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# Exploring Natural Interaction: Using Real-World Materials to Inspire Interaction Design



Figure 1: Examples for fluid materials: experiments with melted ice, oil paint, honey and eggs



Figure 2: Examples for granular materials: experiments with beans, styrofoam balls, rice and iron turnings

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## Abstract

Designers are often challenged to break free from the traditional interaction design for mouse and keyboard to create new and compelling user experiences for natural user interfaces. We conducted several workshops to inspire and provoke critical reflection on interaction and interface design for natural user interfaces based on physical substances that are used in everyday life [2, 3, 5]. The method used in these workshops has been developed as a hands-on alternative to the usual way of focusing on problems and solutions first in order to create new interfaces. We employ a playful experimental approach to generate ideas regarding visualization and interaction. In this paper, we detail our proposed method for exploring natural interaction and provide three examples from our previous workshops.

## Keywords

Inspiration, interaction design, interface design, tangible user interface, physical materials, exploration.

## ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

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CHI 2013, April 27 – May 2, 2013, Paris, France.



Figure 3: Examples for deformable materials: experiments with paperclips, plasticine, cotton wool and wax



Figure 4: Examples for elastic materials: experiments with balloon, fabric, flying rubber and foam material

## Introduction

In the field of Blended Interaction [8], designers of human-computer interfaces use metaphors to transfer functions and structural properties of a familiar concept to a new, abstract concept in a technical system. This paper focuses on finding inspiration for this kind of metaphors to design natural user interfaces.

There are several approaches that exploit physical behavior in digital worlds. Wilson et al. define a modeling technique for a physics simulation using sensor data from multi-touch surfaces as input [13]. In order to map two dimensional input onto three dimensional objects, they propose techniques to approximate their shape by processing multiple contacts. Langner et al. [9] built a collection of educational multi-touch games to enrich lessons for elementary science with simulated physics. Different methods like a sling shot using two or three fingers result in an entertaining interaction, making the underlying basic physics transparent to the user. A similar approach for sling shots investigating dexterity and precision as interaction attributes was developed in the game *Monsters* [12].

These approaches can be summarized as *Reality Based Interaction* [7]. According to Jacob et al. [7] these interaction styles exploit pre-existing knowledge and experiences of a user from his daily physical world – to a greater extent than WIMP interfaces. Consequently, understanding of our physical world – such as naïve physics – can be employed to match real world interaction with human computer interaction.

Most of the related approaches start right away in the “digital world” having only vaguely in mind how real

world materials behave. They presuppose a repertoire of metaphors, but for blending physical non-digital behavior of real-world materials and their visually offered affordances with digital interaction and information necessitates, a better and deeper understanding of materials of our daily lives is required. Döring et al. [4] investigate the implications of material qualities for tangible user interfaces based on material iconography, a research method from art history.

With this paper, we contribute to this body of work by methodically exploring shapeable natural materials and substances from daily life as inspiration in interaction design. We perceive digital data as shapeless, related bits and bytes without a *gestalt*. A shapeable, visual and interactive metaphor is needed to make data graspable. Therefore, we propose a method to investigate interaction with physical real-world materials to find shapeable metaphors for interaction and representation of digital data. This method is illustrated by examples of student experiments.

## Exploring Natural Interaction

In this section, our method developed for exploring natural interaction is detailed (see Figure 5). This method was used and refined in a series of workshops with undergrad students [2, 3, 5]. Participants work together in teams of two. First, they choose a favored material to observe and familiarize themselves with, then participants decide which experimental setup they prefer to use for exploring interactive and visual aspects. After this, they document relevant aspects using photos, videos, sketches, and models. Finally, for a deeper understanding and reflection of the findings, participants develop an appropriate use case, employing a mockup for telling their story.

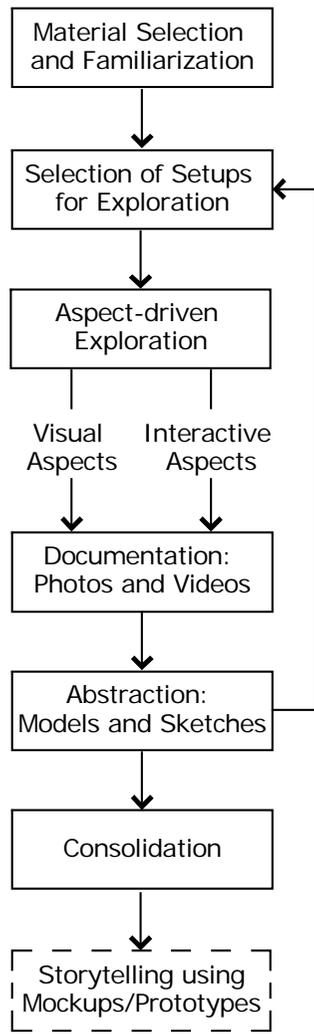


Figure 5: Method for exploring natural interaction

*Material Selection and Familiarization*

We provided shapeable materials from daily life in our workshops and classified these into four main categories: fluid, granular, deformable and elastic. Fluid materials include eggs, soap bubbles, oil, doe, water, and other fluids (see Figure 1). Examples for granular materials are rice, iron turnings, styrofoam pearls, sand, and beans (see Figure 2). Deformable materials can be plasticine, wax and cotton batting (see Figure 3). Deformations to these materials are permanent. Deformations of elastic materials are temporary, including balloons, flying rubber, foam material, and fabric (see Figure 4).

Participants could choose any materials out of these categories to explore the potential for interaction and visualization. To familiarize themselves with the chosen material, they are initially given time to simply play with it and look at intuitive ad-hoc interaction.

*Selection of Setups for Exploration*

To explore the material in a thorough manner, a suitable setup is needed to observe and document interaction and visual aspects. Therefore, we use a variety of experimental setups including our e<sup>x</sup>plora Table [2], overhead projectors, silhouette puppetry, boxes, and fish tank (see Figure 7).

**EXPLORE TABLE**

The e<sup>x</sup>plora Table (see Figure 6) consists of a wooden base frame and an acryl glass panel on top. Liquid substances are kept in place by a special plasticine boundary. Two video cameras capture user interaction and visual appearance from underneath and above the glass. The views of the cameras are instantly displayed

on a nearby wall or screen using a projector and are recorded for later review.

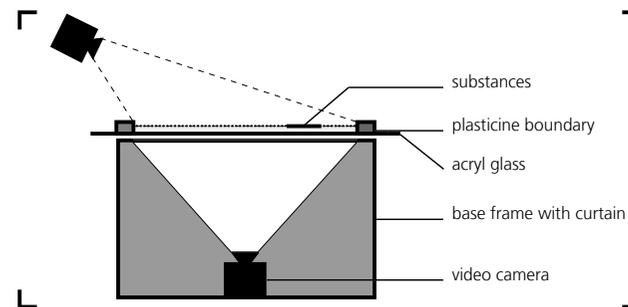


Figure 6: Schematic setup of the e<sup>x</sup>plora Table [2]

**OVERHEAD PROJECTOR AND SILHOUETTE PUPPETRY**

An overhead projector or a silhouette puppetry can be used to observe the schematic outlines, created by materials. Especially the visual reduction to two dimensions and gray shades helps to build a more abstract understanding of materials.

**BOX AND FISH TANK**

Boxes and fish tanks can be used to hold fluids and granular materials like water and sand in place. Fish tanks offer the possibility to observe behaviors from different angles and in underwater conditions. Like boxes, they enable interaction in three dimensions, e.g. sand or pearls can be filled in a box with other items to experience a "blind-fold" haptic search for the items.

*Aspect-Driven Exploration*

Using different setups, participants analyze chosen materials regarding interactive and visual aspects.

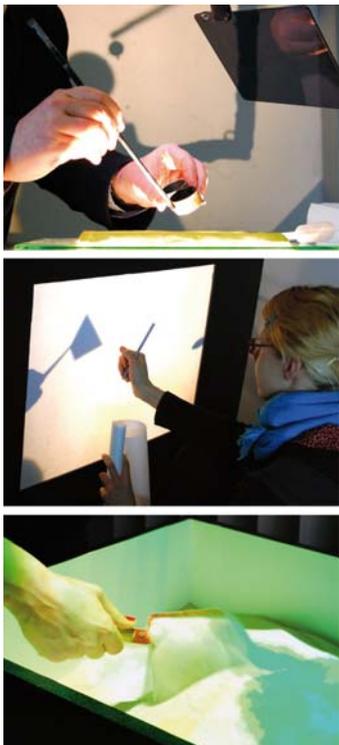


Figure 7: Setups and tools for analyzing interactive and visual aspects of materials: overhead projector (top), silhouette puppetry (middle) and box with shovel (bottom).

Interactive aspects include tasks from file management such as: *create, delete, move, select, link, copy, paste, open, close, and filter*. In the context of information visualization, interaction techniques are designed for adjusting and manipulating visual representations. Yi et al. propose the following categories of interaction techniques [14]: *Select, Explore, Reconfigure, Encode, Abstract/ Elaborate, Filter, and Connect*.

Navigational interaction tasks regarding orientation are: *rotate, zoom, and pan*.

Basic functions that are implemented in relational database applications can also be used as interaction aspects: *CRUD – Create, Read, Update, and Delete*; and *BREAD – Browse, Read, Edit, Add, and Delete* [11].

Visual aspects do not only include shape, silhouette, color, transparency, translucence, and reflectiveness but also aspects regarding movement: visual behavior when being pushed, touched, or otherwise interacted with. An interesting aspect could also be to look at how different materials can be combined visually.

#### *Documentation and Abstraction*

Participants are encouraged to use the interactive aspects mentioned above, to create a morphological box [15] for each material they observe (see Table 1). These boxes can be filled using text or sketches. Following this, they analyze how interaction takes place regarding their chosen materials: directly using hands or fingers, indirectly (e.g. blowing soap bubbles or moving iron turnings with a magnet), or employing a tool (e.g. shovel for sand). All findings are documented with videos, photos, as well as models and sketches.

#### *Consolidation*

In order to explore different facets of their material, workshop participants can iteratively exploit different experimental setups. After these steps, they consolidate their findings in form of short presentation for the other teams taking part in the workshop. This encourages mutual reflection.

	<b>thread</b>	<b>web</b>	<b>fabric</b>
<b>manipulate</b>	align, knot cut	pull, push, cut	pull, push, cut
<b>collect</b>	thread, tear off	push in	push in
<b>filter</b>	combine & separate	holes in web	push

Table 1: Morphological box used to analyze elastic fabrics

#### *Storytelling using Mockups or Prototypes*

To build a deeper understanding of the findings regarding interaction and visualization, participants of our workshops finally develop an intriguing use case and create a mockup or prototype to tell the story. Such a mockup can be a stop-motion video using cardboard cut-outs or the materials themselves. More sophisticated prototypes may consist of mixed setups including projection and real materials as well as digital interactive visualizations showing the observed behaviors.

These mockups, prototypes and stories are a source for inspiration for new interfaces and interaction designs.

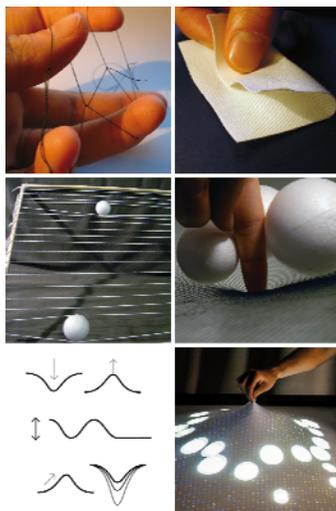


Figure 8: Exploration of fabrics with the resulting prototype *DepthTouch* [6].

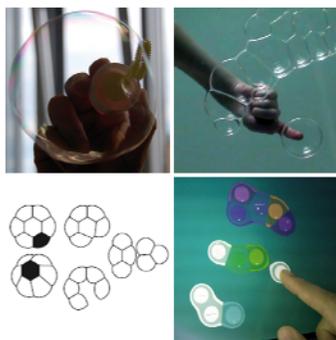


Figure 9: Exploration of soap bubbles with resulting prototype *BrainDump* [1].

## Examples

Some example results from our workshops are shown in Figures 8-10.

### *Fabrics*

For the exploration of fabrics, different parts and abstractions of this material like threads and webs are used for basic interaction tasks (see Table 1 and Figure 8). To document visual and interactive behavior photos, videos, and sketches (see Figure 8, bottom left) are used. During the experiments, students came up with the idea of projecting on elastic fabrics and used a depth camera to recognize touch input. The resulting setup is called *DepthTouch* [6].

### *Bubbles*

Bubbles have been used by workshop participants in air (see Figure 9, upper left) or on soapy water (see Figure 9, upper right). They can be interacted with in a variety of manners: directly – which mostly results in destroying the bubble – or indirectly by blowing them away or touching the water next to them, which results in waves pushing them into a certain direction. An interesting visual feature is the *Voronoi map* like appearance of groups of bubbles. When adding a bubble to a group, it changes its round outline at the contact zone into a straight line. This feature inspired a new visualization for a prototype named *BrainDump* [1] to collect and organize web information visually.

### *Plasticine*

The material plasticine is extremely flexible and deformable. Parts can be removed (see Figure 10, upper left) and added back again later or it can be combined with other objects (see Figure 10, upper right and bottom left). While playing with this material and

documenting possible behaviors and characteristics participants came up with the idea of using the material itself as a computer interface. It can be used to interact with information by squeezing, stretching, sticking, combining, or tearing it apart. Regarding the environment of a person using it, the material can be used to perform gestures to interact with the surroundings. A result of these explorations is the mockup *Kneadable Computer*<sup>1</sup>.

## Conclusion

This contribution presents a first step towards finding novel and compelling metaphors for interface and interaction design. In the future we will address the whole interaction cycle, looking at further necessary steps such as task analysis. An ongoing research question is how to find the suitable degree of abstraction of a real world material for use in the digital world.

## Acknowledgements

We like to thank the participants of our conducted workshops for their great work and the invaluable feedback on the process. On behalf of Marius Brade this research (contract no. 080951799) has been funded by the European Social Fund and the Free State of Saxony as well as SAP Research. Mandy Keck's research has been supported by the European Union and the Free State Saxony through the European Regional Development Fund (ERDF). On behalf of Thomas Gründer this research has been funded by the European Social Fund and the Free State of Saxony.

<sup>1</sup> *The Kneadable Computer*: <http://youtu.be/6TpsW0sL96U>



Figure 10: Plasticine used directly as interface for the *Kneadable Computer*.

## Citations

- [1] Brade, M., Brändel, C., Groh, R. BrainDump: taking fluid interaction literally. *Proceedings of the International Working Conference on Advanced Visual Interfaces (AVI '12)*, Genny Tortora, Stefano Levialdi, and Maurizio Tucci (Eds.). ACM, New York, NY, USA (2012), 790-791. DOI: [10.1145/2254556.2254716](https://doi.org/10.1145/2254556.2254716), Video demonstration: <http://youtu.be/p4JCOcc24BI>.
- [2] Brade, M., Kammer, D., Keck, M. and Groh, R. Immersive data grasping using the e<sup>x</sup>plora table. *Proceedings of the fifth international conference on Tangible, embedded, and embodied interaction (TEI '11)*. ACM, New York, NY, USA (2012), 419-420. DOI: [10.1145/1935701.1935809](https://doi.org/10.1145/1935701.1935809), Video documentation: <http://youtu.be/ygAq8JHGtvM>.
- [3] Brade, M., Keck, M., Gründer, T., Müller, M. and Groh, R. Natural Interface Exploration. *Proceedings of the seventh international conference on Tangible, embedded, and embodied interaction (TEI '13)*. ACM, New York, NY, USA (2013).
- [4] Döring, D., Sylvester, A. and Schmidt, A. 2012. Exploring material-centered design concepts for tangible interaction. In *Proceedings of the 2012 ACM annual conference extended abstracts on Human Factors in Computing Systems Extended Abstracts (CHI EA '12)*. ACM, New York, NY, USA, 1523-1528. DOI=[10.1145/2223656.2223666](https://doi.org/10.1145/2223656.2223666)
- [5] Keck, M., Gründer, T. and Groh, R.: Video documentation of Explore Room experiments: <http://youtu.be/ZdyBQ1HbBVg>. Visited Jan. 17<sup>th</sup>, 2013.
- [6] Peschke, J., Göbel, F., Gründer, T., Keck, M., Kammer, D., Groh, R. DepthTouch: an elastic surface for tangible computing. *Proceedings of the International Working Conference on Advanced Visual Interfaces (AVI '12)*, Genny Tortora, Stefano Levialdi, and Maurizio Tucci (Eds.). ACM, New York, USA (2012), 770-771. DOI: [10.1145/2254556.2254706](https://doi.org/10.1145/2254556.2254706).
- [7] Jacob, R.J.K., Girouard, A., Hirshfield, L.M., Horn, M.S., Shaer, O., Solovey, E.T., Zigelbaum, J. 2008. *Reality-Based Interaction: A Framework for Post-WIMP Interfaces. Proceedings of the SIGCHI conference on Human factors in computing systems (CHI 2008)*, ACM, New York, NY, USA, 201-211. DOI: [10.1145/1357054.1357089](https://doi.org/10.1145/1357054.1357089).
- [8] Jetter, H. C., Geyer, F., Schwarz, T., Reiterer, H. (2012). Blended Interaction - Toward a Framework for the Design of Interactive Spaces. Workshop Designing Collaborative Interactive Spaces (DCIS 2012) at AVI 2012.
- [9] Langner, R., Brosz, J., Dachsel, R. and Carpendale, S. 2010. PhysicsBox: playful educational tabletop games. In *ACM International Conference on Interactive Tabletops and Surfaces (ITS '10)*. ACM, New York, NY, USA, 273-274. DOI=[10.1145/1936652.1936712](https://doi.org/10.1145/1936652.1936712).
- [10] Lee, J. C. *In search of a natural gesture*. XRDS 16, 4 (Jun. 2010), ACM, New York, NY, USA (2010), 9-12. DOI: [10.1145/1764848.1764853](https://doi.org/10.1145/1764848.1764853).
- [11] Martin, J. 1983. *Managing the Data Base Environment* (1st ed.). Prentice Hall PTR, Upper Saddle River, NJ, USA
- [12] Müller, M., Franke, I.S., Kammer, D. and Groh, R.: Business Oriented Design of Collaborative Applications, In: *Workshop Designing Collaborative Interactive Spaces (DCIS 2012) at AVI 2012*, HCI Group, Univ. of Konstanz, 2012.
- [13] Wilson, A.D., Izadi, S., Hilliges, O., Garcia-Mendoza, A. and Kirk, D. 2008. Bringing physics to the surface. In *Proceedings of the 21st annual ACM symposium on User interface software and technology (UIST '08)*. ACM, New York, NY, USA, 67-76.
- [14] Yi, J. S., Kang, Y., Stasko, J., Jacko, J. (2007). Toward a deeper understanding of the role of interaction in information visualization. *IEEE Trans. on Visualization and Computer Graphics*, 13(6):1224-1231.
- [15] Zwicky, F. *Discovery, Invention, Research Through the Morphological Approach*. MACMILLAN, 1969.