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Aesthetics of Haptics: An Experience Approach to Haptic Interaction Design

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Abstract
Technological developments are expanding the interaction possibilities for the haptic domain, allowing designers to program dynamic haptic feedback. While haptic sensations are emerging in design practice, the relation between programmable haptics and the user experience remains underexplored. This study presents a research-through-design approach on the design of a push button and a knob with multiple haptic sensations. Interaction design of these haptic sensations started from an experience perspective building on material qualities. We reflect on the design process and present future directions for research.

Author Keywords
Haptic interactions; aesthetics of interaction; user experience; push button; knob.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Haptics receive a growing interest in human computer interaction due to miniaturization and increased resolution of actuators, and the developments of robotic materials [e.g. 6,7]. Haptics address all aspects...
of touch and extend the possibilities of interactive systems beyond the extensively explored visual domain. Touch is the only sense that is reciprocal. Therefore, haptics has the potential to take full advantage of our perceptual-motor skills and fully enable embodied interaction with the digital domain.

In design practice, haptic interactions are emerging for example the force feedback of Apple’s notebook trackpad. Consequently, haptic interaction design (hIxD) is growing as a community and researchers have explored various ways to support designers in their process. For example, Moussette et al. [5] propose the concept of hands-on sketching haptic interactions. On the other hand, Hurtienne et al. [2] developed a haptic language using pictorial force representations with tangible counterparts. Also, toolkits are developed, e.g. for designing table top applications [3], or editing tools for vibro-tactile grid displays on screens, wearables or even furniture [9].

Although these examples support designers of haptic interactions, their explorations part from a functional and efficient perspective [3,9] or they address the hIxD process from a technological approach (e.g. generating clicks or force) [2,5]. Given the relevance of experience in interaction design (IxD), we want to investigate how one could start designing haptic interactions from an experience perspective. In this work-in-progress we describe the first iterations of what aesthetics of haptics might be. We describe a set of haptic interaction design prototypes, taking material experiences as our starting point. We reflect on our design process in relation to theory-inspired design frameworks. Thereby we follow the research-through-design approach in the tradition of our Designing Quality in Interaction Group [11].

**Aesthetics of (haptic) interactions**

In IxD, there has always been a strong interest in supporting specific experiences when we engage with products [1]. This experience is influenced by the physical, sensual, cognitive, emotional, and aesthetic aspects of an interface. In IxD, the latter aspect has been extensively explored in what is called the aesthetics of interaction (AoI) [e.g. 4,8]. Lenz et al [4] consider that there are two aspects in the notion of AoI; the concrete interaction (the how) and the experience that derives from that interaction (the why).

Furthermore, one of the central principles in the AoI is that it should respect all human skills (i.e. the cognitive, perceptual-motor, emotional and social) [8]. This includes the sense of touch, experienced most prominently through our hands. To address the full potential of haptics we present an alternative approach to hIxD not starting from a concrete development of haptics (the how), as emphasized in the projects mentioned above, but from an experience (the why).

**Design of haptic effects**

We started with the design of a push button, a widely-adopted mechanism in products that can have a variety of haptic sensations. This simple interaction was chosen, to emphasize the haptic qualities.

**Experience**

We initiated our experience driven approach by exploring material properties. Consider for example, a wooly blanket of which the soft haptic experience

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1 Perception of temperature and pain, perception of motion through sensory capabilities of muscles and joints and perception of contact or motion between skin and object.
provokes a feeling of warmth and coziness (Figure 1). Through a variety of material sketches we explored the abstraction of such an experience, which could consequently be translated into the design of the push button. Therefore, the sketches were restricted to small, push button-like interactions. In an abstract manner, Figure 2 and 3 show some examples of either matching or contrasting qualities that we could translate to our intended haptic interaction in the push button. For example, the felt lantern (Figure 2) has low resistance and was lightly resilient. We evaluated these qualities as accommodating and friendly, which matched our intended interaction. The rubber dome (Figure 3), has a relatively high resistance, a sudden resilience and felt a bit unpredictable. These qualities did not align with the haptic sensations of our intended soft and warm blanket experience.

**Abstraction**
The perceived haptic sensations (how) were drawn into small graphs (force to position) (Figure 4). For example, in the lantern the force slowly increases and decreases smoothly (Figure 4, #5). These graphs enabled us to program the effect in such a way that the values of force and position were easily adjustable.

**Prototype**
We developed a prototype consisting of an Arduino DUE microcontroller to program a 3-Phase Brushless Gimbal motor with a high torque (0.35 N/m) range. The position of the motor is measured with a non-contact rotary encoder (AS5145). An in-line slider crank was used to translate the rotational movement to a linear movement. Different effects can be activated and the force intensity of the effects can be changed through the control box (Figure 5, r). The haptic feedback can be experienced through the push button (Figure 5, l).

**Haptic effects**
We designed six effects for the push button (Figure 4):

- **Constant force (#1):** the counterforce of the button is constant along the entire downward movement.
- **Assisting force (#2):** the button renders a force along with the downward motion when pressed, creating a ‘falling motion’.
- **Single click (#3):** a high force barrier is placed at the end of the downward motion, mimicking a click.
- **Two clicks (#4):** both half way the motion and at the end a barrier is programmed.
- **Gradual force (#5):** the intensity of the counter force increases until half way the downward motion and then decreases again.
- **Resilience (#6):** the counter force increases along the downward motion. Inherent to this effect, the button will come up again; as if there is a spring underneath the button.

Various graduate students working on haptics gave feedback on the haptic sensations. From these discussions, effect #6 (resilience) appeared most engaging because there was no end to the interaction (the button returned to its original position whereas in the other effects it did not). Therefore, we continued to explore haptic sensations in a knob, which has no set beginning or end. The technological setup equals the button, but without mechanical translation. Six effects with variables were designed (Figure 6) for the knob:

- **Intensity of barriers (#7):** the amount of force needed to rotate over a barrier as variable.
- **Distance between barriers (#8):** the number of barriers per rotation as variable.
- **Resilience (#9):** the counter force that increases along the rotation as variable. When the button is released, it will rotate back to its starting position.
- **Random barrier (#10):** The position of the barrier with a variable random change once rotated over.
- **Barrier with impact (#11):** when rotated against a barrier, the knob slightly rotates back and the barrier shifts forward in a variable distance.
- **Responsive force (#12):** The variable intensity of the counterforce is dependent on the speed of the user. The faster it rotates, the higher the intensity.

**Discussion and future work**

Haptic effects in interactive products are mostly designed from a technology driven (or concrete) perspective. Here, we present an alternative approach to hIxD, by starting our explorative design approach from an experience perspective (*the why*) and translating material properties into haptic qualities that contribute to evoking an experience (*the how*). Through an experience approach we first abstracted perceived haptic material qualities to design haptic effects using a dedicated prototype. The material sketches were used to relate experiences to perceived haptic interactions.

While previous studies [2,5] focused on designing specific haptic sensations, our work-in-progress illustrates that haptic sensations can have a lot more depth and subtleness. Haptic sensations will need to be designed to support aesthetic experiences and specific tools [e.g. 3,9] could support this process. We will further analyze how designers can start sketching a haptic sensation from an intended experience (e.g. how can we design a button that feels like a foam or what does it mean to inverse the properties of a foam?). Material sketches can enable designers to explore the aesthetics of haptics like sketches or form studies.

Although we focused purely on the haptic sense, it is mostly pre-informed by other modalities such as visual perception of physical properties (e.g. when picking up a plastic cup one applies less force than with a ceramic mug). On a more abstract level, this phenomenon is also addressed as one of the main principles of the AoI, which considers that besides the whole human body, the (social) context, practical use and dynamic form of design play a role too [8]. Thus, it seems impossible to think of aesthetics as an inherent quality of haptics, as experiences emerge in context and in use. Therefore, we will connect dynamic haptic qualities to other modalities (e.g. graphical user interfaces) and apply them in a (product) context to deepen our understanding of programmable haptics.

As part of the AoI, Wensveen et al. [10] explored how digital devices can inform users by coupling action and function through augmented information regarding time, location, direction, modality, dynamics and expression; like mechanical products do with inherent information. Given that haptic interfaces have programmable inherent qualities, further research should explore its effect on feedback and feedforward when merging the digital and physical domain. Particularly, how aesthetic haptics can invite or afford certain interactions? Finally, the resolution of haptic technologies is still rather limited compared to visual displays. However, we believe that an experience driven approach can provide directions to further develop smart actuators and robotic materials enabling high-resolution haptic interactions and experiences.
References


