Designing for Rich Interaction:
Integrating Form, Interaction, and Function

PhD Thesis

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Abstract

The subject of this thesis is human-product interaction, particularly interaction with consumer products.

From the start of the industrial age consumer products became more and more interactive. But, as electronics became small and sufficiently cheap to be incorporated into consumer products a new type of products emerged. Because of the tiny size of the functional components the products became smaller and the designer gained much freedom in giving form to these products. Moreover, the interaction with these products became designable. This had consequences for how these products are used. More importantly here, it has consequences for the product design process.

With the rise of interactive products the information-for-use that these products offered gradually became abstracted. Before products became interactive, information-for-use was a consequence of form and use, they addressed all skills of man (i.e., perceptual-motor skills, cognitive skills, and emotional skills). This contrasts with electronic products that depend for information-for-use on icons and labels on buttons and address primarily man's cognitive skills.

Interactive products have three properties: form, interaction, and function. These properties are related to each other. In this thesis a new interaction paradigm for interactive consumer products is explored: rich interaction. The freedom of form that is a consequence of modern electronics is exploited by having the form of products expressing what can be done with them. Thereby information-for-use can be offered that is inspired by function, and interaction can be opened up for all skills of man. To accomplish this, a new approach for designing interactive products is proposed that is design driven: an integral design process, inspired by the traditional design process, in which the three properties, form, interaction and function, are concurrently explored and designed so that the resulting products have a unity of form, interaction, and function.

This thesis follows a 'research through design' approach. This is an approach where products are designed to explore implications of theory in context. A research through design process generates knowledge on the products that are designed and on the process of designing these products. This knowledge is conditional but can be generalized in the form of design specifications for future products and in new theory or frameworks. This can be done under the condition that the researcher positions himself in theory to provide a context for the knowledge that is generated.

The context for this thesis is provided by two existing areas of research: tangible interaction and the theory of direct perception. The research area of tangible interaction concerns the physicalization of digital information and functionality. It opens up the realm of the digital for people's perceptual-motor skills. This research area is complemented by the theory of direct perception which states that man perceives his environment in terms of what he can do with it. It offers insight into how information-for-use can be given through expressive form.

These two research areas provide a basis for a first definition of rich interaction. To design for rich interaction is to start from people's skills, aiming at aesthetic interaction, concurrently designing form, interaction, and functionality. A framework for exploration is provided that can be used to design for rich interaction.

To demonstrate and further explore the concept of rich interaction five conceptual digital cameras are designed that cover a wide solution domain for rich interaction. Five interaction themes that all fit into the rich interaction paradigm are defined to spark the creative design process:

1. A digital camera with a minimal amount of controls
2. A digital camera with a control for each of its functions
3. A digital camera that fits the human body
4. A digital camera that uses a touch-screen only
5. A digital camera that has no labels on its controls

The designs for the camera are elaborated to the level of physical mock-up. While designing the five conceptual cameras it is found that two typical characteristics keep resurfacing as a result of the integration of form, interaction, and function. First, Mode-relevant action-possibilities (MR APs): action-possibilities that are only offered when they are relevant for the mode-of-use. Second, mode-of-use reflected in physical state (MURPS): in each mode-of-use the form of the camera is different. These characteristics effectively comprise the differences between a rich interface and a more conventional interface. The camera that has no labels on its controls possesses the most expressive relations between the two characteristics, it is therefore chosen for further investigation. For the rest of this abstract that camera is referred to as the camera with the rich user interface (RUI camera).

A first exploratory experiment is set up in which the mock-up of the RUI camera is compared to a mock-up of a camera with a more conventional interface. From this experiment two conclusions are drawn. First, to assess the quality of an interaction-style one needs working, interactive prototypes. Second, to compare different interaction-styles the influence of form should be constant, as far as possible. Therefore it was decided to build a working prototype of the RUI camera. Moreover, the prototype is made modular so that different interface modules can be fitted to make it possible to compare different interaction-styles within the same form-language.

Four interface modules are designed and built. Each module has a different interaction-style, systematically varied, based on the differences between the original RUI camera and conventional digital cameras. The first interface variation is an adaptation of the RUI camera, the fourth interface variation is an adaptation of a conventional camera. The second and the third interface variation each implement only one of the two differentiating factors. The second interface variation has MURPS but not MR APs. The third interface variation has MR APs but not MURPS. By means of combining the interface modules with the prototype four cameras can be assembled. Together these cameras span a range of interaction-styles from rich to conventional.

A second experiment is set up to investigate the qualities of the four interaction styles and to compare the rich interaction paradigm to the more conventional interaction paradigm. An important aspect of rich interaction is the aesthetic quality of interaction itself. Therefore the first hypothesis concerns the aesthetics of interaction. Next the differences between the interaction paradigms are investigated. Hypotheses two, three, and four concern the differentiating characteristics, the independent variables of the experiment. Finally, the fifth hypothesis concerns

two usability measures: efficiency and effectivity. The four different cameras were tested in a real-world setting, a photo-studio. Each participant used all four combinations to make three beautiful pictures of a still life and was asked to fill in questionnaires before and after use.

The analyses of the experimental results indicates that aesthetic interaction is present in the RUI camera, the camera that has both MR APs and MURPS. The experiment also reveales that MR APs influence the perceived ease-of-use positively, moreover, the cameras that employ MR APs are preferred over the other cameras. MURPS on the other hand did not seem to influence perceived ease-of-use or preference, positively or negatively. Finally, the RUI camera is not found to differ on efficiency and effectivity from the conventional camera. Only one of the cameras is found to differ on these measures, the camera that employs MURPS, but not MR APs. This is attributed to a usability problem that is found to be present in that camera.

Lastly a reflection is given on the work that was done. It is started with a refined definition of rich interaction:

> *Rich interaction: A paradigm for interactive consumer products that results in a unity of form, interaction, and function and taps human skills (perceptual-motor skills, cognitive skills, and emotional skills) for information-for-use thereby setting the stage for aesthetic interaction.*

This definition emphasizes three aspects of rich interaction.

First, to design for rich interaction is to integrate form, interaction, and function. Form, interaction, function and the relations between them are concurrently explored and designed.

Second, rich interaction taps human skills for information-for-use. This means that information-for-use is not abstracted from human skills but that functionality is directly accessible through expressive form. The theory of direct perception is an inspiration for this.

Third, the unity of form, interaction, and funtion combined with the skills inspired information-for-use paves the way for aesthetic interaction.

Then it is shown that the research on the cameras is relevant to different areas of research and application, including tangible interaction. Reflecting on the research through design method the knowledge that results from this research is discussed. The notion of rich interaction crosses the boundaries of existing frameworks. This is the result of the design approach that was taken, the specific viewpoint of the designer leads to different insights than the viewpoint from other areas of research. The context where the generated knowledge applies is the area of interactive consumer products. Finally, a plea is made for design as a generator as knowledge. For designers ask different questions. Different questions lead to different answers. Answering those questions is only possible through designing.

Joep Frens, 2006