Exploring Hard and Soft Texture Perception by Force-Haptic Discrimination

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***Abstract*— In this study, an evaluation of hardness and roughness perception during pressing of materials with different surface textures under different forces is performed. Ten textures and forces between 1.5 and 9 N were used for the experiment. The results show a significant correlation between the evaluation of the hardness perception and the roughness of the surfaces. Also, a correlation was found between the roughness perception and the applied force.**

I. Introduction

The human body has a remarkable sense of touch that allows us to perform complex tasks such as recognizing textures. The key to this ability is well-developed tactile perception during finger-object contact [1]. This ability is useful in various fields such as robotics, when we want robots to develop similar perceptions and learn to guess the material they are touching. In previous studies, haptic hardness was mainly equated with the compliance of materials [2], and [3]. In this work, we investigated the relationship between the perception of material hardness and applied forces, and how roughness affects the perception of hardness.

II. Design and Procedure

The materials consist of five different sponges with different hardness and roughness and five different sandpapers. The selection of textures intentionally included surfaces made of the same material with different textures. In the experiment, blindfolded participants were presented with ten materials seven times and asked to rate them according to their roughness. They were allowed to repeat the materials as many times as they wished to eliminate the effect of memory. The order of presentation and the position of the materials were randomized. Four types of forces were applied to the sandpapers, and participants were asked to rate the feeling of roughness on a 5-point scale. To test the effect of softness on roughness perception, the sandpapers were placed on a soft sponge. The roughness effect on the hardness perception was evaluated by placing different sponges under each sandpaper.

From the experiments, we observed that increasing the force improved the roughness sensation, but increasing the force beyond a certain value decreased the roughness sensation again. The overall scoring improved with forces up to 6 N, but it worsened again at 9 N (Fig. 1). Also, it has been found that materials feel different when we use different roughnesses. So it can be concluded that the roughness of the surface affects the hardness dimension.

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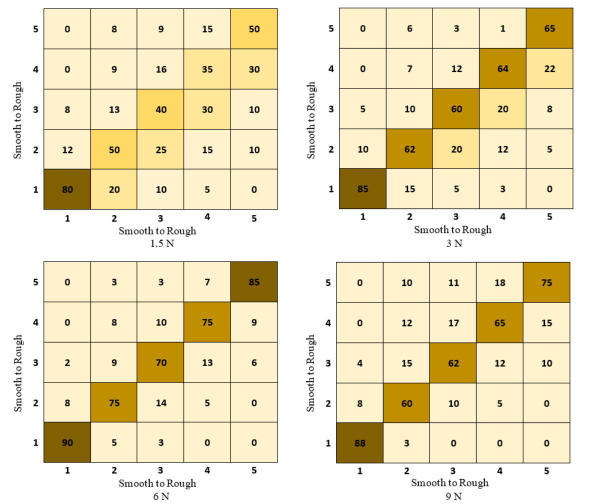

Fig. 1. Percentages of individual rankings for the detection of roughness samples by different forces

III. Conclusion

In accordance with these studies, correlations were found between several parameters. The results of the study indicate a significant correlation between the perception of surface hardness, roughness, and the applied force. The results also indicate that the haptic perception of roughness is most accurate at an optimal force value, with low or high forces resulting in lower precision. Surface material also affects the optimal force value, with soft materials providing better roughness detection at lower forces. Detection accuracy is influenced by the combination of hard and soft materials, which gives the best average value. The relationship between detection accuracy and applied force is complex and depends on the material and the optimum force value.

For future work, a more systematic and broader replication of the established tactile-texture experiments with parallel dynamic recording of the interaction forces needs to be repeated. This will provide a basis for simulating the afferent signals relating Psychophysiological experiments with physical values and neural signals.

References

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