Smartphone-based temporal discrimination threshold assessment: Pilot study in normal and multiple sclerosis function

Wilson O. Torres[1], Michael E. Abbott[1] and Hannah S. Stuart[1]

I. Introduction

Temporal discrimination thresholds (TDTs) are the shortest time interval a person perceives two consecutive stimuli as distinct, with the time between signals called an inter stimulus interval (ISI). Prior work has shown the progression of Parkinson's disease (PD) and multiple sclerosis (MS) can be tracked using this metric [1], [2]. TDTs are usually established using direct electrical signals to the skin, requiring expensive equipment and special training, which may be inaccessible to marginalized low-income populations [3]–[5]. Smartphones are ubiquitous in society and therefore capable of measuring health metrics in both high- and low-resourced communities [5]. Smartphone vibrations have been used previously to understand skin sensitivity [6], [7]. We seek to obtain smartphone established TDTs (SE-TDTs) and compare them against the TDTs established in literature which use conventional electrical stimulation.

II. Methods and Results

A total of fifteen participants took part in a human subject study (mean age 33.67 ±16.71), with two self-identifying with MS. SE-TDTs are measured using a modified method of limits that allows for fast testing and to add additional confirmation of trials. Here individuals are instructed to tap on the touchscreen with steady force. A haptic stimulus is activated with an ISI ranging from 0 sec (single stimulus) to 0.2 sec, with a changing time step of 0.05 seconds. Subjects verbally assert whether they feel one or two vibrations.

Individual participants' responses are modeled using binomial logistic regression with ISI as the predictor variable. SE-TDTs are attained at the ISI corresponding to the model's 0.5 probability mark. Only results from twelve subjects are shown due to statistically insignificant models for three participants.

Figure 1 shows the SE-TDTs for the twelve participants. The study cohort SE-TDT mean is 45.6 ms ±28 ms for the normative participants and 102 ms ±3.1 ms for the MS participants. Mean scores fall within the literature ranges for each population [3], [4]. The normative and MS groups perform differently, with both MS individuals having higher SE-TDTs than any normative participant.

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[1]W.O. Torres, M.E. Abbott, and H.S. Stuart are with the Embodied Dexterity Group, Dept. of Mechanical Engineering, University of California Berkeley, Berkeley, CA, USA.

Corresponding author (email: wilson_torres@berkeley.edu)

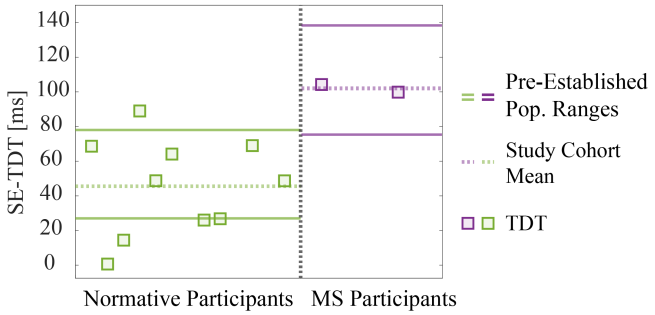

Fig. 1. SE-TDTs for Norm and MS participants with cohort mean shown as a dotted line. Population ranges from literature (normative: 27-78 ms, MS: 75.32-138.32 ms) [3], [4] are shown as a solid line (n=12).

III. Discussion and Future Work

The current work demonstrates that smartphone haptics can be used to establish TDTs, with measurement values comparable with previous TDTs obtained using electrotactile methods. Pilot data suggests this method can differentiate between normative and MS groups. These findings support the prospective use of smartphone applications for TDT diagnosis at home, which holds the potential to make sensorimotor function tracking accessible and equitable.

Future work will look to address psychophysical and behavioral components which could prevent establishing regression models. A larger cohort with a greater number of impaired participants (MS and/or PD) is needed to statistically compare groups. We also aim to correlate SE-TDT scores with TDTs established using electrodes.

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