. These techniques are normally guided by the type of data to be presented and the required user tasks that the sonification can support such as programming debugging (Vickers,

1999), multi-channel display (pauletto, 2004), stock market prediction (Janata et al., 2004) etc.

1.3 Assistive Technology

Assistive technology is a technology used by individuals or persons with disabilities to accomplish their tasks. Examples of assistive tools are mobility devices such as walkers and wheelchairs. Individuals with restricted hand purpose can make use of a keyboard with large keys or a separate mouse to work on computer. Blind people can also use software that recognize text on the screen to computer-generated voice, people with low vision can use software that increase the size of screen words, deaf people can use a TTY (text telephone), or individuals with speech impairments can use a tool that speaks out loud when they typing the text on keyboard (Boyle et al., 2005).

In this research, assistive technology for dyslexia is defined as any technology that can be used to support people with dyslexia. Such technology includes hearing aids, visual aids, sound aids etc. However, this paper will focus on the idea of adopting sonification as an assistive technology to help dyslexic students. Previous researches have shown that assistive technology can recover certain skill deficits (e.g., reading and spelling) (Raskind and Higgins, 1999; Higgins and Raskind, 2000).

1.4 Dyslexia

Although dyslexia was officially recognized in the UK as a disability under the Disability Discrimination Act of 1995, there have been widespread of knowledge of the problems associated with such hidden disabilities (Dale and Taylor, 2001). Dyslexia is a serious disability across the globe, and affects a huge number of people. In the UK alone, it was reported that about 4 per cent of the country's population is severely dyslexic, with another 6 per cent being moderately dyslexic (BDA, 2006). Therefore, the total numbers of people that suffer from dyslexia in the UK make up 10 per cent of the country's population. In such an advanced country where access to quality health care and medications is assured, it must be

worrying to estimate the number of people suffering the same problem in developing and underdeveloped countries.

Taylor et al. (2007) stated the possible difficulties dyslexic patients to be: reading hesitantly; misreading, making understanding difficult; difficulty in clearly organizing thoughts; poor time management and planning; and erratic spelling.

The first issue of dyslexia was reported by Pringle-Morgan in 1896 (Pringle-Morgan, 1896). Pringle-Morgan and Hinshelwood (an ophthalmologist) made speculations that the issue of difficulty with reading and writing is caused by "congenital word blindness" (Hinshelwood, 1917), and it was widely believed that dyslexia is caused by visual processing difficulties.

While this view is not generally acceptable in the modern world, some current literatures still maintain that dyslexia is caused by a disorder in visual processing. Stein and Talcott (1999) reported on visual search difficulties that are caused by reduced ability of a person to correctly control ocular movement. Additionally, individuals who suffer from dyslexia are less sensitive to certain variables like contrast sensitivity and visual persistence when compared with normal people (Lovegrove, 1993). Notwithstanding that these literatures try to link dyslexia with visual difficulties, it is widely believed by researchers that dyslexia is a linguistic disorder, and on a more precise note it's caused by a disorder in phonological processing (Vicari et al., 2005). People who suffer from dyslexia normally experience difficulty with analysis and processing phonological elements of spoken words (Snowling, 1987; Snow et al., 1998). For instance, a dyslexic patient might have problem with subdividing words into their single phonemes (Shaywitz, 1998; Pennington et al., 1990). Thus, it can be stated that there is a possibility of some individuals having "linguistic" causes of dyslexia, while other having "visual" causes of dyslexia or some of them might be caused by both factors. As such, it is important that researchers appreciate the differences that exist between these numbers of causing agents. To be precise, dyslexic readers differ in relation to the extent of their ability to make use of phonological reading and spelling strategies. Research has shown these differences in the seriousness of dyslexic individual's

phonological disabilities can determine their level of reading abilities (Snowling, 2001). Simmons and Singleton (2000) also commented that dyslexic students tend to experience difficulties with reading comprehension that are not usually accounted for by their inability to understand words individually in a page of text, but this difficulty can be accounted for in their construction of references when processing passage of text.

Another survey by the UK Higher Education Statistics Agency (HESA, 2006) revealed that in the academic year of 2003/2004, the number of first year undergraduate students in the UK with a stated disability of dyslexia was 15,600. Hatcher et al. (2002) stated that the number of students with dyslexia has been growing rapidly in recent years. Richardson and Wydell (2003) found that university students with dyslexia are more likely to drop from school during their first year of study and less likely to complete their course fully, but appropriate support for students can increase completion rate of students with dyslexia and it can equal that of students without disabilities. Some of the famous people with dyslexia include: Thomas Edison, Albert Einstein, Michael Faraday (Dyslexia.com, 2013). See Appendix 1 for full more information about some of the famous and talented people with dyslexia.

In that notion, it is important for dyslexic students to be assisted with any form of technology that can help booster their cognitive competence and encourage them not to drop out from school. The reason being that, they will be able to acquire necessary skills that will be used to contribute towards the development of the society they live in.

1.5 Research Questions

The main aim of this research is to investigate and understand the potential of sonification concepts to be used in helping people with dyslexia to overcome their learning disabilities.

People who have dyslexia might get so frustrated and sad as reading and spelling are so hard to them. For kids, they might not like of being separated with their friends during reading class or having to see a special reading inscructors. However, helping them is important to ensure they can go on and do great things in their life. Some successful people have dyslexia, but it did not stop them from achiving their goals. As a results, many applications with assistive technologies have been developed purposely to help this kind of people.

Graphical respresentation currently dominates the fields of external representation, but sound is now seen as alternative and its complement. Previous research has shown the success of using sound in several areas, especially for blind or visually impared users or in situations where the users eyes are occupied with other tasks such as looking at a patient in medical dignosis or something that is difficult to represent using graphics such as multidimentional data.

An example of application for people with learning disabilities like dyslexia is text-to-speech application such as AB-Web (Roth et al., 1998), which is a browser that generates a virtual sound of the information including text and images. Another example is VoiceXML by Teppo et al. (2001) which is design for creating audio dialogs that features synthesised speech; digitised audio, recognition of spoken input,recording of spoken input etc. This is not only good for blind people but also for people with learing disabilities as it brings a better and more convenient text reading and writing experience especially with foreign language texts. Most of these existing applications are using speech sound.

However, this research will look into the potential of 'non-speech sound representation' of data, or also known as sonification, to be implemented as part of assistive technologies to aid people with dyslexia to potentially solve their problem. To the best of our knowledge, there is no current research of sonification concept for dyslexia. As a result, this research aims to find out whether sonification concept can be used in the design of assistive tools for dyslexic students. Before any sonification based assistive tools can be designed, it is important to understand the following fundamental issues and questions:

a. **How to measure or evaluate** the performance of dyslexia peoples in using sonification applications.
b. **What are the listening performances** between both dyslexic and normal people.

1.6 Research Objectives

The main objectives of this research are as below:

1. To introduce a general performance evaluation of sonification concepts.
2. To evaluate the performance of dyslexic students in sonification concepts.

1.7 Expected Contribution

The contributions of this research are:

1. A new general performance evaluation of sonification concepts.
2. Empirical results of general performance evaluation of sonification concepts for both normal and dyslexia people.

1.8 Hypothesis

Below are the hypotheses of this research:

Hypothesis 1

H_0: There is no significant difference between control group and dyslexic students in terms of matching task.

H_1: There is significant difference between control group and dyslexic students in terms of matching task.

Hypothesis 2

H_0: There is no significant difference between control group and dyslexic students in terms of comparison task.

H_1: There is significant difference between control group and dyslexic students in terms of comparison task.

Hypothesis 3

H_0: There is no significant difference between control group and dyslexic students in terms of classification task.

H_1: There is significant difference between control group and dyslexic students in terms of classification task.

Hypothesis 4

H_0: There is no significant difference between control group and dyslexic students in terms of ordering task.

H_1: There is significant difference between control group and dyslexic students in terms of ordering task.

Hypothesis 5

H_0: There is no significant difference between control group and dyslexic students in terms of association task.

H_1: There is significant difference between control group and dyslexic students in terms of association task.

Hypothesis 6

H_0: There is no significant difference between control group and dyslexic students in terms of prediction task.

H_1: There is significant difference between control group and dyslexic students in terms of prediction task.

Hypothesis 7

H_0: There is no significant difference between control group and dyslexic students in terms of finding task.

H_1: There is significant difference between control group and dyslexic students in terms of finding task.

Hypothesis 8

H_0: There is no significant difference between control group and dyslexic students in terms of memorization task.

H_1: There is significant difference between control group and dyslexic students in terms of memorization task.