Web-Enabled Software for Clinical Telegaming Evaluation of Multisensory Integration and Response to Auditory and Visual Stimuli

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Abstract

Clinical telegaming integrates telecare and videogaming to enable a more convenient and enjoyable experience for patients when providers diagnose, monitor, and treat a variety of health problems via web-enabled telecommunications. In recent years, clinical telegaming systems have been applied to physical therapy and rehabilitation, evaluation of mental health, and prevention and management of obesity and diabetes. Parkinson's disease (PD) is suitable for development of new clinical telegaming applications because PD patients are known to experience motor symptoms that can be improved by physical therapy. Recent research suggests that sensory processing deficits may also play an important role in these motor impairments because successful motor function requires multisensory integration. In this paper, we describe a new web-enabled software system that uses clinical telegaming to evaluate and improve multisensory integration ability in users. This software has the potential to be used in diagnostic and therapeutic telegaming for PD patients.

Introduction

Clinical telegaming systems are rapidly emerging as more convenient, comfortable, and enjoyable alternatives to traditional approaches used in the diagnosis, management, and treatment of health problems. Clinical telegaming enables delivery of telecare to patients in the comfort of their own homes. These systems combine the convenience of web-enabled telecommunications with the entertainment value of videogaming for a customized virtual environment intended to address the health care requirements of the patient (1). We are particularly interested in the use of telegaming for the diagnosis and treatment of Parkinson's disease (PD). We present a web-enabled software that evaluates sensory processing ability in PD patients. We aim to use this software in order to determine whether diminished multisensory integration ability contributes to the motor problems experienced by PD patients.

Methods

Procedure

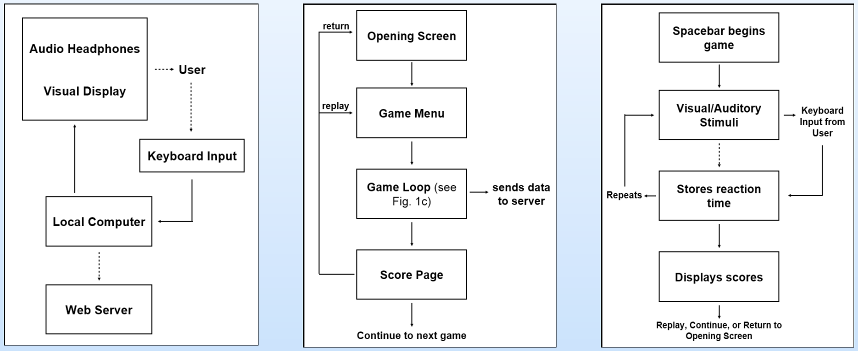
Subjects were tested on seven task variations, each testing a specific type of stimuli (Table 1). The user responded to stimuli by pressing the space bar as quickly as possible after perceiving the cue for control conditions or pressing the left or right arrow keys to indicate which side the stimulus occurred for the sensory conditions. Response time was measured in control conditions and both response time and accuracy were measured in sensory conditions.

Software

Our web-enabled software, Sensory Testing and Evaluation for Parkinson's disease (STEP), was run remotely on user's computer using a web client browser with either Google Chrome or Mozilla Firefox. Performance data was stored under an anonymous identification number for each user. Figure 1 displays schematics for the software architecture. Source code for the prototype version of the software and a video demonstration of its use can be downloaded from www.BrainHealthAlliance.org/XLTSTEP.

Participants

The software was tested with 13 normal subjects in three age groups: 4 young subjects (less than 25 years old), 5 middle-aged subjects (between 30 and 50 years old), and 4 elderly subjects (greater than 60 years old). All subjects were in good health (and known explicitly not to be suffering from PD) and gave informed consent to participate in the study.

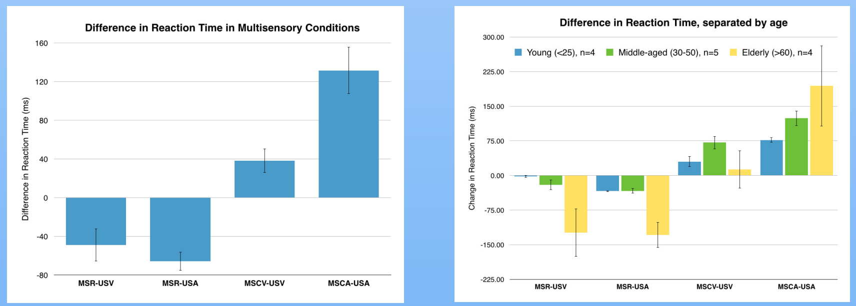


a) System diagram   b) Software flowchart   c) Basic game loop

Fig. 1: Schematics for STEP software architecture

Condition	Description
Control – Visual	A black circle as visual cue was flashed briefly at the center of the screen
Control – Auditory	A 50 ms 1 kHz tone as auditory cue was given through both sides of the headphones while the screen remained blank.
Unisensory Detection Visual (USV)	A black circle as visual cue was flashed briefly on either the right or the left side of the screen.
Unisensory Detection Auditory (USA)	A 50 ms 1 kHz tone as auditory cue was given on either the right or the left side of the headphones.
Multisensory Reinforcement (MSR)	Visual and auditory cues were presented simultaneously on either the right or the left side of the screen and headphones with both cues occurring on the same side.
Multisensory Conflict Visual (MSCV)	Visual and auditory cues were presented simultaneously on left or right sides of the screen and headphones with both cues randomly occurring on the same or opposite sides; response requested to visual cue.
Multisensory Conflict Auditory (MSCA)	Visual and auditory cues were presented simultaneously on left or right sides of the screen and headphones with both cues randomly occurring on the same or opposite sides; response requested to auditory cue.

Table 1: List of test conditions



a) Pooled age groups (n=13): Relative to unisensory condition reaction times, multisensory reinforcement decreased reaction times, while multisensory conflict increased reaction times.

b) Separated age groups: Multisensory reinforcement conditions decreased reaction times by larger amounts in elderly subjects than in young and middle-aged subjects.

Fig. 2: Comparison of reaction time in unisensory and multisensory conditions

Results

Response accuracy did not differ significantly across age groups with subjects responding at greater than 90% accuracy for four of the five test conditions. However, the average accuracy for the MSCA condition was somewhat lower at 84.4%. Reaction times summarized in Figure 2 are displayed with error bars representing the standard error of the mean. Figure 2a shows normalized measurements of the differences in reaction time between unisensory and multisensory conditions. Figure 2b shows the normalized measurements of the differences in reaction time, separated by both condition and age. MSR reaction times were faster than unisensory reaction times with a decrease of -48.8±16.8 ms and -65.7±9.7 ms relative to the USV and USA conditions, respectively. In contrast, multisensory conflict reaction times were slower than unisensory reaction times with an increase of +38.3±12.5 ms and +131.7±24.2 ms for the MSCV and MSCA conditions, respectively. Members of the elderly subject group displayed considerably more improvement in reaction time in the MSR conditions when compared to other age groups. Elderly subjects also had considerably higher increases in reaction time in the MSCA condition but not the MSCV condition. However, this discrepancy from the expected hypothesis may be an artefact of this age group's small sample size.

Conclusions

We developed a prototype for a new web-enabled software system called STEP to evaluate users' abilities to perform multisensory perception and integration of auditory and visual stimuli assessed by reaction time and response accuracy. We anticipate using this software to compare the performance of PD patients with normal healthy control subjects. As seen in Figure 2, normal subjects demonstrated considerable improvement in reaction time in multisensory reinforcement conditions and slower reaction times in multisensory conflict conditions. These results demonstrate the efficacy of this software in evaluating multisensory integration ability in healthy subjects. We expect that these differences in multisensory integration will not be present in PD patients if these patients do experience an impaired multisensory integration ability and overdependence on visual stimuli as has been proposed in the literature (2). We are currently working to implement a secure web-enabled database and REST API while also refactoring the browser client software to meet the standards for a live HIPAA compliant secure system. We will then be able to conduct a clinical trial of our software with a much larger sample of both PD patients and healthy subjects to confirm and extend the preliminary findings of this study.

References

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