Haptic pleasantness, naturalness, and complexity, of geometric raised line drawings

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I. Introduction

In vision, stimulus pleasantness has been shown to relate to complexity following an inverted U-curve [1] or a linear relationship [2]. At the same time, geometric patterns that are more associated with nature are found to be perceived as more pleasant [3]. However, little is known about how pleasantness relates to naturalness and complexity of tactile geometric patterns. Therefore, we investigated whether haptic pleasantness depends on complexity, and naturalness of a geometric pattern. Because exploratory hand movements have been shown to depend on the haptic property to be extracted [4] and can depend on complexity [5] we also recorded hand movements. We examined the influence of perceived naturalness and complexity on movement speed.

II. Method

Twenty right-handed participants (age range 20–29 years) took part in the study after giving informed consent. The study was approved by the local ethical review board.

Stimuli consisted of 15 raised line patterns (Figure 1). The stimulus was fixed on a table below a camera. The camera images were used to track the tip of the index finger with a custom Python script using the OpenCV and Mediapipe Python libraries. Participants were blindfolded and started with the right index finger in the lower right corner. They were asked to explore up to a maximum of 30 s. After exploration, they rated the stimulus on pleasantness, naturalness, and complexity using free magnitude estimation. They rated each stimulus twice in blocked-random order.

III. Results

First, the ratings for pleasantness, naturalness and complexity were converted to z-scores. The lmerTest package in R were used to run a Linear Mixed Model (LMM) with pleasantness rating as dependent variable and naturalness and complexity ratings as independent variables ($Pleasantness \sim naturalness + complexity + (1|Participant)$). The LMM showed a significant positive relation between pleasantness and naturalness ($\beta = 0.34, t = 10.5, p < 0.0001$) and a significant negative relation between pleasantness and complexity ($\beta = -0.18, t = -6.1, p < 0.0001$).

From the hand tracking data we calculated the average speed for each trial. To gain insight into possible effects of naturalness and complexity on the speed of the exploratory movements we again used an LMM ($Average\ speed \sim naturalness+complexity+(1|Participant)$). This showed a significant negative relation for complexity ($\beta = -5.1, t = -14.1, p < 0.0001$), with participants making slower movements with increasing complexity. The relation between speed and naturalness was not significant ($\beta = -0.14, t = -0.3, p = 0.75$).

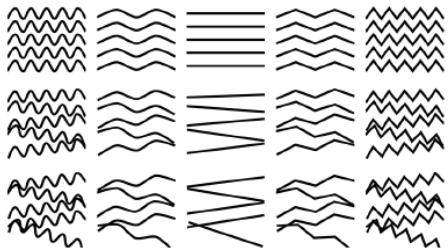

Fig. 1. The 15 geometric raised line drawings (Zytech Swellpaper) presented in the experiment. Line shape, spatial frequency and orientation were varied to ensure variations in perceived naturalness and complexity. Liens were rotated over a random angle between -10° and 10° (middle row) or -20° and 20° (bottom row).

IV. Discussion

Both naturalness and complexity were predictors for haptic pleasantness, where the relation with complexity was negative and with naturalness positive. This is consistent with visual literature. Movement speed depended on the complexity, and not on naturalness, showing that exploratory movements were slower for more complex scenes.

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