Eggs-ploring the influence of material properties on haptic experience

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ABSTRACT
This paper presents a study exploring how changing the material properties of a vibrating device affects users' haptic experience. We built seven simple vibrating eggs and covered them with a range of fabrics. 18 participants were asked to rate the experience of holding each egg against a set of scales, and to describe the experience in their own words. The results showed differences in the ratings for each egg, and that people were able to describe the experience in their own words in terms of both haptic properties, and in relation to other sensory experiences. These results indicate that material properties affect the haptic experience and show that a low-overhead experimental approach can be an effective means of eliciting responses from users regarding haptic experience.

Keywords
Haptics, tactile, user experience

1. INTRODUCTION
When designing haptic interfaces, in particular vibrating devices like mobile phones, most attention has focused on the mechanical side of the haptics, and little attention has been given to how changing the material properties of the device might affect the users' experiences of the haptic output. In addition, the measures used to evaluate most haptic interfaces have generally been task-based, whereas recent work in HCI involves the recognition of experiential aspects of HCI over traditional more task-focused approaches [1]. Jordan [4] states that "the materials from which a product is fabricated play a major role in determining how pleasurable – or displeasurable – a product is for those experiencing it". Visual properties are an important factor (e.g. the use of a walnut dashboard in a car instead of a plastic one to add status [4]), but haptic properties also play a part (e.g. the experience of drinking from a glass bottle is different to that of a plastic bottle since the glass bottle feels cool and heavy, which may be more pleasurable than the warm, light feeling of a plastic bottle [4]). We were interested in how users' experiences of interacting with haptic devices would be affected by changing the material properties of a device while keeping the mechanical haptics the same. Our aim was to find a way to rapidly characterize basic elements of users' experience of a given haptic device, without prejudicing their responses by assuming our own a priori categories and yet facilitate comparisons across users (c.f. [3]). We were also influenced by the repertory grid technique [2], in which individual users' responses to an object of study are presented as a grid representing correlations between different attributes of the object. However, the repertory grid technique is not designed for presenting aggregate data about multiple subjects' experiences, and can be a prohibitively time-consuming process, particularly for preliminary design work.

2. DESIGN
Our aim was to understand how changing the material properties of a haptic device affected users' subjective experience of it. We built seven simple vibrotactile units, consisting of a 3V eccentric-weighted pager motor, a battery and a switch, housed within a 3cm long plastic egg. We picked a diverse selection of materials with differing visual and haptic properties to cover the eggs: shiny silver, blue satin, green fur, black faux-leather, red velvet, leopard-print fur and sandpaper (Figure 1).

Figure 1: The eggs used in this study

3. METHOD
Phase 1: Our method had two parts: term gathering and egg rating. In Phase One, 12 participants were recruited during a weekly informal coffee break. The participants were handed each vibrating egg in turn and were asked to shout out any words that described how it felt. Between 10 and 25 terms were collected for each egg, with some eggs provoking more responses than others. The terms were then collated, and frequently used terms were added to a list, which was carried over to Phase Two.

Phase 2: We created a questionnaire for each egg with an open ended question asking the participant to describe how the egg felt in their own words, and a set of scales on which participants were asked to rate the egg from 1 to 5 on seven parameters. These parameters were the most frequent responses gathered in Phase 1: 'insect-like', 'warm', 'nice', 'rubbery', 'kitten', 'stinging' and 'alive'. The eggs were laid out on a table along with a book of questionnaires for each egg. and 18 participants were asked to pick up each egg and respond to the questionnaire for it.

4. Results
The results are shown in Table 1, where the mean score for each description is shown for each egg. A few things are immediately apparent: the velvet-covered egg was perceived to be nicest, and

the leather egg felt the most rubbery. Pairwise Mann Whitney tests (with Bonferroni corrections) showed that the black faux leather egg was perceived to be significantly more 'rubbery' than the blue satin egg, the leopard skin egg the green fur egg (all $p<0.001$), and the red velvet egg ($p=0.005$). Although the red velvet egg shows up to be the nicest in Table 1, the only significant difference in the scores was between it and the silver egg ($p=0.0126$). In addition to scoring each egg according to these scales, participants were also asked to use their own words to describe how each egg felt. The descriptions given by participants can be divided into two main categories: descriptions using haptic properties, and descriptions using similes or metaphors.

Table 1: Results table showing the mean score for each description by egg.

	blue satin	red velvet	leopard 'fur'	sand-paper	black leather	silver fabric	green 'fur'
nice	2.6	3.7	2.9	2.6	2.6	2.3	2.9
alive	2.2	2.4	3.0	1.7	2.3	2.1	2.6
kitten	1.1	1.5	2.7	1.3	1.2	1.0	2.4
warm	2.2	3.0	3.0	2.0	2.7	1.9	3.0
insect-like	2.4	2.4	2.1	1.9	2.8	2.7	1.8
stinging	2.3	1.2	1.8	1.4	1.7	1.9	1.6
rubbery	1.3	1.6	1.1	2.1	3.5	2.4	1.1

Many responses described the haptic properties, describing the material, the vibration, or both. Subjects wrote that the red velvet egg was 'soft but hard and rigid', 'furry', and 'vibrating'. The blue satin egg was described as 'silky-soft', 'cool (temperature)', and 'tingly'. Subjects described the silver egg as 'slick', 'sticky', 'firm and tingly'. The green fur egg was 'soft, furry, alive', 'soft and fuzzy and slightly warm', and 'warm, furry, tingly'. About the leopard-print fur egg, subjects wrote 'soft and irregular', 'trembling', and 'warm, furry and tingly'. The black leather egg was 'squidgy', 'touchy', and 'shivery'. The sandpaper egg was 'hard, tickles', 'rough, grippy', and 'sticky'. The range of different descriptions given for each egg further suggests that the overall haptic experience was affected by the material properties, as the vibrations were more or less consistent between eggs.

Subjects also used similes and metaphors to describe their experiences. These results give an insight into the sometimes surprisingly vivid nature of the experience. For example, the red velvet egg was described as 'like having caught a fly', 'luxurious, cocoon-like', and 'reminds me of home, comforting', and the blue satin was 'like bedding, satiny'. The silver egg felt 'like a trapped cockroach', and a 'cheap toy', and the green fur felt 'like my cat's head' and like a 'shock (electric)'. The leopard-print fur egg was 'like vibrations of a bike handle over gravel' and 'like a mouse struggling to get out of my hand', while the black leather was seen as 'like a big beetle that ain't happy' and 'mechanical-synthetic, like electric drill tool'. Subjects described the sandpaper as being 'like I've got a bumblebee inside a small case' and 'machine-like'. In addition to haptic qualities and metaphors, some descriptions were influenced by the visual appearance of the egg: the silver egg was described as 'futuristic, modern' and 'space age'; the blue satin egg as 'like bedding, satiny'. Clearly, the visual appearance is perceived as a core element of the material properties.

The variety of descriptions shows that people can be very expressive about what they feel, both in terms of haptic properties and in terms of other experiences. Many of the similes and metaphors employed were particularly evocative. O'Sullivan and Chang [5] note that people have difficulty describing haptic sensations and often describe them in terms of another modality, e.g. audio. The rich use of similes and metaphors confirms that people find it helpful to express what they feel in terms of other experiences, although these tended to be described in terms of real world haptic sensations rather than in terms of other modalities. In addition, many descriptions used haptic properties, e.g. "soft", "furry", "warm", tingly", indicating that people were able to describe the sensations. This may be due to the fact that real materials were used in addition to vibrations; It may be easier for people to describe the feel of fabrics than it is for them to describe mechanical vibrations, as they are used to considering such properties, for example when selecting clothes or soft furnishings.

5. Discussion & Conclusions

This paper reported the results of a study investigating the influence of changing the material properties of vibrating eggs on the haptic experience of the user. The results show that the material properties affect the user experience and indicate the importance of visual and tactile design of haptic devices. Our claim with this research is not, for example, that all haptic devices should be covered in red velvet so that they are perceived to be 'nice'. Rather, these results show that changing the material properties of a haptic device has an influence on the user experience, and that this should be considered when designing devices. Furthermore, the variety of results shows that this technique can be used to rapidly gather data about sensory experience for use by the designer or researcher at a very preliminary stage of their work, in a way that allows for multiple users' experiences to be taken into account between devices with minimal overhead and for comparisons between different devices. We have also shown that users are capable of describing haptic experiences, in a variety of often quite rich and expressive ways. Future work will further explore the possibilities of haptic output for non-task centered uses, and continue to experiment with ways to characterize user experience for the designer or researcher.

6. REFERENCES

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