Design of a haptic-based virtual reality evaluation of discrimination of touch and vibration

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***Abstract*—a sensory impairment in the ability to discriminate between different textures and stiffness of objects in our surroundings may affect the ability to perform daily functions. A design of a precise tool for the evaluation of the extent of the sensory impairment is presented. This tool would be beneficial in early detection of sensory loss and in the evaluation of a treatment method via follow-up examinations.**

Keywords—Neuropathy, Occupational Therapy; Clinical Evalaution.

I. Introduction

Sensory impairments have negative impact on occupational performance and activities of daily living [1]. While several tools are used to assess the level of neuropathy, e.g., Semmes Weinstein Monofilaments and the Moving Touch-Pressure evaluation, their results may be dependent on the examiner skill for stimulus control and judgment of performance [2]. Also, the resolution of the examination is fixed, so that the accuracy level is limited. Finally, current evaluation kit might be compromised by visual information acquired by the subjects, regarding the properties of the objects used during the evaluation. We therefore aimed to design and validate a haptic-based virtual reality (VR) system for the evaluation of discrimination of touch and vibration,

II. Methods

System Design: A VR system (Devinesense; Figure 1) and a haptic pen-like device were used. The Python-based programing of the virtual environment and the haptic feedback was performed in H3DAPI. The evaluation was divided into a texture-module and a stiffness-module. In both modules, two visually-identical surfaces are presented (Figure 1), however they differ in either their friction coefficient or their stiffness, depending on the chosen module. In the texture-module, the subject is requested to touch the top end of a Z-shaped path, presented on the two surfaces, and trace the path to sense the textures of the two virtual materials. The subject is then asked to determine which of the materials, A or B, is smoother. In the stiffness-module, the subject is requested to touch a dot, marked in the middle of both surfaces, and press it to sense the stiffness of the two virtual materials. The subject is then asked to determine which of the materials, A or B, is stiffer. After the subject has chosen A or B, a new screen is presented, where the difference between the friction coefficient or stiffness properties is reduced. The subject is presented with the following screen until he or she cannot discriminate between the textures or stiffness of the two materials, thereby the discrimination threshold is found.

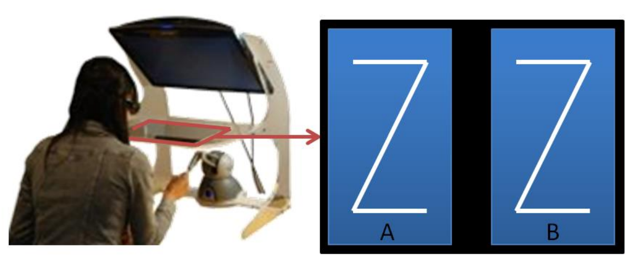

Figure 1: The virtual enviroment is projected on a mirror and percieved as 3D using Nvidia glasses (left frame). The user is shown either two similar surfaces that differ by their friction coefficient (right frame) or two obejcts that differ by their stiffness.

System validation: This is an ongoing trial, during which we will recruit 30 healthy adults. They will complete three evaluations: the described haptic-based VR evaluation, the Moberg Pick Up Test [3], and the Shape\ Texture Identification Test (STI) [4]. They will wear rubber gloves, to reduce tactile sensation and mimic neuropathy [5] during the three examinations. Ten subjects will perform the tests in a Moberg-STI-VR order. Ten other subjects will perform the tests in a

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VR-Moberg-STI order. The rest of the subjects will perform the tests in a STI-VR-Moberg order. This design will be used to test for learning effect or fatigue. Statistical tests will be employed to test the correlation between the haptic-based VR evaluation results and the STI scores, and between the haptic-based VR evaluation results and the Moberg Pick Up Test scores.

III. Results

Presently, the texture module is completed. The friction coefficients range from 0.04 to 1.0. A familiarization screen was prepared, where the texture presented on the left side resembled that of a dry tire (static friction coefficient = 1.0, kinetic friction coefficient = 0.8) and the texture presented on the right side resembled that of an icy surface (static friction coefficient = 0.1, kinetic friction coefficient = 0.04).

IV. Discussion

Successful validation of our haptic-based VR evaluation system will lead for our recommendation of its usage for early detection of sensory loss, due to its high resolution capabilities, and in the evaluation of a treatment method via follow-up examinations. The ability to present the subject with visually-identical surfaces, which differ in frictional and stiffness mechanical properties, is unique. The main limitations of our system lie in its high cost and stationary properties, so that it might not be affordable to all and it is confined to the laboratory/clinic settings.

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