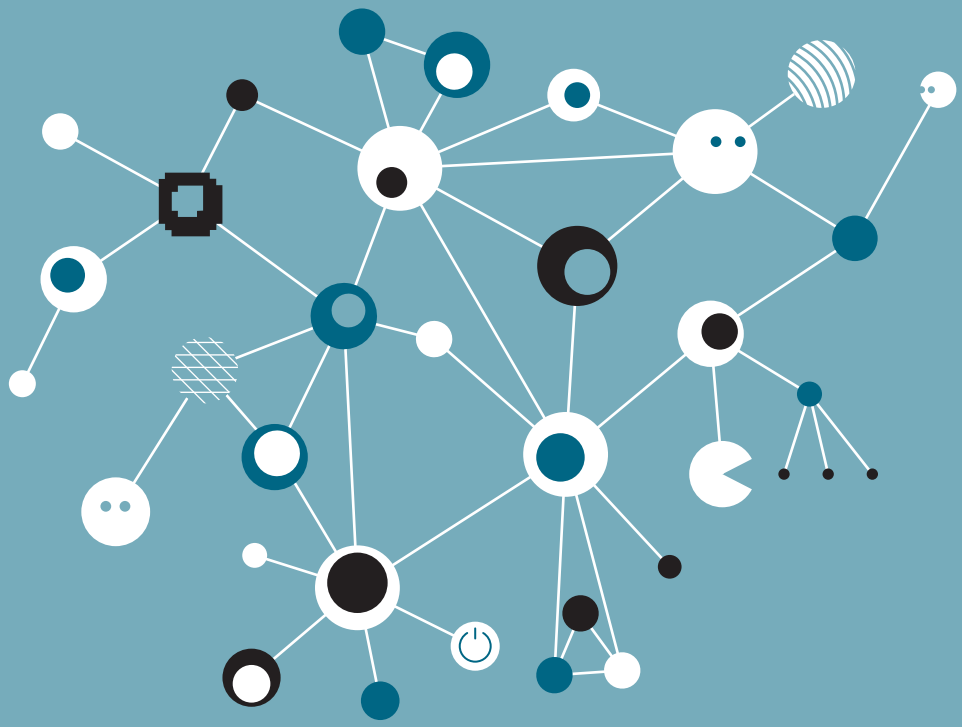

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Interrelating Materials, Artifacts, Interaction Designers, and Users

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Interrelating Materials, Artifacts, Interaction Designers, and Users

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Kurzfassung. Das Ziel dieser Dissertation ist es, zentrale Entitäten der Mensch-Maschine Interaktion sowie des Interaktionsdesigns miteinander in Beziehung zu setzen, um ein besseres Verständnis der Zusammenhänge zu generieren. Dabei werden menschliche und nicht-menschliche Akteure adressiert, d.h. NutzerInnen und DesignerInnen einerseits, physisches und digitales Material, sowie die durch Kombination der Materialien entstehenden interaktiven Artefakte andererseits. Hauptaugenmerk wird dabei auf den wissenschaftlichen Diskurs zu *materiality* gelegt, d.h. auf den Erlebnisgehalt einer Interaktion, der erst durch eben diese Interaktion entsteht. Neben der Auseinandersetzung mit dem Begriff *materiality* bestehen die *theoretischen Beiträge* aus der Erfassung der Beziehungen zwischen NutzerInnen und Artefakten, einschließlich jener Zusammenhänge, die entstehen, wenn Technologien zwar nicht genutzt werden, sich dennoch auf den Menschen auswirken. Dazu dienen die Akteur-Netzwerk Theorie als auch medientheoretische Überlegungen als Grundlage, da beide es nicht nur ermöglichen, die Aktivität der menschlichen Akteure darzustellen, sondern auch jene der Materialien bzw. der interaktiven Artefakte. Als *methodologischer Beitrag* wird ein *materiality*-zentrierter Ansatz vorgestellt, um Interaktionen sowohl aus Sicht menschlicher als auch nicht-menschlicher Akteure abwechselnd zu untersuchen, um sie dann miteinander in Beziehung zu setzen. Die den theoretischen als auch methodologischen Reflexionen zugrunde liegenden empirischen Studien sind in zwei sehr unterschiedlichen Anwendungsbereichen verortet. Zum einen wurden Interaktionen zwischen älteren Menschen und Technologien untersucht, zum anderen jene zwischen Operatoren und Maschinen in einer Fabrik. Die Konsequenzen, die sich daraus für das Design von interaktiven System ableiten ließen, stellen schließlich die *angewandten Beiträge* dieser Dissertation dar. Zusammengenommen zielen alle diese Forschungsbeiträge darauf ab, den wissenschaftlichen Diskurs im Interaktionsdesign, der Mensch-Maschine Interaktion, und auch darüber hinaus, zu unterstützen.

Abstract. The aim of this PhD thesis is to study relationships between central entities in Human-Computer Interaction (HCI) and Interaction Design in order to contribute to a better understanding of the interplay between them. Within my work, I specifically address users and designers as human actors, physical and digital design materials, as well as the interactive artifacts which are constituted of these materials, as non-human actors. Thereby, specific attention is paid to the scientific discourse on *materiality*, i.e., a quality of an interaction with an interactive artifact or material, which emerges only through this particular interaction. Additional to discussing in detail what materiality is constituted of, my *theoretical contributions* provide a framing for interactions between users and artifacts, including relations that reveal influences of technology on human actors even in case of non-use. Actor-Network Theory and media theory are the basis for this framing, as both allow to emphasize not only humans' activity, but also those of materials or technological artifacts. In terms of *methodological contributions*, I illustrate a materiality-centered approach to data analysis, which alternately studies networks from the perspective of material and human actors to subsequently relate them with each other. The empirical investigations, which nurture the theoretical and methodological reflections, are situated in two distinct fields (i.e., older adults using technology, as well as operators interacting with factory equipment in a production environment), resulting in different perspectives on a variety of interactions. The consequences for the design of interactive systems, which were derived from these studies, may finally be considered the *applied contributions* of this thesis. All of these research contributions aim to support the scientific discourse on materiality in Interaction Design, HCI, and beyond.

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Preface

The work, which constitutes my PhD thesis, illustrates a scientific journey that origins from and brings together a variety of disciplines and perspectives. The initial research interest emerged through the involvement with media theoretical considerations that were part of my studies in educational sciences at the University of Innsbruck. Therein, I focused on Media Pedagogy, a field of research that asks questions of whether and how to include media in education, with the aim to not only adequately teach children, but educate all generations about and via media. Furthermore, it discusses what larger impacts media have on the individual and on society. Consequently, both the human and the technology are in the center of attention. I started to specifically look at the situation of older people and their relation to media in order to find out about educational potentials and barriers.

With the possibility to start working on a research project focusing on older adults at the HCI & Usability Unit of the ICT&S Center (University of Salzburg), I became acquainted with applied research. With the previous theoretical work in educational science and this rather applied project work, it took me a while to figure out how exactly they may be combined and what the contribution of such a combination might be. Retrospectively, the main contribution, I would argue, is that theoretical notions of educational sciences allow to critically reflect

on the field, i.e., analyzing empirical, observational data of human-computer interactions through a theoretical lens leads to implications that I would not have been able to derive without a theoretical framing. Conversely, all theoretical work would be meaningless without any possibility of application; it would become an end in itself.

I find it intriguing what connections can be made and how one understanding leads to another, including theory and application, methodologies and practices. During my PhD journey, I found one related field specifically interesting and relevant, namely, Interaction Design. It is the field that I address with my discussions and implications. Presumably, it attracts me as it is concerned with changing the current state, imagining future states, and exploring them. That's what I wish to contribute to.

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Introduction 1

This thesis focuses on the relation between humans and interactive artifacts, including the materials used for designing these artifacts and the materiality that arises through using them. The scientific discourse around issues of materiality is vivid in many disciplines, for instance, in textual studies (e.g., [20, 54]), anthropology (e.g., [51]), product design (e.g., [1]), Media Pedagogy and media studies (see e.g., [100]), HCI (e.g,. [105]), and Interaction Design (see e.g., [94, 104]).

In disciplines which are concerned with digital materials, the scientific discourse is strongly influenced by questions about the nature of interactive artifacts, i.e., physical and computational materials constituting an artifact, which is experienced by users. However, users do not experience the materials separately, but as combinations that allow a specific interaction, which may be referred to as the *materiality of interactive artifacts*.

For instance, in HCI and Interaction Design, a "material turn" has emerged over the past few years (e.g., [24, 79, 105, 106]), which led to an increased attention towards material aspects in design research. However, with this emphasis on interactive materials, a fundamental discussion on what materiality is evolved (e.g., [39, 53]). Media are considered as being hyper, virtual, or cyber in order to indicate that they are situated outside of the known materiality. They exist independently of the usual (e.g., physical, societal) material constraints and determinants [101], although computation or software is bound to a physical data carrier [84].

The complexity of digital code is necessarily black boxed in user-friendly interfaces, and this makes assumptions of mysterious immateriality hard to exorcize. [101, p. 9]

Fuchsberger, V., Murer, M., Wilfinger, D., and Tscheligi, M. Attributes of successful intergenerational online activities. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology* (New York, NY, USA, 2011), ACE '11, ACM, pp. 50:1–50:8.

Fuchsberger, V., Nebauer, J., Moser, C., and Tscheligi, M. Design challenges and concept for intergenerational online learning. In *Proceedings of the 11th International Conference on Interaction Design and Children* (2012), ACM, pp. 192–195.

Fuchsberger, V. Generational divides in terms of actor-network theory: Potential crises and the potential of crises. In *Online proc. 7th Media in Transition Conference*, MIT, Cambridge (2011).

Fuchsberger, V., Murer, M., and Tscheligi, M. Human-computer non-interaction: The activity of non-use. In *Proceedings of the 2014 Companion Publication on Designing Interactive Systems* (New York, NY, USA, 2014), DIS Companion '14, ACM, pp. 57–60.

Fuchsberger, V., Murer, M., and Tscheligi, M. Materials, materiality, and media. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (New York, NY, USA, 2013), CHI '13, ACM, pp. 2853–2862.

Fuchsberger, V., Murer, M., Wurhofer, D., Meneweger, T., Neureiter, K., Meschtscherjakov, A., and Tscheligi, M. The multiple layers of materiality. In *Proceedings of the 2014 Companion Publication on Designing Interactive Systems* (New York, NY, USA, 2014), DIS Companion '14, ACM, pp. 73–76.

Fuchsberger, V., Murer, M., Meneweger, T., and Tscheligi, M. Capturing the in-between of interactive artifacts and users: A materiality-centered approach. In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational* (New York, NY, USA, 2014), NordiCHI '14, ACM, pp. 451–460.

The work described here is positioned in the scientific realms of HCI and Interaction Design, with strong influences of media studies, and references to further related disciplines, such as textual studies. It attempts to *provide a theoretical framing of the materiality discourse*. Understanding materiality as residing in the interactions between materials and designers, or between users and the designed interactive artifacts, I aim to enhance our knowledge of materiality when it comes to interactive artifacts by investigating these interactions and interrelations. Based on reflections (e.g., referring to Actor-Network Theory and media theory) and investigations in the field (e.g., considering the question of how to assess materiality) this thesis provides theoretical, methodological, and empirical contributions. It is a cumulative thesis, meaning that seven published scientific articles are its core, accompanied by an introduction that clarifies their relations and which summarizes and discusses the contribution.

This thesis is structured as follows. In the beginning, I briefly outline the three scientific disciplines that I have explicitly addressed in my thesis, i.e., Media Pedagogy, HCI, and Interaction Design (Chapter 2). Subsequently, I juxtapose their characteristics to illustrate intersections that I found relevant for my work (Chapter 2.4) and describe the theoretical background and related work (Chapter 3). Then, I provide an overview of my research contributions for this cumulative thesis (Chapter 4.2), before detailing my individual research contributions (Chapters 5.1 to 5.5), i.e., seven research papers.[1] Afterwards, I summarize and discuss these contributions and their limitations (Chapter 6), and conclude by depicting prospective work (Chapter 7).

[1] The actual publications can be found in the second part of this thesis

Foundations 2

In order to clarify the scientific positioning of this work, the main characteristics of *Media Pedagogy*, *HCI*, and *Interaction Design* are outlined in the following paragraphs. Subsequently, I will contrast them in order to illustrate how they relate in regards to this thesis.

Media Pedagogy 2.1

Media Pedagogy may be regarded as a subdiscipline of educational science [97]. Educational science itself is threefold; there is an empirical strand that applies experimental methods, a humanistic school of thought that employs hermeneutic procedures, and an emancipatory strand with its ideology critical analyses. In order to be practically relevant, recent approaches center around action, for instance, action research or "Design-Based Research" (i.e., having a design experiment as its main practical method in the wild [78]). These approaches attempt to develop for and explore innovative learning as well as teaching scenarios and to establish and refine contextual theories [97]. Media Pedagogy, being oriented towards new media (such as Web 2.0 [25]), is concerned with knowledge production that is influencing or influenced by media.[2]

Thereby, media may be understood as interfaces that mediate between humans and the world (designation), between humans and their acquaintances (communication), and between humans and themselves (self-understanding) [16]. They appear self-evident, but upon reflection, they appear to be multifaceted and multivalent "things" that are non-localizable at best [107]. However, the study of phenomena related to media in education

[2] Reflecting on the term "new media", Boomen et al. [101] note in the introduction to their book on Digital Material that, although digital machines are widely distributed and taken for granted at the beginning of the 21st century, we still call them new media.

becomes inevitable with the technological diversity and societal, as well as educational, reactions towards media:

In order to understand knowledge dynamics and to find orientation in contemporary media constellations, we need knowledge about the relationship between media forms and media knowledge. [50, p. 32]

Key concepts in Media Pedagogy are, for instance, media education, media literacy, and media competence. Media education may be considered a synoptic term, which covers educationally relevant processes that are related to media [96], but which are not coercively related to school or children's education [95]. Media literacy, considered as a specific concept within the area of media education, is often used synonymously to media competence; however, considering media literacy as a set of skills and competences may fall short, as it neglects the social diversity of literacy practices [9]. Media literacy is, consequently, more than the minimal skills that enable users to operate media effectively. This calls for a broader conception of media literacy than a purely functional definition, which, for instance, includes

[...] the symbolic or persuasive aspects of digital media, of the emotional dimensions of our uses and interpretations of these media, or indeed of aspects of digital media that exceed mere 'information'. [9, p. 47]

However, many concepts of media competence that emerged in German-speaking countries (see e.g., an overview of the respective history in [103]) are similar to what is discussed internationally under the notion of literacy. This resulted in a vast variety of understandings of media competence, literacy, and literality [49]. Additionally, not only is the challenge on how to distinguish and contrast these notions discussed, but actually whether these "literacifications" are part of the problem, or the solution [49].

In order to face these challenges, the field is opening up towards a variety of disciplines (e.g., not only psychology or philosophy, but also cybernetics, information technology, or neurosciences) and the

[...] debates about media competence have reached a point at which the opposition between technophobic humanities and cultural studies, on the one hand, and techno-euphoric engineering and natural sciences, on the other, has become historically obsolete. [48]

However, Media Pedagogy is not only concerned with competencies, but also with aesthetic experiences and educational processes, although they are harder to verify [48]. In a broader perspective, Media Pedagogy contributes to the scientific discipline of media studies, i.e., a constellation of interdisciplinary studies and activities holding a common interest in (electronic) mediation, including television, film, the Internet, games, or any new technologies [107]. Media studies are strongly influenced by cultural studies and critical theory [107], or considered as complementary [40].

Human-Computer Interaction (HCI) 2.2

HCI is concerned with the design, evaluation, and implementation of interactive systems to be used by humans and includes the study of surrounding phenomena [88]. It is an interdisciplinary field of research that includes notions of psychology, engineering, design, philosophy, linguistics, communication sciences, and so forth. According to Harrison and colleagues [41, 42], HCI currently is in its third paradigm.

While the first paradigm was characterized by research on human factors (i.e., interaction as a form of man-machine

coupling), the second focused on classical cognitivism and information processing (i.e., human minds and computers are coupled information processors). The third paradigm

[...] contains a variety of perspectives and approaches which focus on interaction and its study as phenomenologically situated. The goal for interaction is to support situated action and meaning-making in specific contexts, and the questions that arise revolve around how to complement formalized, computational representations and actions with the rich, complex, and messy situations at hand around them. [41, p. 389]

Similar to Media Pedagogy, which focuses on the "mediatic turn" and the "digital turn" to frame current educational phenomena, several contemporary turns in HCI may also be observed, i.e., a turn to design, to culture, to the wild, and to embodiment [81].

These indicate that interactions are no longer considered apart from cultural situations (i.e., they are situated). Therefore, the "wild" becomes a necessary area of investigation, as situatedness cannot be simulated. Furthermore, embodiment is regarded as a central characteristic of our current understanding of interactions. Briefly speaking, it means that interactions are a practical engagement with the social and the physical environment [81], i.e., context and activity are mutually constitutive,

[...] allowing users to negotiate and evolve systems of practice and meaning in the course of their interaction with information systems. [18, p. 28]

Additionally, cultural aspects are increasingly paid attention to, bringing along a variety of theoretical, interdisciplinary discussions (e.g., [2, 21]). And finally, design becomes central to

explore and inquire about interactions, culture, or designs (e.g., [23, 36, 83]). Thus, the discourse around Interaction Design is strongly interwoven with HCI phenomena and research.

2.3 Interaction Design

Interaction Design "is about shaping digital things for people's use" [69]. According to Löwgren, there are five major characteristics of Interaction Design:

1. Design involves changing situations by shaping and deploying artifacts

2. Design is about exploring possible futures

3. Design entails framing the "problem" in parallel with creating possible "solutions"

4. Design involves thinking through sketching and other tangible representations

5. Design addresses instrumental, technical, aesthetical and ethical aspects throughout

One specific challenge of Interaction Design rests in the nature of its design materials, being physical and computational. The computer, as a design material, is specifically complex and different than other materials, as it has the ability to change between states, i.e., its temporal form [98]. This requires a design practice that encompasses temporal form giving in combination with physical form giving and performance of the interaction gestalt (i.e., a performance of movements that users do in relation to the interactive artifact) [98]. While these design practices are

essential for every interaction design effort, there is one distinction to be made regarding design practice and design research. This distinction is necessary, as many of the below described contributions address design, but in different ways. When I refer to design practice, it is the profession I am addressing. Referring to design research, such as Constructive Design Research (e.g., [56]) or Research through Design (e.g., [3, 13, 35, 109]), I specifically aim to contribute to research that incorporates constructive design. Design practice and research differ in several ways (e.g., [22, 74, 80, 90]), requiring a sensitivity towards the goals and purpose of design.

2.4 Media Pedagogy, HCI and Interaction Design: Intersections

All three disciplines address interrelations of humans and technology. While Media Pedagogy addresses educational issues, HCI and Interaction Design Research – a priori – do not address specific users, purposes, or technologies. Design, as a precondition in all three disciplines, is not only considered an object of study, but also a means to study phenomena, e.g., when it comes to Constructive Design Research in Interaction Design and HCI, or Design-Based Research in Educational Sciences. All three disciplines' scope ranges between studies of individual phenomena, e.g., a specific interaction, learning environment, or artifact, and orientations towards impacts on society and culture.

They certainly vary in paradigms, epistemological interests, methodologies, and terminology, but at the same time share the overall goal of improving people's and society's worlds, which is permeated by technology (e.g., critical theory can be found in all three disciplines as an means to question the status quo). All above-mentioned disciplines value interdisciplinarity in order to cope with the phenomena that surround usage and design of

technology, which change fundamentally with the progress in technological and societal developments. However, the extent of interdisciplinary research differs; for instance, a mixture of disciplines is fundamentally anchored in HCI's self-conception, whereas Media Pedagogy is just opening up (see e.g., [48]).

The tension between theoretical and applied research is one further commonality, which challenges all of these disciplines by requiring them to provide applied, practically relevant research while at the same time generating theoretical knowledge to nurture the scientific discourse. Borrowing Donald Stoke's terminology on basic science and technological innovation (which he labels as "Pasteur's Quadrant"), these three disciplines provide contributions in terms of pure basic research, use-inspired basic research, pure applied research, and finally, what may be called curiosity-driven explorations. These explorations are not a priori basic or applied research, but are likely to be precursors for subsequent basic or applied research [89]. HCI, Interaction Design and Media Pedagogy are characterized by a range of scopes and epistemological interests, which are not coherent even within each discipline. While these tensions are challenging in terms of understanding and legitimacy of research contributions, they also allow a broad range of perspectives and approaches.

This thesis is affected by these tensions, but also contributing to better understand, utilize or, if necessary, overcome them. It consists of theoretical, empirical, and methodological contributions, connects media theory with Interaction Design, and social theories with HCI. Apart from these paradigmatic positionings, there are specific theories and discourses that this thesis addresses in particular, as described in the following section.

Theoretical Background and Related Work 3

The theoretical background for this thesis is constituted, on one hand, of Actor-Network Theory, i.e., a theory originating from the social sciences. On the other hand, McLuhan's work on media is drawn upon, which is an early contribution to media theory. Both allow to address the *active* role of media, interactive artifacts, and materials and are, thus, fundamental for my thesis. For this reason, they are further described below. Afterwards, I depict the current scientific discourse that is addressed in this thesis, i.e., materials and materiality in HCI and Interaction Design. This background informs the research questions and approach, which are described subsequently.

Actor-Network Theory and Monads 3.1

Actor-Network Theory (ANT) originated from Science and Technology Studies, attempting to describe "the social" as associations between different actors, which constitute a network. One of its main characteristics is that both human and non-human "things" can be actors the moment they influence another actor. This can be the technology influencing a human, but also a human influencing a technology. As soon as there is activity between actors, they form a network; however, this is only for the purpose of this specific activity [61]. ANT is, therefore, not a stable theory of actors, it rather assumes radical indeterminacy [10]. Any given phenomena is described in its actual constitution (e.g., what actors are involved, how they are interacting), but it is not decisive why the actors do certain things [64]. Bruno Latour (e.g., [61]), John Law (e.g., [65]) and Michel Callon (e.g., [10]) were leading in the development of ANT in the 1980s and still contribute to its discussion and refinement. In their later work, Latour and colleagues refine actor-networks by referring to *monads*,[3]

[3] Monads have been introduced in the 18th century by the philosopher Gottfried Wilhelm Leibniz. However, in this thesis, Bruno Latour's understanding of monads is the basis (see e.g., [62, 64]), although recognizing that his notion of monads is informed by a grand scientific discourse. Latour refers to Gabriel Tarde's notion of monads, arguing that there are not individual elements, but monads (i.e., representations, reflections, or interiorisations of a whole set of other elements borrowed from the world around) [62].

emphasizing that the social is characterized of networks rather than of separable individuals. Entities that are initially "just a dot", but then they fill in

[...] with more and more elements that specify it more and more until the observer considers that he or she knows enough and begins to take the name of the entity for the entire list. [64, p. 7]

In HCI, ANT has been referenced several times (e.g., [57, 91, 93]). However, it has primarily been considered to describe the relation between artifacts and users, not regarding materials and their relation to designers. Furthermore, it has been criticized for the symmetry of actors it assumes (e.g., [91]), as

[...] persons and artifacts do not appear to constitute each other in the same way. [91]

However, whereas the assumed symmetry may be problematic when human's motives are in the center of an analysis, it is valuable to take symmetry as a starting point for analyzing actor-networks (or monads) (see also Chapter 5.5).

3.2 Media Theory

From an ANT perspective, interactive artifacts have agency in relation to humans. Similarly, the notions provided by McLuhan's media theory also emphasize the active role of media. The media (and not the content) would influence, if not determine, their effect on humans [72]. Based on Fiore's and McLuhan's writings in their seminal book on "The medium is the message" [72], they have been interpreted as just being technology determinists. Contrasting this notion, Friesen and Hug [26] rather construe their position as defining the media "coming before" other

considerations, but media do not necessarily found or give rise to social, cultural, and historical phenomena. A further (for this work relevant) notion provided by McLuhan is his observation that media from previous media ages would influence younger technological developments, which he considers problematic, as we would not make use of the full potential of new media, especially electronic media [70].

McLuhan also differed between sensory impressions and sensory effects; while the first are what a medium provides (e.g., releasing sound waves), the latter is the sense obtained, i.e., the sensory impact (e.g., acoustic perception) [26]. These notions still provide a relevant source of theoretical underpinnings, although they have been expressed almost 50 years earlier. The issues, which McLuhan described, can still be found in the discourse on materials and the materiality of human-computer interaction. However, while media theory has been referred to in HCI before (e.g., [39] as a recent example), there have been only few references to McLuhan's work (e.g., [6, 102]), and none of them relating it to the materiality discourse (see details in [30]).

3.3 Materials and Materiality

Additional to these theories, the work described here is also strongly informed by current HCI research on "materials" and "materiality" (e.g., [24, 39, 82, 99, 106]).[4] In terms of Interaction Design, both physical and computational materials are in the focus of research, as well as the combination of those in the design of an interactive artifact, which consists of a temporal form, a physical form, and an Interaction Gestalt [98]. The physical form is an artifact's three-dimensional shape, the temporal form is the pattern of the state change (which is a key characteristic of interactive artifacts), and the Interaction Gestalt is the

[4] As will be detailed later on, not only notions of materials and materiality as provided in HCI and Interaction Design play a significant role in this thesis, but complemented by discussions in disciplines like textual studies, anthropology, or information studies.

performance of movements a user will do in relation to the artifact (e.g., touching) [98]. The Interaction Gestalt is experienced by the user in form of an interaction quality [68].

In contrast to materials, which are related to the form giving practice of Interaction Design, materiality is related to the user's perception of an interactive artifact. It is a rather abstract concept of the relationship between users and the material artifact in terms of how it is used out in the world [53]. One aspect that relates to the materiality of artifacts is meaning, i.e., a user's subjective interpretation of qualities and values, which influences how users experience the artifacts and how they understand them in their personal and social life. Another aspect is related to material ecology, i.e., how different artifacts surrounding users are related to each other, how they work together, or compete with each other [53].

Gross et al. [39] explore three major strands of contemporary materiality research in HCI, i.e., physical materiality, metaphysical materiality, and craft-oriented approaches. Tangible user interfaces (e.g., as understood by [52]) are what Gross considers having physical materiality. Metaphysical materiality refers to the combination of physical and computational materials (e.g., [99]). Thereby, the materiality of computation can only be observed indirectly, i.e., through the artifacts that employ it and the interactions with the artifact. Materiality, considered as a form of tradition communicating, emphasizes the crafting aspect in design practice (e.g., [37]) that involves materiality of interactions with design materials. Gross and colleagues relate these strands to philosophical aesthetics, visual cultural studies, and media theory, arguing that media theory is able to accommodate and augment individual understandings of materiality [39]. They recognized that the materiality discourse in HCI is closely related to framings provided by disciplines apart from HCI and Interaction Design, which is a fundamental argument of this thesis as well.

Research Contributions 4

Having outlined the theoretical background and related work, an overview of, and relations between, my research contributions are presented in this chapter. I begin with a description of the main objective, the research questions, and the approach.

Research Objective and Approach 4.1

The main research objective of my thesis is to reflect on materials and materiality based on Actor-Network Theory and media theory, in order to better understand the relation between several actors in HCI and Interaction Design. Therefore, the research questions that I aim to answer with this thesis are as follows:

1. How is the relation between different central actors in Human-Computer Interaction (users, non-users, interactive artifacts, Interaction Gestalt, etc.) and Interaction Design (designers, materials, etc.) constituted?

2. How do physical and digital materials, as well as materiality, relate?

3. How would a materiality-centered approach to data collection and analysis look like?

The work presented here is based on hermeneutic procedures, i.e., methods for text interpretation are applied, as they support *understanding the meaning* of phenomena (opposed to natural sciences that seek to *explain* them). By interpreting the topics outlined above through these discursive approaches, the aim is to broaden the theoretical framing of relations between various actors in HCI and Interaction Design.

Furthermore, ANT itself provides a method to describe relationships between actors, i.e., fully established descriptions of actor-networks [61]. This means that either the user, the designer, or the artifact, the material (which are also understood as actors) can be a potential starting point in framing their active role in relation to further actors. Based on this methodology and a respective refinement due to Latour's work on monads [64], we[5] furthermore discuss methodological potentials for a materiality-centered approach, which will be described later on (see Chapter 5.5). The core of this thesis is constituted of seven research publications. Before summarizing them, I describe the way this thesis evolved and how the respective contributions are related.

4.2 Overview of Contributions

I started my research with an interest in technologies for older adults (e.g., [27]). However, I experienced some dissatisfaction with not being able to describe the relationship between seniors and computers adequately, which would have been needed in a project aiming at assistive technology for older adults (e.g., [32, 34]). The notion of seniors being too old or not capable of using technology in a beneficial way was often inherent in research and development (e.g., [46]), ignoring seniors' *active* choice of not using technology. Drawing on Actor-Network Theory (e.g., [10, 58, 61, 63, 65]), I found a possibility to contrast this notion, as it allows to frame seniors' non-use as an activity, providing them with a voice to actively choose not to use technology [28]. The reason is that ANT does not require a-priori assumptions about positive or negative effects of technology on actors, but considers them equally [61]. After reflecting on the relation of seniors and technology (see more detail in Chapter 5.1), I described non-use as an activity in terms of ANT in a more general way, resulting in a discussion of Human-Computer Non-Interaction [31] (see Chapter 5.2).

[5] Most of the work described here has been conducted together with research fellows. However, the main part of each paper was in my responsibility and authorship.

Through engaging with ANT, I came across the potential of ANT to not only refer to artifacts in a holistic sense, but also to their material dimensions, aligning with the aforementioned emphasis on material aspects in HCI research (e.g., [5, 11, 17, 106]). This encouraged me to explore the role of materials on basis of ANT and when looking at the material as an actor, their influence on interaction designers became apparent. Considering the materiality discourse in depth, we found relations to a further theoretical notion, i.e., Marshall McLuhan's media theory, that considers the media (i.e., the technology) as highly influencing, if not determining, humans' perception (e.g., [72]).

Additionally, McLuhan argued that time would affect media usage, e.g., former media influence the perception of current ones [72]. Pursuing this line of thought, we have theoretically discussed different relations in HCI and Interaction Design [30] (see Chapter 5.3). Both theoretical lenses (i.e., ANT and McLuhan's considerations about media) provide a framing of materials in relation to something or someone else, i.e., the social life of things. While ANT and media theory have already been discussed over the past decades, their currentness is nurtured by the ongoing requirement to understand people's interaction with the technological world. The technological world, however, is changing continuously. For instance, the current emphasis on materiality in HCI and Interaction Design is at least partly due to the characteristics of digital design material, which is, in contrast to physical material, harder to describe and understand (e.g., as it is not visible without any physical "substrate"), resulting in difficulties to grasp its agency. Thus, using ANT and media theory as theoretical background is still promising.

After having reflected on the networks in HCI and Interaction Design, we engaged more deeply with the terminology on materials and materiality. Therefore, we considered concepts

for materials and materiality in HCI and Interaction Design and related them to notions of digital and physical materials in other disciplines, which also face the transition and combination of different kinds of materials, such as textual studies [33] (see Chapter 5.4).

While Actor-Network Theory provides a theoretical framing of relations between human actors in HCI (users, designers) and non-human actors (materials, interactive artifacts), we then reflected on the methodology that has been suggested as mode of inquiry in ANT. Therefore, we took Latour's recent work on Gabriel Tarde's monads as a foundation [64]. The resulting paper illustrates a synthesis of my previous research efforts, as it refers to the theoretical assumptions mentioned earlier, leading to a methodological quest for not only considering materials, interactive artifacts, users, or designers, but also to combine different perspectives in the analysis of human-computer relations towards a "materiality-centered approach" [29] (see Chapter 5.5).

Individual Research Contributions 5

The following subchapters provide summaries of the individual research contributions. Most of them are presented in the chronological order of their publication dates, but a few were rearranged in favor of content-wise relations.

Technology and Seniors 5.1

As described earlier, my research on the relation between users, technology, and designers initially focused on seniors interacting with artifacts. My first considerations towards that topic were related to the needs of older adults [27]. Thereby, I reflected on the Ambient Assisted Living (AAL) movement, in terms of older adults' needs by means of Maslow's hierarchy of needs (e.g., [55]). Although this position paper was only an initial thought on older adults' interaction with technology, it was the starting point for intense work on technology for seniors. Having had the chance to work on a project of an intergenerational online platform (i.e., a web platform that offers activities for remote meetings between grandparents and grandchildren), I continued to focus on seniors' technology usage in my research [32, 34].

For instance, in [32], we describe how we identified attributes of intergenerational online activities, which were appreciated by grandparents and their grandchildren in offline activities by means of workshops and interviews. We then discussed how they could be transferred to online activities as well. The aim was to provide entertaining and appropriate online activities for grandparents and their grandchildren, who were geographically separated. For instance, we reflected on attributes related to the structure of activities (e.g., the duration of activities, how to schedule them, whom to involve), the appearance of the activities (e.g., what

[32] Fuchsberger, V., Murer, M., Wilfinger, D., and Tscheligi, M. Attributes of successful intergenerational online activities.

[34] Fuchsberger, V., Nebauer, J., Moser, C., and Tscheligi, M. Design challenges and concept for intergenerational online learning.

[28] Fuchsberger, V. Generational divides in terms of actor-network theory: Potential crises and the potential of crises.

topics to provide, how to integrate artifacts), or the special user groups (e.g., relationship specifics).

In [34], we presented design challenges and concepts for a specific online activity for grandparents and grandchildren, i.e., intergenerational online learning. We contrasted the grandparents' needs with those from their grandchildren in terms of learning, leading to what is required for such online teaching. For instance, children are likely to appreciate narrative content. At the same time, many grandparents indicated to like telling stories to their grandchildren. Thus, providing possibilities for storytelling and, thereby, attracting attention was one of the potentials we identified, in order to make intergenerational online learning a success.

When working with the grandparents, I found many of them being active, confident, and open to technology. However, both in literature and in the public, the picture of older adults' technology usage is often a negative one, loaded with stereotypes (e.g., [12]) that depicts older adults as needing assistance when they are not as fluent in their abilities with technology as the younger generation. Therefore, I took ANT as a starting point for describing the relation between seniors and technology [28]. It allowed me to analyze the relation from the perspective of agency, which is distributed among them.

Taking the notion of programs and antiprograms (e.g., [60, 87]) as a basis, agency may be detected even in case of non-use. This means that actors are in constant negotiations. An actor's program (e.g., a technology) tries to convince other actors (e.g., older adults) to perform a specific action (e.g., humans using the technology). However, the actors, which are attempted to be convinced, may have different goals and, thus, form an antiprogram. Thereby, agency and activity arises between them, even if

the program does not succeed. This results in a perspective on older adults' non-use, which highlights their activity in rejecting technology, in actively deciding not to use a technology and pursuing this interest. I then extended the analysis by reflecting on the "generational divide". Trenchantly speaking,

[...] the generational divide is typically interpreted to mean that people on one side of the gap – youth – have more access and a greater ability to use new technologies than those on the other side – the adults (especially, older adults) who had the misfortune to be born before the advent of the Internet. [45, p. 71]

Building on this consideration in combination with the older adults' antiprogram to rejecting some technology, I established that the generational divide may be interpreted from different perspectives. Usually, the concept of the generational divide conveys the pictures that usage differences in new media are a disadvantage to the older adults.

However, the generational divide also implies that there is a generation that the older adults are divided from, i.e., the group of younger, technology affine individuals. A variety of technologies is addressing the younger generation through, e.g., providing digital books, which have qualities that traditional books do not have (e.g., quickly searching within the book). Thereby, the younger people may develop an antiprogram towards traditional books that, for instance, could lead to disadvantages in the usage of traditional books. This results in what I called a "reversed generational divide". The aim of this example is to illustrate that there are different perspectives to this phenomenon, which is not negative per se. It is rather the interpretation that requires several viewpoints to be analyzed to detect the activity between different actors.

5.2 Human-Computer Non-Interaction

[31] Fuchsberger, V., Murer, M., and Tscheligi, M. Human-computer non-interaction: The activity of non-use.

Having described the actor-networks of seniors and technology, we then tried to do the same in a rather generic way to describe non-use and learn from analyzing non-use from an ANT perspective [31]. Therefore, we considered technology non-use from an agency point of view, again drawing on the concept of program-antiprogram. For instance, being used may be the goal (i.e., program of action) of a non-human actor, such as technology. However, not only does the program require activity, but also the resistance in case of rejection (i.e., the antiprogram), which undermines the goal of the technology. If we consider the interplay between human and non-human actors as a continuous struggle between programs and antiprograms, the activity becomes visible.

If a technology is rejected by humans, the program of the technology is not strong enough. The struggle between the technology's program and the human's antiprogram may lead to the creation of a new goal, for instance, a new technology adapted to the humans' needs. Referring to ANT, we not only look for reasons on why humans do not use the technology (e.g, the technology not being easy enough to use), but what they do to reject it. We do not only focus on an analysis of the program's failure, but also on the success of the antiprogram or the new goal evolving.

Consequently, we analyze four aspects of human-computer non-interaction on basis of ANT:

- the program
- the antiprogram
- the constant struggle and negotiation between them
- the outcome of the negotiation (use, non-use, the emergence of a new goal)

We argue that the relevance of this analysis for technology non-use may enhance our understanding of humans in a technological world, as we consider them in non-use as well; they are given a voice for *choosing* whether to use a technology.

Additionally, we may find that technology, which is not used, also influences the human actors. For instance, social media (such as Facebook) also influence humans that are not using them. For instance, the "like" button becomes a common icon also in the offline world, which affects non-users as well, or non-users are often also part of the social media (e.g., through being pictured in a shared photograph), which may influence them in their social world as well.

Through an ANT lens, we consequently perceive the border between program and antiprogram clearly and find relations apart from those between users and artifacts. The struggle between program and antiprogram might be less relevant as soon as their is no attempt to change the situation. However, in that case, it would not be a relevant phenomenon to analyze in an ANT sense, as actors are required to evoke activity from another actor; otherwise, there is no actor and no network.

In this discussion, ANT proved to be a valuable starting point for an analysis of human-technology relations. Thus, I proceeded with reflecting on such relations based on ANT, this time reflecting on the relation between design materials and designers, as well as users and interactive artifacts, which may be considered the main actors in HCI and Interaction Design.

5.3 Materials, Materiality, and Media

[30] Fuchsberger, V., Murer, M., and Tscheligi, M. Materials, materiality, and media.

In this work,[6] we not only took ANT as a theoretical background, but also referred to Marshall McLuhan's media theory for reflecting on the activity of materials in Interaction Design [30]. Thereby, we addressed the current discourse on materials in Interaction Design, where design materials (either physical or computational) are emphasized in terms of material practices and crafting. However, we recognized a lack in the theoretical framing of this emphasis, which would be able to frame both digital (or immaterial) and physical materials appropriately.

We chose to take ANT and media theory as a starting point, as both allow to consider media and any other type of non-human actors as active parts in their relation to humans. Thus, we discussed junctures between these theories and materials as they occur in Interaction Design and HCI. Regarding McLuhan's media theory, we found his basic notion that the medium would strongly influence the message [72] as similar to current claims in Interaction Design. Those emphasize that materials and the resulting materiality of interactive artifacts would be decisive for the user's (and also a designer's) experience when interacting with the artifact or the design materials.

We reflected, in detail, on McLuhan's work to figure out further junctures. In the course of the work, we specifically focused on his claim to focus on sensory effects as they are provided by certain media, as well as respective ways to interact with them. We then took ANT as a frame to describe the connections between materials, designers, and users, including a discussion on the respective methodology and its relation to Research through Design (RtD; see e.g., [3, 13, 35, 56, 108, 109]).

[6] The respective conference paper was nominated for a best paper award (less than 5 % of submissions were nominated).

Our reflection revealed that through referring to McLuhan's media theory (e.g., [72]), we can frame the material as a substantial element in an interaction, which not only impresses users through stimuli that the material provides, but also affects humans beyond physical reality, being the sense obtained. McLuhan emphasized the media's qualities providing these impacts, instead of only considering the content that is represented via a medium. In McLuhan's terms, the medium then extends the human [71].

While McLuhan primarily referred to physical materials, we emphasize that the digital materials provide a variety of sensations that are yet to be explored. Furthermore, McLuhan postulated that "old" media would influence new ones, e.g., through passing on familiar ways of interaction [72]. Again, an explicit exploration of qualities, properties, and affordances of new digital materials in their interplay with physical representations is required to make use of sensations that we may obtain through interacting with them.

In reference to ANT (e.g., [10, 61, 65]), we then framed the relation between materials, designers, and users. Thereby, the materials' agency becomes visible; associations between, for instance, designers and the materials are reciprocal, as not only the designer crafts, shapes, or inscribes behavior into the material, but the material also inspires, constrains, or forces the designer. In terms of the user-artifact relationship, the same is true. While the artifact stimulates, directs, or impresses the user, the user also touches, alters, or objects it.

The junctures found between the two theoretical notions and HCI, as well as Interaction Design, finally led us to discuss several implications that arise through this reflection. Amongst

others, the strong emphasis on the effects of media, as described by McLuhan, provides designers with an argument to take the qualities and properties, as well as the emerging possibilities, of *new* digital materials and artifacts seriously (e.g., properties and qualities that contribute to the temporal form of an interactive artifact [98]). Much research and development is trying to re-use concepts for interaction (e.g., [38]) from former media to make new artifacts easy to use through allowing users to recognize familiar interactions. While this is not a disadvantage in itself, it may, nevertheless, inhibit explorations of new forms of interactions, which would be inherent to the materials that are emerging. Thus, the emphasis on the effects of media on designers and users allows to explicitly focus on, and design for, new ways of interaction.

While McLuhan explicitly highlights the role of the media, ANT does not assume priority of either non-human or human actors. However, through this equal consideration of all actors, it does not ascribe activity only to human actors. Instead, activity (or "the social" [61]) is distributed amongst the involved actors, be it human actors (e.g., users, designers), or non-human actors (e.g., materials, interactive artifacts). Following the activity through such a network thus reveals the important role of the materials as actors, which, however, require human-actors to result in an activity. Complementing this consideration with McLuhan's thoughts, we may thereby also be able to make unconscious design assumptions, procedures and constraints visible, which were induced by former media ages, materials, or interactions.

In terms of methodological approaches to describe human-computer and designer-artifact relationships, we also found connections to ANT. Research through Design (RtD),

which is an approach that employs methods and processes from design practices for inquiries [109], already claimed that descriptions of design processes would be an appropriate outcome of design research. However, the discussion about how this will lead to theory in Interaction Design has not yet resulted in agreement. In ANT, detailed descriptions of activity that do not need any further explanation [61] would be a satisfying outcome of a research endeavor. If we consider descriptions in ANT's sense being a scientific outcome, we may also strengthen outcomes of RtD to arrive at theoretical foundations for this kind of research.

Overall, ANT and McLuhan's media analysis were valuable to provide a perspective on materials, which equally integrates the activity of materials, designers, and users.

5.4 On Materiality

With the aforementioned discussion, we mainly focused on the materials from a designer's point of view and the interactive artifacts from a user's point of view. Within the previous paper [30], we already came across the term "materiality". It's a term that is frequently used, but it transfers very different meanings. In previous work, we considered materiality as follows:

Similar to the distinction between method and methodology, we understand materiality as the theoretical discourse about materials. This includes all illustrations and discussions of materials in HCI, like their roles in design processes, their forms, functions, ontologies, etc. Thus, under the umbrella of the materiality discourse we are talking about materials when we refer to what things are made of or represented by [30].

[33] Fuchsberger, V., Murer, M., Wurhofer, D., Meneweger, T., Neureiter, K., Meschtscherjakov, A., and Tscheligi, M. The multiple layers of materiality.

However, through further engagements with the discourse on materiality and materials in HCI and Interaction Design, we re-considered our understanding [33].

Therefore, we took a step back and collected different notions of materiality as they occur in HCI, Interaction Design as well as textual studies. We included textual studies in this analysis, as this discipline is also concerned with different types of materials and materialities. The transition from physical to digital materials (e.g., texts, libraries) characterizes the current state of the discipline, since it is a scientific field that is concerned with the creation and consumption of texts in material form in its core. Additionally, we still struggled with the terms used for design materials to create interactive artifacts. While physical materials are rather easily comprehensible (see a description of kinds of physical materials relevant in Interaction Design provided by Vallgårda [98]), the terms digital, computational, and immaterial are harder to grasp and distinguish, especially as they are often used synonymously (e.g., [4, 76, 92]).

In order to detail our respective understanding, we analyzed the following notions:

- Hybrid status of born-digital artifacts: Referring to collections of writers' archives, Kirschenbaum et al. [54] argue that artifacts, even if they are born-digital (i.e., they were created digitally), require some form of analogue material to be conceived or collected. Thus, even digital materials are characterized by a hybrid status of digital *and* analogue materials.

- Materiality versus immateriality: Drucker [20] poses the question, whether textual "information" can be perceived without any relation to a material form of input or a material form of output. Through referring to Kirschenbaum, she

distinguishes between "phenomenological materiality" of a text and "ontological immateriality" of its existence. She argues that information itself is immaterial, but as soon as it is in-the-world, it necessarily holds a form of materiality. This means that the existence of an information may be imagined without any reference to a specific form, but as soon as we think of what it is, we immediately include an embodied form and aesthetics into that thinking.

- Computational composites: The notion of computational composites, as suggested by Vallgårda and Redström (e.g., [99]), offers a material perspective on computers. Vallgårda emphasizes the state changing properties of interactive artifacts, arguing that the computational material that induces the state changes, requires further materials to manifest in the form of a computer. Thereby, specific properties emerge, such as reversibility or connectability [98].

- Structure of the digital computer: Similar to the notion of computational composites, Hayles [43] thinks of digital computers as having an "Oreo-cookie" like structure; they have an analogue bottom, a "frothy" digital middle (where fragmentations and recombinations happen), and an analogue top. She considers materiality not just as an inert collection of physical properties, but a dynamic quality that emerges from the interplay between a text in a physical form, its conceptual content, and the reader's or writer's interpretation.

- Interaction Gestalt and its relations: Although the concept of Interaction Gestalt (e.g., [68]) does not explicitly refer to materiality, it also refers to an in-between of an interactive artifact and a user (including her/his experience) through defining some form of Interaction Gestalt, which results from the interaction with an interactive artifact. In our

> previous work, we integrated a "material" level into this concept (adding to the already existing levels of the interactive artifact, Interaction Gestalt, and User Experience), emphasizing that the interactive artifact is constituted of different forms of materials [30].

Analyzing those notions, we found that all of these concepts consider materiality as being *layered*. Hayles argues that

Materiality can thus not be specified in advance; rather, it occupies a borderland [...] joining the physical and mental, the artifact and the user. [44, p. 72]

Even if the level of details differs, all concepts referred to combinations of materials, i.e., computations with any other (analogue) material. This means that the digital represents an ontological immateriality, which gets its phenomenological materiality through the interaction with it. Interaction Design, in our opinion, aims for creating phenomenological materiality. Materiality is emerging through one's being in the world, which design targets to affect. The digital materials, however, seem to be inexistent as long as they are not combined or enriched with analogue materials. Thus, "digital" material only exists ontologically immaterial, getting its phenomenological materiality initially for the designer in the process of combining it with further materials to eventually enable the users to experience the artifact's and Interaction Gestalt's emerging materialities.

Actor-Networks, Monads, and Methods 5.5

After having reflected on ANT in HCI and Interaction Design and having deepened our comprehension of materiality, we proceeded with related methodological issues. In HCI, a major paradigm is user-centered design (e.g., [75]), i.e., the user's needs are determining the design of an interactive artifact through focusing on users as much as possible in the design process. On the other hand, as stated before, research on Interaction Design currently emphasizes material aspects as essential to design activities, including material studies and studies of design practice in order to benefit from a designer's explicit and tacit knowledge.

Jung and Stolterman [53], thus, claim an artifact-oriented perspective that would complement the user-centered one. Based on these two notions, we posed the questions of how we may bridge them, i.e., how we may capture the perspectives of both users and artifacts for and in design, as well as what approaches to data collection and analysis might be appropriate to orient studies towards human and artifacts.

In reference to our understanding of materiality [33], which I described before, we see materiality as emerging from the interaction that is highly depending on the qualities and properties of an interactive artifact, which in turn are influenced by the designer. Thus, materiality is *between* the user and the interactive artifact, as well as the materials it is constituted of and the designer. Based on this understanding, we elaborated further on the following question [29]: How would such a *materiality-centered approach* look like?

While we found appropriate data collection methods in HCI (e.g., as used in Contextual Inquiries [47], i.e., users are observed and interviewed in situ), we identified shortcomings of current

[29] Fuchsberger, V., Murer, M., Meneweger, T., and Tscheligi, M. Capturing the in-between of interactive artifacts and users: A materiality-centered approach.

data analysis approaches. These shortcomings primarily affect the lens that is taken for the analysis; in design ethnographies, for instance, the users' requirements are analyzed, leading mainly to design implications. However, the artifact (or its material properties) is hardly addressed. To approach this, we again referred to ANT and the respective research method, i.e., rich descriptions of actor-networks. In the very specific context of an industrial production plant, we applied this methodological thinking by describing how employees interact with artifacts (both physical or electronic ones). However, according to Latour's latest work on monads, the perspective on these networks (i.e., the actor, we start to trace other actors from in the network) is influencing the outcome [64]. In consequence, this would mean that we not only might start with the human employee as an actor to follow through her/his network, but also the artifact, such as an interactive system or analogue artifact (e.g., paper). Therefore, one actor is chosen to be an entry point to an actor-network, from which associations are established to explore the network.

The reasons for choosing the example of the production plant were twofold. First, we had a variety of data already available and, furthermore, we had the possibility to again observe the interactions between the factory workers and the interfaces they use in situ. Second, the very production plant had a transition in their cleanroom ongoing, which aimed to result in an exclusion of paper in the cleanroom (due to contamination problems). Thus, several paper artifacts were replaced by electronic artifacts, giving us the possibility to not only gather data about either physical or digital artifacts, but both of them used for the same work tasks.

After the final data collection in the cleanroom, we analyzed four different actor-networks (or monads), i.e., employees' interaction with the paper artifact from the perspective of the human and the perspective of the artifact and the employees' interaction with the electronic artifact also from a human's and an artifact's perspective. We then compared the resulting monads in terms of attributes they share and differences that are visible. The findings were related to the number and relation of actors, when we started the analysis from an artifact perspective versus starting it from a human-oriented perspective, including differences in the chronological course of the activity.

Discussing the overlappings and differences of all four monads, for instance, led to an increased visibility of the "information" (or the data, the content) that the factory workers interacted with. When looking at the paper artifact, the actor "information" did not play any significant role, i.e., we did not illustrate it, as the information was not perceivable without a specific artifact. In contrast, when starting from the electronic artifact, the separation between the physical artifact and the content it represents got visible immediately, as there are other qualities emerging (e.g., synchronous modification through various users at the same time).

The monads provided us with an overview of actors and attributes that differed according to the entry point to a network and the traces that we established. The value of such an approach, thus, lies in the meandering between different perspectives, bridging them as far as possible. Our suggestion for a *materiality-centered approach* did not entail step-by-step instructions on how to proceed. Rather, it was a conceptual discussion with a recommendation to researchers and practitioners to take a step back from their analysis and looking at the data from another perspective.

Summary and Discussion 6

The work described here contributes to the theoretical framing of the relations between users and artifacts, designers and materials, and the connections among them. It addresses problems inherent to HCI and Interaction Design by providing a language and terminology that aims to support a comparable, and at the same time distinct, illustration of human-computer relationships.

The respective research questions were finally answered by means of several research contributions. Regarding the first research question of how the relation between different central actors in Human-Computer Interaction (users, non-users, interactive artifacts, Interaction Gestalt, etc.) and Interaction Design (designers, materials, etc.) is constituted, I started with reflecting on the very problem of the picture of older adults (not) using technology. In reference to ANT, I then analyzed technology non-use that allowed to visualize rejections as an active choice, which changes the picture at least a little. However, this analysis was based on a general distinction between use and non-use, neglecting the different forms of use (e.g., individuals, who used technology once or seldom). Thus, my analysis provides a first step and will be continued by integrating different forms of uses in future work.

Having found this theoretical framing an appropriate one for non-use, I drew on ANT also for further investigations of human-computer and designer-material relations. The current discourse and emphasis on materials and materiality provided the case for a reflection that includes human actors (e.g., users, designers) and non-human actors (e.g., artifacts, materials), as ANT allows to consider them equally in an analysis. Furthermore, a connection to McLuhan's media theory was promising,

as he already engaged with the role of the "material", in his case, media, to highlight the important role of the media itself, complementing the perspective that the content (i.e., the information) is exclusively decisive for users' or consumers' experience. This reflection provided us with a theoretical framing of interrelations between different actors in HCI and Interaction Design, and was specifically valued by the research community.

After the reflection on the actor-networks that are part of HCI and Interaction Design, I engaged with the second research question of how physical and digital materials relate to materiality. Therefore, different notions of materials and materialities were analyzed in detail to provide a better understanding of what materials and materiality are. We ascertained that several concepts of materiality consist of different (im-)material layers, i.e., materiality is depending on a variety of different materials and the combinations of them. Furthermore, we refined our understanding of materials, and especially materiality, arriving at the following definition:

[...] materials is what we work with, materiality is what emerges through design or usage. The perception of digital material is only possible through combinations with other materials, allowing the emergence of materialities in an interaction. [33, p. 76]

As described earlier, the discourse around materiality is not specific to HCI or Interaction Design. For instance, in relation to organizational studies, Leonardi reflected on what materiality means apart from physical matter, e.g., when it comes to software [66].[7] He defined materiality as a form of practical instantiation or significance rather than requiring physical substance. Thereby, materiality is not considered as a property of an artifact, but a product of the relationship between artifacts and individuals producing and consuming them. Later on, Leonardi and

[7] Although situated in information studies, a similar discussion has been provided by Jean-François Blanchette [7], or, situated in informatics, by Dourish and Mazmanian [19].

colleagues provided a book on organizational materiality [67], with contributions specifically focusing on social and organizational issues of materiality. While our materiality definition is far from disagreeing with, for instance, Leonardi's notions of materiality [66], we rather focus on how materiality emerges and how it is related to materials used in the design of interactive artifacts. Leonardi and colleagues primarily consider the consequences of materiality (both physical and digital materialities) on social structures. Thus, those notions are to be understood as complementary, instead of being exclusive. Our reflection on what materiality actually is a promising starting point for discussing it within the community, which we will carry on to enrich the respective understanding continuously.

The latest work finally addressed the third research question, i.e., how a materiality-centered approach to data collection and analysis would look like. Therefore, we discussed a methodological approach to capture the "in-between" of a user- and an artifact-oriented perspective, i.e., a *materiality-centered approach*. Therein, we referred to Latour's younger work on monads [64], which may be considered actor-networks with a special focus on the traces that are established through the network. This means that networks are "entered" at a specific actor, from which the connections to other actors (i.e., the activity) is traced. Through applying this procedure from different entry points, junctures and differences in the networks are analyzed.

Thus, we analyzed monads from an artifact-centered perspective as well as a human-centered perspective, which allowed us to make differences and commonalities visible that would otherwise not have been easily found. As we consider materiality as emerging from the interaction with an interactive artifact, being strongly influenced by its material properties and qualities, we think that this alternating between different analyses will help

us to develop theoretical framings to increase our understanding of the materiality of interactions. Certainly, the presented approach to assessing materiality is one potential approach among a variety of approaches, complementing purely user- or artifact-oriented perspectives. It created awareness that, when we refer to materiality, the respective approaches need to be in-between users and artifacts, which requires alternative ways to assess the materiality of interactions. Applying the proposed approach in the field was beneficial, but further applications, apart from the very specific context of the factory, need to be done to strengthen the legitimacy of the approach.

The contributions of this thesis provided us with a variety of findings and challenges related to HCI and Interaction Design. However, it also faces limitations. One limitation concerns the multitude of theoretical background when it comes to ANT. As it is a rather prominent theory in the social sciences, it has been discussed in a variety of disciplines, tackling a variety of phenomena (e.g., from technical sciences to communication sciences, etc.). The literature is vast and so are the interpretations. The work at hand only addresses a segment of notions that have been provided in the context of ANT and probably the interpretation of this segment may also not always represent what the authors and creators of ANT wanted to say. However, even if the interpretation differs, approaching phenomena in HCI and Interaction Design from our point of view proved to be valuable as a theoretical framing and contributed to the respective discourse.

Furthermore, in order to discuss my interpretations with experts of the social sciences, I took part in the 1st Vienna Ethnography Lab,[8] which focused on the *Practices of Materiality*. Participants of this Ethnography Lab were young scholars, as well as senior scholars, from various disciplines, such as Sociology, Science and Technology Studies, or Anthropology. One of the

[8] see http://methods.univie.ac.at/de/veranstaltungen-einzelansicht/article/1st-vienna-ethnography-lab-practices-of-materiality/

participants was John Law, who contributed to the development of ANT (e.g., [65]). Although my interpretation of ANT as a framework that allows for generic illustrations of relations between actors was challenged, it was considered an appropriate means for reflecting upon those relations, especially promising when empirical data is the basis for reflection.

Strongly related to the aforementioned issue, the terminology is somehow problematic in ANT. First, ANT is not really a theory, as it does not provide an explanatory framework. Thus, the term theory was primarily added to strengthen the concept of actor-networks [73]. Mol [73] highlights this problem in detail and argues that ANT was nonetheless a theory, though one with a different meaning of what a theory was; in the case of ANT, it is an adaptable, open repository.

In the multitude of essays on ANT, a large number of particularizing terms are introduced (from activity, agency, actors and actants to delegates, inscriptions, descriptions, prescriptions, to intermediaries and mediators, programs and anti-programs, and many more). While all of them provide interesting and relevant aspects of the theoretical background, at the same time, they complicate communication and discourse when the theory is transferred to a discipline that incorporates theories and concepts from a variety of scientific backgrounds, e.g., natural sciences, humanistic sciences, or social sciences. Thus, it is necessary to carefully balance the level of details and terms to be appropriate for such an interdisciplinary audience. Therefore, I may not always have satisfied the theory in favor of communicability. I attempt to overcome this limitation through going on with the work, to reflect on the details step-by-step.

Finally, a remark on the actual choice of the theories drawn on is necessary. Both ANT and McLuhan's media theory have been criticized for various reasons. The scientific and public perception of McLuhan's work, for instance, has suffered from rather negative reports about his personal, religious, and political opinion, a tendency that is now slowly disappearing again. Among other reasons, Actor-Network Theory has been criticized for its inherent symmetry (as already mentioned earlier), which would neglect humans' motifs, motivations, and psychological constitution. Bloor [8] provided a detailed critique on ANT. Regarding the proposed symmetry, Bloor stated that it would lead to confusion to treat all actors equally. For instance, using the same terms for describing the characteristics of human and non-human actors (such as both would have "interests") would not provide any additional insights. Similarly, Bloor argues that the usage of terms such as monads would be obscure [8]. In response to Bloor's critique, Latour refutes these argument, e.g., by clarifying what he attempted to emphasize when referring to monads, i.e., considering the empirical world at the same time as a non-social nature, a social nature and the connection between them instead of considering them separately [59]. However, even if the arguments of both, Bloor and Latour, are comprehensible, they carry on paradigmatic debates, trying to state what is the right world view.[9]

Certainly, Latour's worldview was adopted for several contributions of this thesis. Being aware of the respective critiques, it nevertheless provided us with a perspective on HCI and Interaction Design that allowed us to frame materials and materiality appropriately. For instance, we benefitted from the proposed symmetry by taking it as a starting point for the analysis of interrelations. However, we acknowledged both human and non-human attributes, which were not shared, in order to account for problems inherent to a strict symmetry, e.g., in terms

[9] The controversy between Bloor and Latour is a worthwhile reading, but for reasons of this thesis' focus I will refrain from going into more detail here.

of terminology. With the respective reflection on the limitations and a careful consideration of how to draw on which theories, or how to refine them if necessary, we are convinced that such a combination of basic and applied research shows great promise also for prospective work.

Conclusions 7

The contributions of this thesis are positioned within and across the realms of educational sciences, HCI, and Interaction Design. They carry characteristics of these disciplines, connect them, or complement them. The intended impact of my contributions are in the field of Interaction Design research, aiming to provide framings, for instance, as a basis for articulation and reflection (on the need for articulation and reflection, see, e.g., [14, 15, 77, 85, 86]). By providing reflections, methodological proposals, and notions of what materials and materiality are and how users as well as designers relate to them, I aimed to increase our understanding of the relation between several actors in HCI and Interaction Design.

Given the diversity of disciplines that are concerned with questions of materiality, advancements of technology, and changes in society, many questions are still to be answered or only to emerge. As an example, how is materiality experienced when the user becomes a designer? Current technological and societal trends allow increasing participation not only in the production of content, but also in the design of software [84]. According to Schäfer, three domains of participatory culture are characterizing the current situation, i.e., accumulation (collecting, altering, or remixed content, which was originally produced within established media industries), archiving (organization, maintenance and distribution of digital artifacts), and construction (forms of production taking place outside the established production and distribution channels) [84]. These developments in participation form new and complex sets of relations between producers and consumers [84], or between users and designers. Regarding design materials and materiality, it seems to be worthwhile to consider how materiality evolves when users actually experience the design materials as such.

For this future work, my thesis provides a foundation, as it addressed the respective scientific discourse in several ways. First, it provided theoretical contributions. By reflecting on materials, materiality, and media by means of ANT and media theory, theoretical framings were established that allow to depict the relation between several actors. At the same time, the material aspects in design and in form of materiality as it appears to users were made visible. Additionally, the analysis of non-use from an ANT perspective allowed to identify the activity that is inherent in rejecting interactive artifacts and enabled us to analyze consequences of non-use, which are again related to the interactive artifact. In order to enhance our understanding of materiality, the terminology has also been discussed and related to different notions of materiality. Independent from the disciplines, which they originated from (e.g., textual studies, HCI, etc.), all notions considered materiality as being layered, i.e., computation or "the digital" is always connected to some other material that is analog or physical. The digital represents ontological immateriality, which gets its phenomenological materiality in the interaction.

Second, this thesis offered methodological contributions. By applying a method derived from ANT (respectively its refinement towards monads) on interactions taking place in a factory environment, we established an approach that requires alternating between different perspectives when analyzing the interactions in complex contexts and domains. Thereby, empirical data is analyzed from a user viewpoint *and* material perspectives. Through complementing these two modes of analysis with each other, this approach is centered around materiality, which, as described earlier, just emerges in the interaction.

Finally, the applied contribution is constituted by the application areas, user groups, and problems that were addressed. Although some of the research contributions are highly

theoretical and as such primarily addressing the research community, some contributions are connecting the theory with the "field". The research on the interrelation between older adults and technology, which I focused on in the earlier contributions, concerned technology non-use. Although analyzing non-use is uncommon, it provided us with insights on how to understand and acknowledge humans' reluctance to technology. Later on, I empirically investigated specific interactions in a factory environment, paying attention to the materiality that emerges when factory operators interact with electronic or purely physical artifacts. Apart from the methodological contribution of this work, consequences for designing interactive systems in such exceptional environments were derived to pass the knowledge gained back to the field.

Understanding and taking into account materiality in HCI and Interaction Design, nevertheless, will remain a challenge, even more as the scientific discourse around materiality is broader than the discussions taking place within these two disciplines. It is a discourse that not only will benefit from a looking into related (or even unrelated) disciplines, but may require to do so. I find it encouraging that many researchers and practitioners engage with materiality, and will continue to contribute to this discourse by carrying on my research in the intersections of HCI, Interaction Design, and Media Pedagogy. If we manage to further intensify transdisciplinary collaborations on materiality (e.g., with sociology, anthropology, or Science and Technology Studies, where intense debates about materiality are held as well), I am confident that our epistemological interests will be embraced.

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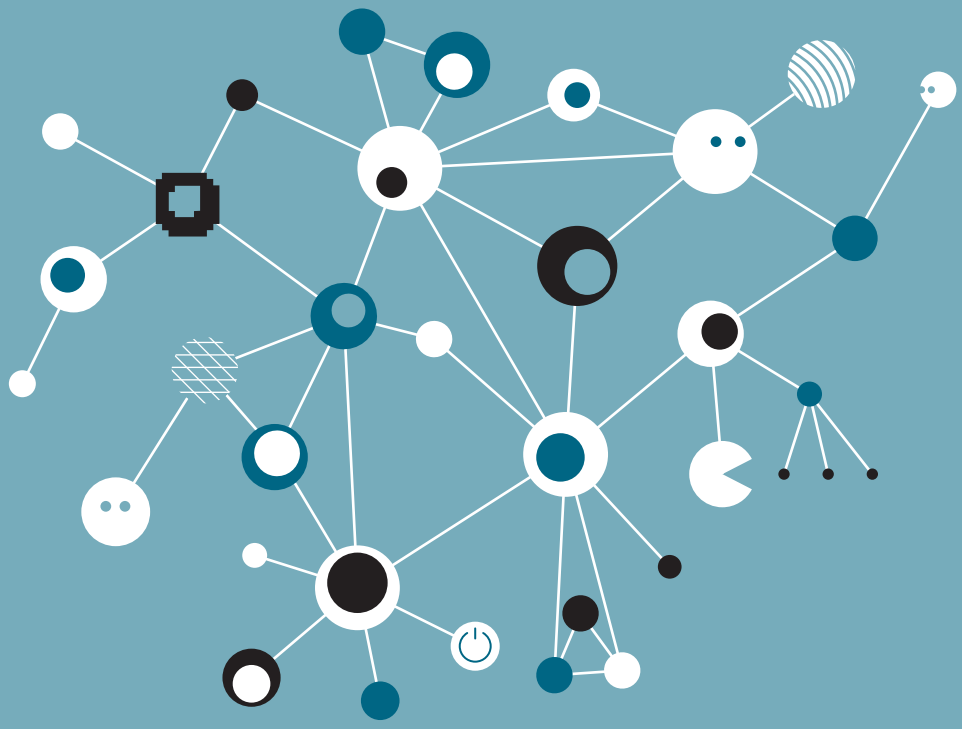

Verena Fuchsberger

Interrelating Materials, Artifacts, Interaction Designers, and Users

Publications

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Attributes of Successful Intergenerational Online Activities

Abstract. Changing family structures and associated geographical distances between family members lead to a transfer of offline activities to online environments to maintain and facilitate the relationships. Especially in the case of grandparents and grandchildren this is crucial both for grandparents to be included in family activities and grandchildren to benefit from their grandparents' experiences and time. In order to create successful, i.e. appropriate and entertaining intergenerational online activities, we identified attributes of offline activities conducted by grandparents and grandchildren, which can be applied to interactive systems as well. During a user requirements analysis phase end users were involved to assess the most important activities as well as the communication behavior and the characteristics of relationships between grandparents and grandchildren. Finally, 13 attributes of entertaining activities have been deduced, which focus on the structure, the appearance and the users' goals as well as on special characteristics of the user groups.

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Attributes of Successful Intergenerational Online Activities

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ABSTRACT

Changing family structures and associated geographical distances between family members lead to a transfer of offline activities to online environments to maintain and facilitate the relationships. Especially in the case of grandparents and grandchildren this is crucial both for grandparents to be included in family activities and grandchildren to benefit from their grandparents' experiences and time. In order to create successful, i.e. appropriate and entertaining intergenerational online activities, we identified attributes of offline activities conducted by grandparents and grandchildren, which can be applied to interactive systems as well. During a user requirements analysis phase end users were involved to assess the most important activities as well as the communication behavior and the characteristics of relationships between grandparents and grandchildren. Finally, 13 attributes of entertaining activities have been deduced, which focus on the structure, the appearance and the users' goals as well as on special characteristics of the user groups.

Categories and Subject Descriptors

H.5 [**Information interfaces and presentation**]: Miscellaneous

1 Introduction and Motivation

The 20th century has brought a substantial change in the way families live together. While in the past different generations often shared one roof, members of many families nowadays live distributed over the globe. While in traditional families grandparents acted as support for the parents and therefore were in contact with their grandchildren, the modern western way of life often leads to a geographical separation of grandchildren and grandparents. This can be caused by parents moving for employment opportunities or simply because more international couples create families and thus live far apart from at least one pair of grandparents. But not only living on different continents leads to separation, also moving into a different town might significantly influence the communication between and the activities conducted by grandparents and their grandchildren.

Many geographically separated families thus depend on telecommunication technology (i.e. ICTs) to stay in contact with family members. Nevertheless up to today technology mediated communication has not been able to reach the quality level of face to face activities and communication. Thus, it is often a poor substitute for face to face activities and leads to a slow alienation of communicators although both sides are in contact with each other. While certain qualities of real world communication will not be reproduced by technology in the near future, we believe that current ways of technology mediated communication can be improved by adapting attributes from face to face activities. This would allow grandparents and grandchildren to stay in contact over distance while maintaining a high level of social connection, leading to a lower degree of alienation. Furthermore, interacting over distance with other family members will be entertaining and varying especially for grandparents living alone.

The issues raised above argue for research on how to combine the advantages of both face to face activities and telecommunication in order to design entertaining intergenerational online activities. The spectrum of activities on target reaches from offline activities that can be easily transferred to online activities (e.g. reading books, playing games) to offline activities that call for a more detailed analysis of characteristics and properties in order to be re-interpreted as an online activity (e.g. cooking together, physical activities).

Deploying ICTs (in this context telecommunication systems, e.g., the Internet) for intergenerational interactions between grandparents and grandchildren is challenging. This is not only true due to potential technology barriers and user interface issues, but also to a low amount of existing knowledge on what functionality should be provided and which usage behaviors supported. With the presented work we therefore introduce a way in which intergenerational online activities should be designed in order to entertain both involved parties and to successfully bridge the distance between geographically separated grandparents and grandchildren. The basis are offline activities, which are preferably and frequently conducted by grandparents and their grandchildren. The goal is to deduce attributes (i.e. characteristics and qualities) of the proposed activities and the embedding interactive system in order to provide settings grandparents and grandchildren are used to and which they like.

Those attributes seek to help developers of intergenerational interactive systems, i.e. online activities, to meet elderly's and children's needs. Furthermore, the attributes can serve as a basis for the design of these online activities, but also for the evaluation of concepts, prototypes or existing activities. There are some attempts in research drawing attention to the importance of remote communication (e.g., [26] or [30]) for geographically

separated family members, but up to now there has been no systematic investigation of attributes which need to be considered in intergenerational online activities.

2 Related Research

Although seniors' usage of ICTs (e.g., [19]) and the challenges of game design for elderly users (e.g., [11]) are currently investigated intensively, there are few attempts focusing on an intergenerational context. However, this would be of specific importance as intergenerational relationships are decisive for senior's well-being, which is the focus of Ambient Assisted Living (AAL). Relationships with family members also contribute to a feeling of being cared about [10]. Furthermore, they are beneficial for sharing skills, knowledge, experiences [12], besides being a source of fun and entertainment. However, the problem is that many families do not live near each other due to a rising flexibility of living, e.g., for job purposes. In order to overcome geographical distances, online ICTs might support those relationships. Nevertheless, intergenerational relationships between grandchildren and grandparents innate a peril, as both age groups are usually not used to ICTs very well.

While children might cope with ICTs in order to interact with their grandparents (at least with the help of their parents, who are anyhow necessary to maintain the relationship between grandchildren and their grandparents [1]), the situation of seniors is complex. Older persons are regarded to have more difficulties in acquiring new skills than young people and might achieve a lower level of performance [24]. When developing intergenerational online activities it has to be clear that the applications are developed for a very special target group, which has special needs and requirements. Rau and Hsu [24] indicate

that learning experiences of older Internet users can be very frustrating. However, the interaction with beloved ones might help overcome this burden.

Although the importance of intergenerational entertainment is recognized, there are few digital possibilities facilitating these family interactions [17]. Regarding entertainment through digital games, Mahmud et al. [21] observed that elderly prefer playing games with their grandchildren over playing with peers [21]. Digital games might "hold a significant promise for enhancing the lives of seniors, potentially improving their mental and physical well-being, enhancing their social connectedness, and generally offering an enjoyable way of spending time." [15]

Although computer mediated interactions are optimized (e.g., through real-time communication, video and audio casts, etc.), they are still not equivalent to face to face interactions (as there is no physical contact). "Media spaces in general use a combination of audio, video, and networking to create a 'virtual window' across a distance and into another room" [28]. Bits of the real world of other family members become perceivable - the social distance will not be equivalent to the geographical distance any more. Singh et al. [28] furthermore suggest that supporting social presence in online interactions is not depending on physical similarities but on continuity in treating interaction partners.

When providing such media spaces in the form of online activities for grandparents and their grandchildren, it is obvious to use available guidelines and heuristics for elderly and children to meet their needs in terms of general web usability. Although there are guidelines available ([5] for example defined usability guidelines for children and [31] for elderly), they only refer to overall usability aspects and do not focus on what to consider when developing entertaining intergenerational activities (e.g., the type of activities).

3 Research Goals

All research activities presented in the following chapters are addressing the main research goal of this work: The identification of interactive system attributes, which need to be considered when designing services for intergenerational online activities that both entertain the users and foster the relationship between grandparents and their grandchildren.

As described before, successful intergenerational online activities have to combine both the advantages of face to face activities and communication over distance. In the tradition of the requirement gathering phase in user centered design (i.e., users are in the focus of every development phase), we aimed at understanding how grandparents and grandchildren conduct these face to face activities currently in real life. Our goal was to extract aspects, which make those activities a positive entertaining experience. Additionally, we wanted to understand the characteristics of successful remote communication. For that purpose we also investigated factors, which negatively affect face to face activities and communication over distance.

We defined the following research questions:

- How do grandparents and grandchildren communicate over distance at the present day? How is the communication organized? Which factors affect communication over distance negatively?

- Which face to face activities do grandparents and grandchildren conduct together for entertainment and for fostering their relationship? How are those activities organized? What affects face to face activities negatively?

- Which activities would grandparents and grandchildren like to conduct with each other, but are unable to do so, due to the geographical distance between them?

We expect that with the information gathered on these questions, the development of attributes for successful online activities is possible.

4 Study Setup

In order to find answers to the research goals mentioned above several studies were conducted within an Ambient Assisted Living Project on intergenerational interaction: workshops (4 workshops, n = 15), end user interviews (n = 11) and expert interviews (n = 10). Following a user-centered design (UCD) approach, end users (i.e. seniors) were invited to explore and discuss their communication behavior and the activities they conduct together with their grandchildren within workshops of 3 to 5 participants each. The results of the workshops informed the design and implementation of structured end user interviews. Thus, the

results, which have not been clear or were inconsistent within the workshops, were clarified through individual interviews.

Furthermore, expert interviews were conducted to assess the children's point of view. Questions in the interviews were also based on the findings of the workshops. The reason for talking with experts (e.g., teachers, psychologists, educational scientists) instead of inviting children was based on the consideration that the intergenerational activities also aim at reaching very young children (from three years on), who cannot be interviewed appropriately. Therefore we decided to talk to experts, who were able to provide information on the preferences and abilities of children between the age of three and nine. Altogether these approaches were a valuable mixture to explore the preferences and dislikes of two different generations as well as their perspectives on their relationship.

The workshops as well as the interviews were recorded by video and audio in order to transcribe them for the analysis. All statements were categorized (based on a grounded theory approach, i.e. an examination of the interplay between data collection and analysis to produce a theory during the research process [4]) and summarized using the software nVivo. In the following, the individual studies will be described in order to clarify the specific procedures.

4.1 Study 1: Workshops

The goal of the workshop was to assess seniors communication behavior with their grandchildren as well as the activities they conduct together. Creating a relaxed atmosphere was crucial to motivate discussions. Therefore, creative methods (e.g., the random picture technique, adapted from the random word

technique [8]) were used as well as unstructured and semi-structured discussions and card sorting techniques (e.g., [22]). Four workshops were conducted in summer 2010, two of them in Austria and two in Switzerland, each took about two hours. The participants were seniors between 62 and 85 years, all of them having grandchildren. The geographical distance between the participants and their grandchildren varied between living in the same house and living on different continents.

Study 2: End User Interviews 4.2

After the workshops had been analyzed, the found contrasts and uncertainties were used to phrase the interview questions. This aimed at clarifying all important issues, noticing so far unmentioned aspects and intensifying the findings of the workshops. A structured guideline was the basis for the interviews, consisting of 27 open questions. Eleven end user interviews were conducted in total, six in Switzerland and five in Austria. The time needed for the interviews varied between 45 minutes and one and a half hours. The participants were seniors between 52 and 75 years, all of them having grandchildren.

Study 3: Expert Interviews 4.3

The expert interviews were conducted to explore children's perspectives on their relationship with grandparents, preferences for activities and abilities in using computers. Therefore, teachers, psychologists, educational scientists, etc. were interviewed, all of them having an expertise for children between three and nine years. The interviews were based on the results from the workshops. Thus, the grandparents' appraisal of their grandchildren and their preferences was examined on its appropriateness

and the grandchildren's point of view was clarified. 38 open questions were asked, summarized within a structured interview guideline. Five interviews in Austria and five in Switzerland were conducted; each interview took about one hour.

5 Attributes

The assessed data finally led to the identification of activities (e.g. playing games, singing, sports, etc.), characteristics of communication (e.g. duration, means of communication, etc.) and qualities of the relationship between grandparents and grandchildren (e.g. geographical distance, frequency of contact, etc.). These findings were then used to deduce attributes that are relevant to the design and implementation of successful and entertaining intergenerational online activities. The deduction process was done by card sorting (e.g., [25]). Therefore, three researchers investigated the assessed activities to find relevant attributes, based on a grounded theory approach. Afterwards, the results of the three researchers were compared, sorted and categorized. Within the next section all 13 extracted attributes will be presented by quoting selected statements from participants and the respective study at the beginning of each paragraph. Thereafter the important characteristics and implications deduced from the study results are illustrated.

5.1 Activity Duration

"Sure I would like to have my grandkids more often. Not for too long, but more often" (Workshop); As soon as the youngest grandchild will visit the Kindergarten "It will be getting calmer for me, that will not be too bad for me" (Workshop)

The duration of activities needs to be considered for meeting grandparents' needs. Allowing flexibility for handling the duration of activities is required; nevertheless grandparents appreciate a limitable duration. Due to the fact that they often devote much time for their grandchildren, they want to have time for themselves as well. Thus, the challenge is to provide enough, but also limitable time. However, different activities require different durations to be conducted appropriately. Allowing one party to decide on the duration would in fact mitigate the time issue, but disempower the other party. A determining factor will thus be the grandchildren's age. Children will differ in their attention span, e.g., 7-year-olds show a better attention than younger children [2]. Depending on the age of the involved children, the duration of an interactive activity or session might be discussed in advance. In case the grandchildren are too young, their caregivers might decide together with the grandparents.

Furthermore, it is important for both interaction partners to have the possibility to exit the activity at any time without fearing negative consequences, e.g. hurting the other ones feelings. This is important especially for the children. Young children sometimes quit a communication without saying anything and start a new activity. Offline this might not be a problem, as the interaction partner can perceive the whole situation and will be able to better understand the child's reasons for ending the activity. In online situations it might be painful or dissatisfying for the grandparents if their grandchild leaves the interaction without knowing what happened.

Scheduling Activities 5.2

"The kids are at school, from 7.45 a.m. to 4 p.m. Afterwards, the older grandson needs to do some homework. Then they want to play, so their

time is rather rationed." (Workshop); "You never know, how you find your children, when calling them."; "Mainly I call them on weekends, so they do not have school on the next day (...) this is well organized" (Workshop)

Due to the fact that at least some children are occupied with all kinds of school and leisure activities, the time for activities with their grandparents needs to be scheduled to a certain extent. Conversely, also grandparents want and need to schedule the activities, as they often have steady intentions about their activities of daily living. Thus, both parties follow routines, which are usually fixed in everyday life. In order to meet the users' requirements on scheduling activities, sufficient possibilities should be elaborated. Online activities benefit from being detached from time, i.e. they could be conducted almost independently from the time of the day (except for time differences, which need to be taken into account in case grandparents and their grandchildren life in different time zones). However, the users cling to their daily schedule, so it will be necessary also for online activities to consider the time of the day and allow for integration into everyday life schedules. Additionally, scheduling activities can also contribute to support rituals, which might tighten the relationship between grandparents and grandchildren, as rituals are very important for both of them; e.g., scheduling an activity every Saturday evening could serve as a fixed time for recalling the past week.

Furthermore, there might be activities that family members or other caregivers should know about, as they might influence routines [23], e.g., a grandchild needs help from her/his mother to turn on the computer for an online activity, which requires her being there at the right time. Nevertheless, the request for scheduling activities might not be suitable for everyone so allowing flexible handling will be appropriate to facilitate every user

in scheduling the activities if she/he wants to. This means, different alternatives need to be provided, which can be chosen on basis of individual preferences.

Preparation and Initiation 5.3

Preparation is needed for "doing handicrafts, for which I borrow books in the library before to get suggestions" (Workshop); "We are doing handicrafts in autumn, or similar things, then I go shopping before because clearly I do not have everything at home" (Workshop)

An issue of high importance for intergenerational online activities is the pre-usage phase. Since both participating parties are placed at distant locations, the activities have to be initiated by means of telecommunication. Highly relevant for the initiation of activities therefore is the computer literacy of both parties. Young children for example do not use email or have an email account, due to the inability to read or simply a lack of interest. Initiating an activity via email would therefore fail. The example shows that the initiation method and procedure has to be child suited for independent use.

Before conducting real world activities with their grandchildren, grandparents often prepare an activity. Preparation could be shopping when it is planned to bake a cake or skimming through a book to see if it is appropriate. The same is necessary for intergenerational online activities. Access to the activity has to be given to the grandparents before the activity is conducted with the children. This enables the grandparents to try the activity out without time pressure, to get used to the interaction design and to prepare it for the children to join.

Regarding the selection of an activity as part of the preparation phase, grandparents care about the wishes of their grandchildren. Therefore the specific online activity will often be chosen by the children. Nevertheless, the children's caregivers or the grandparents themselves might have a certain activity in mind, which they think will be good to conduct, for example for educational purposes. In order to smoothen the selection process and avoid displeasure, the selection of the online activity has to be conducted in a consensual way. This allows to develop compromises and explaining the reasons to the children. The online system therefore should support communication before an activity is chosen, to make the consensual decision possible.

5.4 3rd Party Involvement

"This begins with calling. Because you are calling your daughter, and she says then 'mum, Daniela is now here, and then Anna'." (Workshop); "For the 3 to 6 year old children the parents are definitely important as participants for activities, also as planners of the activities." (Expert interview)

Besides the grandchildren and the grandparents there is a third user group involved in online activities, namely the caregivers. Concerning children, caregivers are mainly parents or other adults who look after the kids. Caregivers of grandparents can, if the grandparents need them, be manifold (nurses, own children, ...). What unites all caregivers is their role as mediators in intergenerational activities by planning, triggering and supporting the activities. This role has to be supported by the interactive system.

Caregivers must have the possibility to initiate activities, mainly because they have the computer literacy and they often

manage the day schedule of the individuals they take care of. Caregivers on the children's side are also an important source of information that should be taken into account. They know about current events in the children's life, up-to-date trends and topics currently covered in school, all information that supports the selection of an activity. The system therefore has to be open towards input from the children's caregivers. Caregivers will also be able to help and support the communicating users, hence they need the possibility to handle and observe the online activities.

Nevertheless the involvement of caregivers has to be done carefully. Caregivers will support the activities, but have a limited amount of time. The online activities therefore cannot require a constant presence of caregivers to be conducted successfully. Additionally, the involvement of caregivers is a privacy issue. Third persons from outside the family might not be welcome in private conversations. Children might want to tell their grandparents something they don't want their parents to know. A successful online activity system will allow the involvement of caregivers but reduce their effort and still guarantee privacy and transparency.

5.5 The Content of Activities

"It is important to impart values and meaning in life" "Because they are happier in life then" (Workshop); "Imparting values is of special importance, as the grandmother is the only one, who can impart those values" (End user interview)

Activities, offline and online, can be described in terms of their content. Especially for grandparents the content of activities is very important and they often have very concrete ideas of what they like and dislike. According to a study of [3], the most

common leisure-cultural activity between grandparents and grandchildren is explaining things, a result that was reproduced within our study. This means, grandchildren benefit from their grandparents' experiences. Grandparents are often homework assistants, career-advisors, or general supports for educational issues [13]. Furthermore, grandparents often try to impart values or educate their grandchildren morally through the activities they conduct together, e.g. reading fairy tales containing ethical questions, discussing social and moral issues or values, etc. Grandparents sometimes define their role explicitly by the transport of moral education. In order to achieve this goal, (1) content can be provided, which transports values itself, e.g. fairy tales; (2) moral or educative content can be prepared, e.g., stories which force reflection and reflective discussions or (3) impulses for real world involvements and curiosity (e.g., references to current political situations, etc.) can be offered.

5.6 Topics to Choose for Activities

"There are gender differences; girls in kindergarten prefer horses and barbies, boys rather prefer adventure stories, everything around cars" (Expert interview)

In order to achieve attractiveness in activities, the chosen topics are of special importance. While the above-mentioned attribute on content refers to the rather implicit and thus abstract transport of values, this attribute refers to the concrete information or knowledge, which is presented. The main demand is to integrate real world topics into all kinds of activities, whether offline or online. For online activities, this might be ensured through an equivalent to real world activities, e.g., playing chess online, which does not differ except for the medium by which it is presented.

Beside the activity itself, the context, which grandparents or grandchildren are situated in, may serve as a cue for potential topics. On the one hand, geographical and cultural topics can be used, which comply with the users' actual environment. On the other hand, the course of the year might be reflected in the activities, e.g., Christmas, seasons, etc. Finally, there are particular topics, which can be addressed easily, i.e. trends. Although these trends differ according to the users' situation and location, they can be assessed easily through analyzing the market or TV shows.

Shortness and Simplicity 5.7

"I am not perfectly familiar with the computer, there are some things that I cannot use. (...) For me the computer is just for working (...) I would like to have the abilities for more, but I do not." (End user interview)

Successful intergenerational online activities have to be short and simple. This relates to aspects of usability and user interface design, but also to the conceptual design of the activities. Both children and grandparents are user groups, which require special attention in terms of usability due to their limited computer skills and requirements. For that purpose aspects like the inability of young children to double click with a computer mouse have to be taken into account. Guidelines and heuristics can support the design for children (e.g., [5]) as well as for grandparents (e.g., [18]).

Simplicity is highly important, not only in terms of usability but also in terms of the activity design. The activities have to be easy to understand, to learn and to conduct. Both children and grandparents benefit from repeated interaction designs that

allow users to apply what they have already learned. Children are especially trained in imitating and repeating, thus, unexpected interaction steps will cause a barrier. Grandparents on the other hand are more patient and will benefit from an explanation of the activities, for example in the form of a tutorial.

Regarding shortness as important attribute of online activities, activities need to be brief, since children have a rather limited attention span in comparison to adults [9]. The online activity therefore has to be flexible taking into account the expected attention span of the children depending on factors like their age, phase of development and potential disorders like attention deficits.

5.8 Artifacts

"Pictures are made every time, when the granddaughter is visiting, that is happening very often." (End user interview) "The artifacts are stored or put up on a wall or shown during the next visit ('look, it is still working')" (End user interview) "We have a small gallery, where we put up our grandchildren's paintings and handicrafts" (End user interview)

One irreplaceable aspect of the relationship between grandparents and their grandchildren are meaningful artifacts that remind them of each other as well as of shared experiences and interests. Those artifacts are ranging from physical artifacts (e.g., photographs showing the grandchild carried in the wallet, drawings, gifts) to non-physical artifacts (e.g., a song the grandchild was taught by the grandparent). Equally, artifacts can also serve as important parts of intergenerational online experiences (e.g., [29]).

A first step to incorporate this concept of artifacts into the system is to allow the joint creation of online artifacts (e.g. digital paintings). Storing those artifacts for future sessions will generate a shared memory and thus support the relationship of grandparents and grandchildren as well as foster the attachment to the system. The integration of artifacts that already carry weight (e.g. photos taken during the time spent together) and the subsequent usage of those artifacts across various activities (e.g., co-creation of a digital photo album) might further support that. Vice versa, the transfer from online artifacts to physical artifacts (e.g., a printout of a digital drawing) will create tangible objects, serving as a memento of the other person.

Intersession Transfer 5.9

"I always invent stories (...) the children are saying, 'grandma, please make a story up for us'."; "I tell them a story every day." (Workshop)

Regarding offline activities between grandparents and their grandchildren, continuity is of high relevance. People like to play games they are already familiar with, they continue an action at a later meeting, they reuse material created during one session at another time, etc. This behavior helps to generate a consistent experience and thus supports the relationship. In order to achieve those goals with intergenerational online activities the system has to allow for the adoption of the aforementioned behavior.

This can be established by enabling an ongoing use of artifacts across the system (e.g. using a painting that was created together as the theme of a jigssaw puzzle) and by providing shared topics across different activity types. Again, by adopting a well known behavior from offline activities, online activities

might support one-time, continuos and multiple usage: the users might for example want to continue a half-finished jigsaw puzzle at another session, redo it from start or perform a certain activity over and over again.

5.10 Diversity and Balance

"For children it is important to address as many senses as possible, to have movement, to have action." (Expert interview)

In order to be attractive the system and the offered activities have to be diverse and balanced in many aspects. The content, topics, means of interaction and addressed sensual channels should be manifold across the system to keep the activities entertaining and challenging. Regarding the balance between challenges and skills the well established concept of flow [7] has to be considered: The activities have to be challenging while avoiding that users experience anxiety or frustration. Achieving this optimal balance that allows for flow experiences is alike important for group experiences.

Another important issue regarding the attractiveness of intergenerational online activities is to find a balance between activity and communication. The system should drum up interest and attract the attention of children and grandparents while still leaving room for satisfying conversation. Thus, activities must not require fast reactions nor should games be based on speed (e.g., speed chess).

"Connectedness is important. It would be sad to have no contact to the child"; "I got all the staff (photos) on a DVD, from their holidays, so you are somehow experiencing things together" (Workshop)

When designing interactive technology, user goals need to be taken into account. Tasks, which can be conducted with the system have to support the goals, that made the users use the technology in first place [6]. Within our studies, we identified goals, which are driving forces to stay in contact, even when the other person was geographically distant:

The main goal that has to be supported by intergenerational activities and related interactive systems is the creation of social presence [27]. Grandparents expressed a strong wish of being together with their grandchildren. Since a physical presence was often not achievable, their goal is to experience social presence virtually. In order to do so it is necessary to allow the communication of emotional expressions through the online activity. This will support the experience of presence as the expression of emotions plays a central role in interpersonal communication. Secondly, the limitations of communication technology can lead to misunderstandings regarding the emotional state of the other user. Grandparents fear that children might get a wrong impression of their current condition and that they had no possibilities within the online activity to clarify this. By allowing the transport of emotions, online activities will support social presence and reduce misunderstandings caused by limitations of the media used.

Although the benefits of computer mediated communication are generally acknowledged, the goal of having more personal, real world contact is always present. Therefore the

virtual presence can only be seen as solution during the inability to experience real world presence. All intergenerational online activities therefore have to provide virtual presence, but need to foster personal and real world meetings. Online activities can substitute real world contact for some time, but can never replace it. Giving grandparents the impression that using the online activity could reduce their chance to experience real world presence will lead to a rejection of the system.

5.12 Relationship Specifics

"The grandparents do not have the responsibility for their grandchildren, so it is easier for them. Children enjoy things, to which their parents would say 'no, we do not allow this at home', so the grandparents have a different relationship."; "They have life experiences, as they are the grandparents, they are older, they can be immensely important for their grandchildren."; "They are not excited any more to achieve many goals ('this is needed to learn', 'that is important'), they just highlight what is important for life, like basic values." (Expert interview)

Intergenerational online activities have to take into account that the relationship between grandparents and their grandchildren is significantly different in many aspects from other types of relationship. First and foremost the *resource grandparent* has to be considered: Grandparents offer experience and knowledge hardly to get elsewhere. Most often they are up to date what is going on in their grandchild's life, they can share rich stories from their family history and usually possess certain specialized knowledge (e.g. from their professional experience). The online system might use those special types of knowledge and experience by offering activities that allow for the integration of own stories, personal issues and special topics. Moreover, activities may provide content that fits shared interests and (offline)

activities conducted together, e.g. stories about fishing when it is planned to go fish at the next face to face meeting.

Miscellaneous 5.13

The card sorting process also resulted in two cards, which could not be attached to a group but are nevertheless highly relevant for successful intergenerational online activities:

"It would be nice, if further family members could take part, e.g., grandma communicates with the grandchild and grandpa joins." (Expert interview)

The activities have to be flexible regarding the amount of users. There are different constellations possible on both sides of the interaction. Multiple grandchildren using the system at once might appreciate having fair, well-balanced interaction possibilities in order to avoid fights between the kids. But also on the grandparents' side at least two users have to be supported in the design of the activity, when for example both grandparents want to take part. Multi-user aspects of a system cover the application design (e.g., support of two mice) but also aspects of communication (e.g., microphones and cameras for multiple users).

"I usually write a text message, if she is available (...) and then she answers, so we skype or speak on the phone then." (Workshop)

While online activities are usually bound to a single medium (i.e. computer, mobile phone, etc.), there might be the need for the integration of multiple ICTs, e.g., for scheduling activities by text messaging or landline phones. The easier the scheduling, planning and conducting of activities are, the more likely it is that the activities will be conducted. In order to minimize

barriers of online activities the integration of well-known ICTs will reduce fears and worries and thus facilitate usage. Especially older people are often suspicious of new means of communication and interaction, they use technology only with a specific aim in mind [14]. Although children might not be that skeptical, their parents will. According to Livingstone and Helsper [20], parents regulate their children's Internet usage; the younger the children are, the more regulations they implement. Thus, it is important to integrate known and familiar means to enhance the feeling of security for grandparents and grandchildren as well as the middle generation, i.e. the parents of the grandchildren.

5.14 Summary

Finally, 13 attributes have been deduced from the investigation of offline activities and communication between grandparents and three to nine year old grandchildren, describing the characteristics and qualities of entertaining intergenerational online activities that need to be considered when designing and evaluating the respective services and systems. These attributes can be summarized into the structure of the activities, the appearance of the activities and the users' goals as well as on special characteristics of the user group.

- Structure of Activities: *Activity Duration, Scheduling Activities, Preparation and Initiation, Intersession Transfer, 3rd Party Involvement*
- Appearance of the Activities: *Topics to Choose for Activities, Diversity and Balance, Artifacts, Shortness and Simplicity*
- Special User Group: *The Content of Activities, Social Presence as a User Goal, Relationship Specifics*

Furthermore, flexibility is needed in terms of the amount of users due to very heterogenous family structures. Be, the integration of further ICTs should be considered to allow using familiar ICTs in order to reduce barriers of access.

Future Work 6

One limitation of the identified attributes is the so far missing validation through the development of new and/or evaluation of already existing intergenerational online-activities. Within a next step it is planned to implement activities, which correspond to the attributes and will be evaluated in lab and field. By taking the attributes as a basis for design considerations and decisions, entertaining intergenerational interactions will be supported and will facilitate the social connection between grandparents and grandchildren. All those attributes do not serve as a set of guidelines, i.e., the higher or more the attribute is met, the better and more successful the activity will be. Instead, the attributes illustrate characteristics for entertaining intergenerational online activities, which need to be considered according to the goal of the activity that is designed or evaluated. They rather represent a checklist of issues aiming to make sure that the activities are suitable for and adapted to an intergenerational context.

Conclusion 7

The raising need of grandparents and their grandchildren to stay in contact over distance while maintaining a high level of social connection led to the presented investigation of intergenerational activities. By identifying characteristics and qualities of offline activities and communication between grandparents and grandchildren we developed a set of 13 attributes which can be applied

to intergenerational online activities. As the attributes have been identified from first-hand data, i.e. collecting data through the involvement of end users, they will be a relevant indicator for preferences, likes and dislikes of the addressed parties to satisfy their needs regarding the maintaining of intergenerational interactions, social presence and entertainment.

8 Acknowledgments

This research was enabled by the FamConnector project (funded by AAL JP). Special thanks go to end user organizations *(Hilfswerk Salzburg, AT; Kotosalla Foundation, FI; terzStiftung, CH)*, which supported us in conducting the studies for our research.

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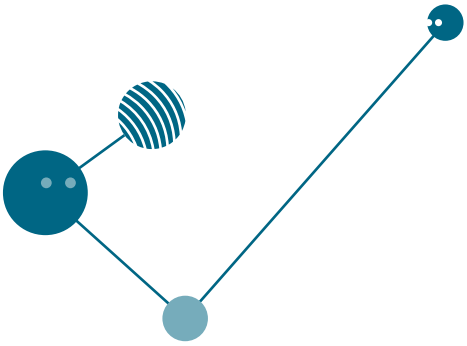
Design Challenges and Concept for Intergenerational Online Learning



Abstract. Online learning activities between grandparents and grandchildren are a promising solution for those, who live geographically separated or cannot meet face-to-face. Up to now, little is known about the characteristics these activities should have. In order to find out about the challenges that arise when designing an intergenerational online learning activity we analyzed children's preferences and needs, as well as those of grandparents. Investigating both perspectives ensures that the children benefit best from the activity itself and their grandparents' support. As the identified challenges mainly refer to the general set-up of learning activities, we also discuss a design concept illustrating how to meet the challenges.

Design Challenges and Concept for Intergenerational Online Learning

Verena Fuchsberger, Julia Nakauer, Christiane Moser, Manfred Tscheligi

ABSTRACT

Categories and Subject Descriptors

General Terms

Keywords

1. INTRODUCTION

2. BACKGROUND

2.1 Children's Problems and Tools

2.1.1 Contributions to Learning Theory

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1 Introduction

Education through the Internet provides many possibilities for children to engage in learning, e.g., through simply researching information or working together with others on learning platforms. As in "the offline world" grandparents are often involved in their grandchildren's lives, they are also concerned with school activities [7]. However, if the children do not live near their grandparents, it is challenging to connect and engage with each other [11]. In order to nevertheless allow for joint learning, possible online settings and requirements have to be investigated. Although the learning activity primarily aims at promoting the children's learning, it is also beneficial to take the grandparents' needs into account. If both are motivated for conducting the activity, the children can benefit best from the knowledge and experiences of their grandparents. This is addressed by our first research question (RQ1): "*What preferences and needs do children and their grandparents have in terms of interaction and activity design for learning together online?*"

Based on the identified needs and preferences, challenges for the design of the activity can be derived, which are addressed by our second research question (RQ2): "*Which challenges arise in the design of online learning activities for children and their grandparents?*" In order to support the development of intergenerational online learning activities, we will describe a design concept that provides possible solutions for the challenges. Our design concept advances already existing online learning activities by focusing on the remote interaction of children and their grandparents. It copes with different challenges, which have not been described so far for an intergenerational setting.

In order to answer RQ1, an analysis will be presented, which illustrates children's and grandparents' preferences and needs. The children's perspective has been researched thoroughly within the Interaction Design and Children community (e.g., IDC conference, like [1], [4], or [8]). Thus, we rely on this research for assessing the children's perspective. In order to investigate the grandparents' preferences and needs regarding online learning activities with their grandchildren, we conducted workshops, as there are no experiences available in literature. On basis of the results, we derive design challenges (RQ2) and discuss those at the end of this paper on basis of our design concept.

Background 2

In order to find out how intergenerational online learning should look like, the preferences and needs of both involved parties need to be investigated. As learning activities primarily aim at children's learning, a detailed analysis of their preferences and needs is required. Although the grandparents are not primarily targeted in terms of learning outcome, they are crucial in spending their time together with their grandchildren, motivating them and sharing their own knowledge and experiences.

Children's Preferences and Needs 2.1

On basis of a literature review, we identified several important aspects in terms of activity and interaction design, which are promising for supporting children's learning.

Constructivist Learning Theory. In interaction design for children's learning, the constructivist learning theory is often referred to [14]. Constructivism in its original meaning believes

that the personal world is constructed in one's mind, which defines the personal reality. The mind, as an instrument of thinking, interprets events, objects, and perspectives, rather than remembering and comprehending objective knowledge [9]. Thus, children are constantly trying to make sense of and to understand their experiences [13]. According to this, learning is more likely to be successful, if the learner is not just a passive recipient of the presented content, but engaged actively. Reflection on experiences further facilitates the learning process, and can be achieved by building associations with children's lives through images or objects. Those support exploration and "active construction of knowledge in domains, where children still have unstable ideas." [1] Allowing exploration with all senses and manipulating the environment also promotes children's learning [12]. Furthermore, Antle et al. [1] and Hunter et al. [8] regard the process of making mistakes as an opportunity for humor and surprise. Thus, the children need space to explore, understand and make mistakes in order to learn.

Narrative Content and Multimedia. Traditional offline storytelling fosters creativity and imagination, supports reading, writing, as well as speaking, and contributes to the cultivation of social and cultural understanding. Digital storytelling offers further benefits like a multitude of expression possibilities, which will encourage children to participate in the activity [8]. Thus, children can be actively supported in creating, sharing and performing stories, which enhances the creative, social and fun aspects of learning. Furthermore, Göttel [6] found out that children automatically learned the computer tools they had to use when creating and sharing stories. Children need to be engaged with the content for learning, which can be enhanced by the integration of narrative elements.

Additionally, new media can be used for storytelling in order to foster socialization, creativity and imagination. The goal is to attract children's attention for an activity. While younger children prefer visual perception for remembering content, older children are able to use verbal forms too. Moving objects seem to attract more attention and to be more memorable, "[...] presumably because action provides a developmentally appropriate visual mode for children to encode and think about information." [3] The children's need for visual content and their preference for animations are thus believed to contribute to learning effects.

Simplicity. The activity has to be easy to conduct [12] and easy to learn, because the goal is not to learn the system, but to learn through the system [1]. In terms of interaction design, the activity can include objects from every day life and simple actions for using them. Cognitive load needs to be reduced in order to get the children focused on the main issues of the activity. To do so, objects and digital actions need to be consistent with the real world to facilitate learning [1]. Children need to be engaged with the actual learning activity, which the technology needs to support.

Collaboration. Learning is a fundamental social process. The Internet provides unique learning spaces, as it not only delivers content, but contains many possibilities for mutual support between learners [2]. Preferably, the support for learners will not be limited to teachers and classmates, but extended across ages and distances, e.g., with the support of older adults, who like to teach children and might have free time to contribute [2]. Learning is not a solitary act, as it is embedded in social and cultural understandings. Thus, children need to derive their knowledge not only from direct experiences with the environment, but also from the input of other people [5], e.g., peers, parents or grandparents. Collaborative learning is possible in different settings,

e.g., in museums. Moura et al. [10] reported about a game in the Boston Museum of Science (USA), where students and their parents collaborated to solve fictive crimes.

The literature analysis revealed many insights on children's preferences and needs regarding online learning. However, as we aim at describing the collaboration between children and their grandparents, also the older adults' needs and preferences have to be considered, which are presented in the following.

2.2 Grandparents' Preferences and Needs

In order to assess the grandparents' preferences and needs for conducting online learning activities with their grandchildren, we conducted four two hour workshops with older adults (aged between 50 and 70 years, average age 62) in Austria, Switzerland and Finland. The 16 participants (12 female, 4 male) had at least one grandchild between three and nine years (who did not participate in the workshop). They were asked to discuss and work on tasks in order to identify their needs in learning activities with their grandchildren. We considered the grandparents' perspective as important, as they will influence the children's perception of and performance in the activity.

Variety. The grandparents emphasized the importance of variety in learning activities. On the one hand, they referred to different levels of difficulty to have an appropriate activity for their grandchild. On the other hand, they requested a range of different themes and topics, which were mainly connected to the real world (e.g., learning about nature or learning in museums). Furthermore, they stated that a variety in the activity supports getting the child's attention and avoids boredom.

Self-Made Tasks. Some participants in the workshops stressed the importance of being engaged also in the development of the tasks. Some disliked constraints, and some feared blaming themselves when not knowing the correct solution or how to proceed. Thus, they asked for tasks, which they could create themselves in order to teach the grandchild according to their individual preferences.

Keeping up the Interaction. The participants liked the idea of interacting with their grandchild online and supporting it in learning. They appreciated the possibility to gain shared experiences in order to get a better connection to the grandchild. Keeping up the interaction in the activity is thus crucial to get the grandchild's attention for a longer time. On the one hand, the activity itself was supposed to be able to keep up the interaction, but the grandparents also emphasized to require hints for communication and especially for telling stories to the child.

Mental Challenges. The participants appreciated the possibility not only to support the grandchild in learning, but also to remain young through conducting the activity. Although the intergenerational setting would at a first glance provide the role of the coach for the older adults, they stressed the importance of mutual learning. Thus, not only the children can benefit from a constructivist interaction design, but also their grandparents.

The workshops revealed that the grandparents have additional preferences and needs to their grandchildren's ones, which were assessed in a literature review.

3 Design Challenges

On basis of the above described needs and preferences of children and grandparents, several design challenges were derived addressing RQ2 (Which challenges arise in the design of online learning activities for children and their grandparents?). The identified needs of children and grandparents mainly refer to the general set-up of the activity, e.g., possibilities for exploration, narration and collaboration, different topics, and support for keeping up the interaction. The concrete content depends on the goal of the specific learning activity.

3.1 Knowledge Construction

According to the constructivist learning theory, children's knowledge construction (and also those of their grandparents) is supported by exploration and manipulation of the environment. The difficulty in implementing those features in an activity is that all possible outcomes have to be considered. In case of mistakes, amusing solutions have to be found to avoid frustration. Allowing the children to explore the activity without reading instructions can enhance the experience, so a proper replacement for written instructions is needed.

3.2 Personal Engagement

Besides achieving personal engagement through exploration, the integration of grandparents into the development of tasks can foster the personal engagement. However, allowing them to create some tasks themselves requires more complex activities or respectively a separate creation tool. The more possibilities for creating activities they have, the more they will be engaged,

and as they will know their grandchildren best, they can adapt it to the child's needs and preferences. Nevertheless, creating activities requires a more complex handling of the technology, which might overchallenge older adults, who require a simple and easy usage.

Storytelling and Attracting Attention 3.3

Storytelling is a favored offline activity for children and their grandparents. It fosters their personal engagement and enhances the memorization process [4]. Therefore, a reasonable way of integrating narrative content into the activity has to be found. While the narrative elements need to arise children's interest and curiosity, they should also provide room for own creativity.

Furthermore, animations (i.e. moving objects) and actions within the activity are decisive. However, it is challenging to find a proper level of action. In addition, a reasonable variety of themes, related to school or everyday life is required to keep children and grandparents interested. The decision about which and how many different topics to choose is difficult, as the interests differ according to the children's age and cultural background.

Collaboration 3.4

Both children and grandparents might fear not being able to cope with an activity on their own. Therefore, a teamwork situation has to be established through combining children's and grandparents' tasks. Additionally, it has to be avoided that children wonder, whether they could have done the activity alone too. Thus, the tasks have to be clearly illustrated as collaborative ones.

The identified design challenges need to be considered in intergenerational online learning. They form a basis for the design and should be met in order to facilitate the children's learning. Thereby, it is important to find a balance between the different challenges in order to avoid contradictory activities, e.g., engaging the grandparents in the creation of the tasks is not a collaboration opportunity. However, the collaboration can be increased afterwards, as the grandparents are deeply involved in the task and will therefore be able to support the children better. In order to demonstrate how to cope with the challenges, we describe a design concept in the following, called "Visit the museum", which we are planning to implement on an intergenerational online platform.

4 "Visit the Museum": A Design Concept for Intergenerational Learning

Our design concept provides an online learning environment, which integrates the benefits of a real museum, i.e. it provides space to explore and understand. The children are supported in engaging with the content through a variety of tasks, narrative elements and animations, which are believed to contribute to learning. The activity is easy to use and understand for both the children and their grandparents. Furthermore, there is a focus on collaboration, which will facilitate conducting the task.

In order to foster *personal engagement* within the activity for both parties, a museum was chosen as activity location, as it was mentioned by the grandparents to be one of the favorite offline locations to visit. Using the scenery of a virtual museum meets two different requirements. On the one hand a museum can provide a *variety* of themes and topics, from real paintings and sculptures to school related content. On the other hand, the

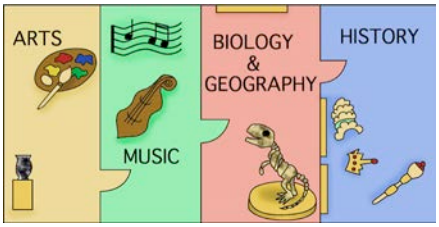

Figure 1
Potential departments of the museum

Figure 2
Exercise in the history department

grandparents could for example decide, which departments (see Figure 1) they would like to explore with their grandchildren (i.e. integration of grandparents into the *task creation*).

The objective is to solve riddles in the different departments. The grandparents are given the task to tell stories related to the objects, and children have to listen closely and e.g., put objects back into the painting (see Figure 2). Thus, *mutual engagement and collaboration* are supported.

The whole activity is framed by a story (i.e. *narrative elements*), which aims at maintaining the children's *attention* and provides hints for the grandparents to *keep up the interaction*. The main

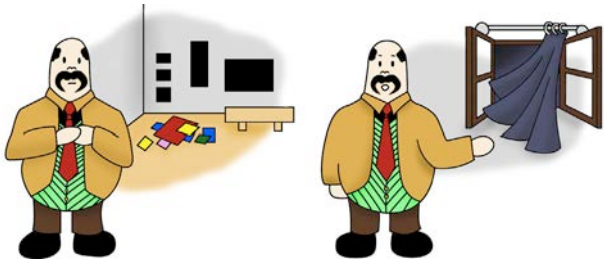

Figure 3
The curator explains what has happened

character in the museum is the curator, who finds his exhibits completely mixed up after last night's storm. Unfortunately the night guard forgot to close a window, so the wind blew through the exhibition rooms and caused havoc in the exhibits (see Figure 3).

Furthermore, the main character can be animated. The use of *animations* is very closely connected to a *narrative content*, because every character comes to life through animation and synthesized voice, and leads to increased attention. In order to avoid that the character of the curator speaks when someone else is speaking, the utterances could be connected to a play button to click on. Furthermore, the curator knows a lot about the museum, so he may provide *support* without the need to read anything. According to *constructivist learning* theory, the actual learning will take place by exploring the departments and exhibits of the museum. Children can experiment and get amusing solutions, also in case of mistakes. This will lead to ease and fun, and may provide hints for new stories. Grandparents may get a recap of their general knowledge and they can assist the children in solving the riddles, so both are *mentally challenged*.

Our design concept seeks to meet the challenges, which arise when designing intergenerational learning activities (RQ2). Those challenges are based on the children's and grandparents' needs and preferences (RQ1) for learning activities. Thus, our design concept provides space to explore, understand and make mistakes. The children are supported in engaging with the content through narrative elements and animations, which are believed to contribute to learning. Besides the experiences with the activity itself, the children benefit from a collaborative setting. Thus, also the grandparents' needs and preferences need to be considered. Our design concept provides a variety of themes and topics, which allows choosing according to individual preferences. The activity supports them in keeping up the interaction, and seeks to challenge both involved parties mentally.

Future Work 5

The design concept, which we presented in this paper, will be implemented on an intergenerational online platform and evaluated afterwards. Although many challenges, which we described, can be met with our design concept, some challenges still remain (e.g., how to decide on the content). However, we are convinced to meet the primary needs of both parties and correspond to their preferences to create a successful online learning environment.

Acknowledgements 6

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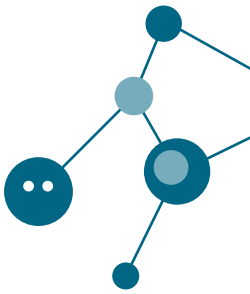
Potential Crises and the Potential of Crises



Abstract. Using the term generational divide implicitly contains the idea that the generational divide is exclusively or at least mainly disadvantageous for the older generations. Regarding western societies, they do not keep up with the younger ones in terms of new media, i.e. the Internet, social media etc., still less in an environment of manifold and rapid technological transitions. However, when considering traditional forms of media, e.g. newspapers or books, there might be a reversed generational divide. Do younger ones unlearn how to read books and newspapers? The aim of this paper is to describe the generational divide as a crisis, which is driving changes positively or negatively. According to Bruno Latour's actor-network theory and its explanation for adopting a change, a divide illustrates a crisis, which leads to action. As soon as any prescription is perceived, actors will act (according to Latour, those can be humans or non-humans, e.g. technology or media).

This paper tries to figure out how the generational divide might be described in terms of Latour and his understanding of the process of change. Thus, two modes of action in the relationship between seniors and media are conceivable:

(1) The program (i.e. an attempt to cause a change) is stronger than the antiprogram, (i.e. the (re-)action of the attained actors to avoid a change) – seniors might accept and use new media as the media make them to.

(2) The program cannot convince the antiprogram – the adoption is not performed by the human but by the non-human actors through a resignation in the prescriptions.

If the program and the antiprogram are equal, there will be no crisis or divide and thus no change. The paper will describe those structures in detail and illustrate them through examples about reading in times of ongoing transitions and instability, e.g., seniors reading the news "online" or "offline", their preference of printed books instead of reading them online, etc.

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1 Introduction

Media and their rapid transitions are a hardly comprehensible phenomenon because of their enormous diversity and variability. New possibilities (i.e. devices, content, structures) are emerging, which are both transient and determining for at least some consumers. This is illustrated distinctly by the history of the term "new media", which is used to describe digital media, but initially focused on video communication or email (e.g., Dennis and Kinney 1998, p. 256). Due to the immense progress in digital media, like mobile phones or virtual worlds (e.g., Reinhard and Dervin 2010, p. 3), the term is still used to cover all of these possibilities, although many of them are obviously not new any more. Thus, also the meaning of terms changes rapidly and requires people's constant pursuit to be up to date.

The aim of this paper is to describe and discuss changes and instabilities of media in regard to their potentials and problems for old as well as young people. My interest in this topic is intensified through an involvement in the project FamConnector, which aims to facilitate online interactions between geographically distant grandparents and grandchildren. It is located in the field of Ambient Assisted Living (AAL) and focuses on intergenerational activities. Within this project, both young and old people are addressed and thus it is of specific interest how they are affected by the instabilities and changes of media.

Discussions about the effects of changes on individuals and societies mainly focus on "young" people, from children to adults and their usage of digital media (see, e.g., Kaplan and Haenlein 2010 or Vandewater and Lee 2009, for two illustrative examples). When talking about young people it is assumed that they are able to cope with changing circumstances and environments, especially those young people are often driving changes and

progress. At least there are efforts to educate them by addressing "issues that are central to the experience of growing up in a world full of mass media, popular culture and digital media" (Hobbs and Jensen 2009, p. 9). These digital media require a range of important new media literacy skills (Hobbs and Jensen 2009, p. 9), involving 'writing' the media as well as 'reading' them (Buckingham 2010, p. 68).

Nevertheless, there is the apprehension that these media transitions will or might have negative effects at least for some individuals or groups. One very popular and also well-researched domain is the digital divide (e.g., Zillien and Hargittai 2009, p. 274 or Agarwal et al. 2005). This divide in access and usage of digital media is addressed in various ways by the investigation of the variables that seem to influence or cause a gap between users or usage. Typically, those variables involve barriers due to people's ethnic origin, culture, gender (Brandtzæg et al. 2011, p. 123) or socioeconomic background (Zillien and Hargittai 2009, p. 274). Thereby, the digital divide does not only refer to an access divide, but also to an imbalance of usage; it can thus be described as a participation inequality (Brandtzæg et al. 2011, p. 123f).

Besides, there is one important factor determining an inequality of technology usage, i.e. age. Brandtzæg et al. (2011, p. 133) investigated the relationship between access and age of Internet user types in five European countries (Austria, Spain, Norway, Sweden and UK). Their results showed evidence that most older people are non-users, who often do not even have access to the Internet (80 % of 65 to 74 year old people). About 15 % of persons aged 55 to 64 years are instrumental users, who use the Internet in a goal-orientated fashion (e.g., searching for information about goods and services). However, this kind of usage decreases for 65 to 74 year old persons beyond 10 %. The authors conclude, that

"*It is to be expected that the penetration and diffusion of broadband, digitalization, and media convergence will increase in the near future. It is reasonable to believe that, together with the emphasis on new technology in schools, this convergence will result in a trend towards more widespread use of the Internet among young generations*." (Brandtzæg et al. 2011, p. 134)

All these findings refer to a generational (digital) divide, which also extends beyond questions of access (Loges and Jung 2001, p. 556). Although the gap seems to disappear due to the increased work with computers for almost everyone, there is still the evidence that seniors will not use certain media (e.g., the Internet for homebanking) as an intrinsic consequence of ageing, e.g., to guard privacy or preserve resources (Loges and Jung 2001, p. 559). Herring (2008, p. 87) suggests focusing on life-stage related behavior rather than indicating an ongoing change for all users. However, Gilleard and Higgs (2008) rebut this perspective of age as an 'endogenous' explanation for the digital divide on basis of a longitudinal study of ageing in the UK and infer that "those now entering retirement may well bridge the current divide." (Gilleard and Higgs 2008, p. 238) These perspectives correspond mainly with two major social theories of ageing, i.e. the activity theory and the disengagement theory (e.g., Alley et al. 2010 or Franklin and Tate 2009), which describe seniors' tendency to participate in social life actively versus refusing to as a kind of retreat.

Discussing the usage of digital media does not only mean focusing on access to or the technology itself, but also on changing behaviors to be able to cope with the content provided, e.g., for reading texts. In the past, reading texts required printed papers or books and thus specific skills to handle these print-based texts, but reading (and writing) is now changing in terms of altered demands for competencies and behaviors

(Hagood 2003, p. 389). When reading this statement, one is tempted to interpret it as a disadvantage for older users to the benefit of younger ones, or as Herring (2008) writes ironically:

"*... the generational divide is typically interpreted to mean that people on one side of the gap – youth – have more access and a greater ability to use new technologies than those on the other side – the adults (especially, older adults) who had the misfortune to be born before the advent of the Internet.*" (Herring, 2008, p. 71)

In order to overcome this perspective, Herring (2008, p. 72) suggests moving away from a fascination with technologies to a focus on people themselves. The competencies and behaviors in using digital media adjudicated to the youth are more or less visions of adults, who construct a certain picture of the youth (Herring, 2008, p. 72ff). She claims a more balanced view that recognizes not only flux and change in new technologies but also continuities and trends (Herring, 2008, p. 86). The generational divide thus might be a construct, which is influenced by the perspectives of those, who deal with it. Furthermore, the generational divide almost always portrays the seniors as the losing part of this dichotomy. However, is it really only one dimension, i.e. a gap between 'winners' and 'losers'? Maybe there is another dimension, illustrating a dichotomy *within* one party of the gap, i.e., gaining specific knowledge for and of digital media might also mean losing (or never getting) knowledge about other kinds of media. Perhaps younger people unlearn how to read books or newspapers, or at least are not willing to handle printed texts. The following example, found in a blog about the future of books, perfectly illustrates these concerns:

"*This is going to sound incredibly lazy, like someone who gets in their car to drive a few blocks rather than walk, but the physicality of the book, having to hold it open then lift and turn each page, was a lot*

more exhausting than I remembered. All of that holding and lifting and turning distracted me from the act of reading, took me out of the story if you will. A few pages into it I gave up, logged in to Amazon, and bought the Kindle book." (White 2011)

Currently there are efforts to even create books with characteristics of digital media (Dresang 2009), probably to address readers like the author of the blog entry. This means that changes of media lead to altered behaviors, which again cause changes in technology or media to meet the new requirements.

All these changes, instabilities and concerns are now becoming obvious and require to be investigated on their potential and problems for different generations. Within the following chapter this will be done based on the actor-network theory to create a new perspective on the generational divide.

2 The generational divide in the light of the actor-network theory

What we *know* after the preliminary chapter is that we *do not know* how the generational divide affects the young and the old generation, and if it does, whether it is beneficial or disadvantageous. What we further know is the assigned characteristics to digital media, i.e. driving changes and instabilities, which can be considered as potential crises. In the following these crises will be discussed on their potential especially for older generations regarding their media usage.

It seems to be obvious that digital media are advantageous for many purposes, e.g., the Internet is seen as an extraordinary educational and cultural heritage resource (Preece 2002, p. 24). But, some authors, e.g., Nickerson and Landauer (1997, p. 19),

wonder what happens if access and computer-based resources become a critical determinant of how effectively one can function in society? Apart from "functioning effectively" in society, the essence of this statement also brings along a negative connotation in terms of seniors' voluntary goals. Thinking about seniors reading the newspaper, one might not be surprised if it involves a printed version. We might not be concerned about this situation, but having in mind the prediction that there will not be any printed newspapers in the near future[1] any more, seniors will have to cope with a somehow changed situation – and a crisis will have begun.

Describing a crisis in terms of actor-network theory (short: ANT[2]) requires at least a brief comment on this theory, which will be presented in the following.

One basic postulation of ANT is the view of everyone and everything being an actor as soon as he/she/it acts and thus influences or evokes an action of someone or something else. Actors can thus be humans, but also every kind of artifact that influences the behavior of others as the term implies no special motivation of human individual actors, nor of humans in general (Latour 1996, p. 5). In this sense technology, media, younger or older people are considered equally as actors. They might have different assigned attributes (e.g., being human or not), but this does not make a difference in their role as actors.

This is illustrated best with an example, which is frequently used to describe ANT (e.g., Schulz-Schaeffer 2006, p. 131). Imagine a hotel manager telling you that you should hand in your key when you leave the hotel, as she does not want you to lose it. Maybe you follow her wish sometimes, but you might also forget to hand it in. This happens very often, so, in frustration, she places a note at the reception desk which repeats the wish. As this

[1] Estimations vary considerably, with some believing printed newspapers might cease to exist within the next two years, whereas others believe within thirty years (Thurman and Myllylahti 2009, p. 691).

[2] When using the acronym "ANT" for the actor-network theory, Latour (2007, p. 9) also establishes a connection with (non-human) animals and their behavior, which he finds comparable in some ways to humans (e.g., both try to find trails).

does not bring about the effect either, she decides to use heavy and bulky key chains. Every time you leave the hotel, the key-chain prompts you to hand it in just because of its heaviness and bulkiness. As soon as the artifact leads to an action, i.e. handing in the key, it is an actor. If the note on the front desk had got you to hand in the key, it would also have been an actor. Within ANT this is called *prescription*, i.e. a behavior that is imposed onto humans by non-human delegates, which in the example is the key chain or the note (Latour 1992, p. 232).

After having illustrated briefly what an actor is in terms of ANT, the next step is to define the network, being a central part of the theory.[3] The actors act – but always within a network, which they form in turn. If a network falters, the actors may falter too (Mol, 2010, p. 258). A network consists of associations, which initially have to be made, and this is hard work. The associations define the relatedness within the network, and can be clarified by the terms collaboration, clash, addition, tension, exclusion, inclusion etc. (Mol, 2010, p. 259). The term "tinkering" is now more frequently used than "association", which might better describe the step-by-step activities performed by the actors. Thereby, not only gaps (i.e. places where no associations exist) are depicted in networks but also tensions (Mol, 2010, p. 264f).

"*... there is not a net and an actor lying down the net, but there is an actor whose definition of the world outlines, traces, delineate, limn, describe, shadow forth, inscroll, file, list, record, mark, or tag a trajectory that is called a network*." (Latour 1996, p. 11)

This quotation highlights that a network is not stable, but is constituted by the actions of the actors involved. Actors participate and mediate the relational networks, but are also the outcome of the same relationships (Cordella and Shaikh 2003).

[3] The pioneers of the ANT (Latour, Callon, Law, etc.) developed the term "actor-network theory", although they indicated often that it is not a theory in a regular sense, as it does not provide an explanatory framework. The third link was added to strengthen the term, which "actor-network" could not serve. Mol (2010, p. 253f and 261f) highlights this problem in detail and argues that ANT is nonetheless a theory, though one with a different meaning of what a theory is (Mol, 2010, p. 262) – in case of the ANT it is an adaptable, open repository (Mol 2010, p. 265).

ANT, its actors and networks, will now serve as a basis to describe seniors' rejection of online newspapers and their preference of reading offline versions instead. The actors seem to be quite clear in this case: seniors and the (offline, print-based or online) newspaper. Both act, somehow, in this relationship, i.e. the seniors are reading a printed newspaper and the newspaper provides the information, which can be read. Although the online version is not read, it is also an actor, as it *tries to be read* by seniors. We could go further by looking at potential actors: What about the paper the news is printed on? What about the Internet content providers? What about the editors? What about everyone and everything else that is involved in the relationship between seniors and their newspapers? The network we are talking about will get very complex if we try to find every participant (human or non-human), involved in any way. Thus, the following steps will focus on the network senior-newspaper to illustrate the basic idea.

After having figured out the basic actors and the foundation of the network senior-newspaper the next step will be to have a closer look at what makes the involved actors behave like actors. An actor-network is characterized by 'something social' that connects the actors. In this sense, the social is not a substance, but a movement between non-social elements (Latour 2007, p. 159). This means that the social is temporary; it is within the network and attributed to actions, not to the actors. Thus, both human and non-human actors are non-social elements within the network. As soon as they interact, the interaction itself is the social component of the relationship.

Thus, there needs to be an interaction to talk about an actor-network, here constituted by seniors and newspapers. The senior buys the newspaper, reads it, stores it or throws it away. The newspaper is printed, sold, read, stored or thrown away.

These passive expressions might lead to the impression[4] that the newspaper itself cannot be an actor, as it does not do anything itself, it does not act. But, in a different way, it does. It is the newspaper that e.g. provides information and news. The argument against this might be that it is not the newspaper itself, but the journalists, who investigated and wrote the articles. But here is a key point of the actor-network theory: Although journalists (also editors, designers, graphic artists etc.) intend to affect or influence the potential readers, they can only inscribe the readers' anticipated behavior into the artifact (i.e. the newspaper), what can both succeed or fail. Nevertheless, the interaction takes place without them as it only includes the newspaper and the person reading it. Finally, these two actors constitute the network, which will be described in the following chapter.

3 Arguing for activity: Program or Antiprogram

In order to describe[5] the relationship, the interaction or the interplay between seniors and newspapers, it is necessary to understand that we can only notice and describe phenomena if they are about any kind of controversy. Latour suggests to "paradoxically take all the uncertainties, hesitations, dislocations, and puzzlements as our foundation." (Latour 2007, p. 47) Regarding the situation of seniors and unstable media this becomes obvious. If there were no recognition of a generational divide, we would not think about it and we would not talk about it. In this sense, a change (i.e. a crisis) is needed to become aware of situations, actors and networks. Thus, the generational divide can serve as a starting point to figure out about the effects of media, their usage and potential.

[4] This statement also illustrates the basic assumptions of ANT: An expression leads to an impression – the actor 'sentence' has an effect on the actor 'reader', i.e. the impression. A network is made. As soon as the reader really gets the impression, or is amused or annoyed about it, there is a 'social something', which connects the actors.

[5] According to Latour, describing phenomena is central in research, rather than finding explanations. Thereby, the object will be focused, and nothing else. Many arguments for this perspective can be found in Latour (2007, p. 141ff) as an readable interlude in form of a dialog on the difficulty of "being an ANT".

One essential point of ANT is its perspective while describing phenomena. Actors are – as already indicated by the term itself – acting and thus active. This is one aspect that makes the ANT interesting: when using it to describe things, there is no possibility to assign a passive, pitiful role to any involved party. Especially if the phenomenon has per se a negative connotation, i.e. being disadvantageous for seniors,[6] it helps to evade clichés and stereotypes.

With regard to the active role of the involved actors I will now try to define the relationship between seniors and online newspapers. To do so, I will briefly come back to the above-mentioned example of the key chain to illustrate the term 'program of action', which was introduced by Latour to "… denote goal-directed behavior of human actors as also of technological artefacts" (Schulz-Schaeffer 2006). The example of the key-chain is a typical one, which Latour (2000, p. 41) described in terms of a program of action, saying that the key chain tries to reach a goal, i.e. to be left at the reception desk. The hotel guests have another goal, they just want to have the key available as soon as they need them, regardless of whether they take it with them or leave it at the reception desk. Consequently, they form the anti-program, i.e. they do not want to leave the key at the reception desk primarily, as this would mean to think about it every time they leave the hotel and come back.

Regarding the network of seniors and newspapers, this would mean the following: The program is the newspaper; its goal is to provide information and to be read. Regarding the generational divide I will focus on the online version, as the digital equivalent of the newspaper. Consequently, the seniors constitute the anti-program, trying to avoid reading the newspaper online. As we have seen before, there is the need for a crisis to be able to perceive situations, to become aware of them. Thus, if seniors read

[6] In terms of the ANT, I could also argue for the disadvantageous role of the printed newspapers, which might cease sooner or later. But as the paper is about the generational divide, I will focus on the seniors to be consistent.

the newspapers offline there is no crisis. Crises arise as soon as there is a change of the situation. Talking about media transitions, crises become obvious. All instabilities and changes can cause crises, and as media change rapidly, we have to deal with many of them.

4 Two modes of action

After having figured out what the program and the antiprogram might be, two modes of action are conceivable in the network of seniors and new media. Using online newspapers as an example illustrates the program-antiprogram link.[7]

(1) The program is stronger than the antiprogram. Briefly, this means seniors accept and use new media as the media make them do.[8] Thereby, the program can be understood as having all the benefits that will arise in case of reading the online version of the newspaper, but also the disadvantages that appear when not reading it.

In case of seniors and online newspapers the program might be phrased as follows: as long as there are many printed versions, there will not be the necessity to deal with online versions. But, as stated above, the printed versions will cease and thus the availability of alternatives changes. Not reading an online version would possibly mean not reading any newspaper. Furthermore, it might be beneficial for seniors to read the newspaper online due to its form of appearance: being in a good physical condition, a senior might be outside, traveling etc. In this case, the online version would only be advantageous if the senior would have a mobile device to take with her/him, but then it would increase mobility as it becomes unnecessary to find a seller, to deal with

[7] Besides, the two modes of action could be transferred to almost every example about seniors and new media.

[8] Although this seems currently not to happen for online newspapers, it is for printed ones (or also books, the program remains the same).

many large-format pages, which will crumple if it's raining, and with small font sizes, which could be adjusted in online versions.

All these possible benefits of the online newspaper are prescriptions as soon as they impose an action on another actor, i.e. the senior. However, the seniors are striving against this program and form an antiprogram. This means they might not agree with the benefits or accept potential disadvantages. In case the prescriptions are strong enough, they will convince the antiprogram and its actors, thus the seniors will read the newspapers online.

But, as stated above, this is currently not happening, so there is the need for a second mode of action to describe the situation, which will probably be more adequate to describe seniors' interplay with newspapers:

(2) The program cannot convince the antiprogram. Although there is a program trying to convince the antiprogram, the attempts might fail due to the strength of the antiprogram. For the senior-newspaper network this implies that there is no adoption by the older adults. Instead, the non-human actors (i.e. the newspapers) resign; they do not prescribe behavior onto seniors any more. Thus, seniors have a strong antiprogram, which is defined by the rejection of buying, reading or even considering online newspapers. Again, this can be transferred to other phenomena as well, e.g., reading books online.

The important point within this case is that the seniors *choose* not to act (either consciously or unconsciously); they are *actively not adapting or changing* anything.

Although both above-mentioned modes are conceivable, neither of them represents the current situation exhaustively. If one of

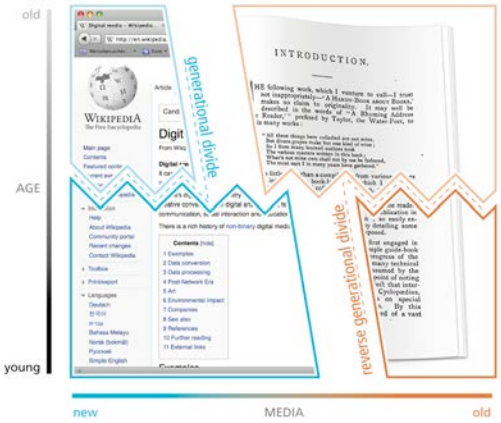

Figure 1:
reversed generational divide

them would, we would not have a crisis, because the situation was defined than as there were no more efforts of the program or antiprogram. Furthermore, there would be the problem of simply producing clichés, which would mean in case (1) e.g., to describe all seniors as early adopters of new media without a reflection of whether the progress is good or bad, in case of (2) to describe them as deniers of potentially beneficial programs. Consequently, this is not a question of either/or, but a continuous struggle of two opposed parties.

To bring it back to a reversed generational divide, there would also be many examples for describing the situation of younger users in terms of programs and antiprograms. Just imagine the above-mentioned attempts to create books with digital characteristics – the program of the books changes to convince the actors of the antiprogram, i.e. young people, who do not want to or are not able to read conventional books.

The reversed generational divide (see figure 1) is a gap in access, knowledge or skills that depends on the one hand from the media itself (old versus new) and on the other hand from the people's age (young versus old).

5 Balancing the programmatic behavior: the effect of transitions/crises

The situation we are now able to describe is a struggle between program and antiprogram, or between actors of the program and those of the antiprogram. There will be temporary outcomes[9] (Rip 2009, p. 410), or as Schulz-Schaeffer (2006) states, referring to Latour:

"*His answer is that the programmes of action will affect each other with the result that neither of the original goals will be realised but a new programme of action will emerge and a new goal to which it leads.*" (Schulz-Schaeffer 2006, p. 132)

This implies that every actor, and thus every program, has a specific goal, which he/she/it seeks to achieve, but as long as the program and the antiprogram are not equal, this is associated with efforts and thus activity. Nevertheless, I would not refer to it as a 'new' goal emerging through these attempts of balancing, rather as an adopted, adapted or balanced goal. If one of the two programs is stronger than the other one, it is clear which goal will be achieved. But – as we already know this might rarely happen – it is more a continuum, within which the goal is balanced or also 'hard-fought'.

The potential of crises has now become visible. There would be no activity at all, if there were no transitions or instabilities. There would be no struggle for change, or even more important, for situations to remain unaffected. A crisis is on the one hand a point of departure for an involvement and an analysis of situations, triggered by transitions and instabilities. On the other hand it is also the result of the struggles, which might lead to new or adapted crises.

[9] In the example of the key, Rip (2009, p. 410) refers to its shape, which changes and remains open to further changes induced by the program.

6 Conclusion

Describing seniors' joint behavior with media and not being a senior myself demands to acknowledge that this paper is influenced by my perspective on seniors,[10] which is not first-hand, but *mediated*. This means that all the descriptions are from the outside of the target group, but are mediated by literature, theories and observations. Nevertheless, this paper tries to describe the relationship between seniors and media – and hopefully it will serve as a basis to better understand it or at least for rising the discussion about the potential of transitions and instabilities (i.e. crises).

Using ANT for this purpose had two reasons: First, this theory allows to ascribe to both seniors and technology an equally important role – as soon as they are actors, there is no assumption about who or what is in a better (i.e. convincing) situation. Second, the ANT makes specific, surprising, so far unspoken events and situations visible, audible, and sensible (Mol, 2010, p. 255). However, one problem when using the ANT for the examples above is the complexity of the situation as soon as actors are involved in more than one network, with their different discourses, logics, modes of ordering and practices (Mol, 2010, p. 260). E.g., the online newspapers try to persuade seniors to read them. The program could be very specific for seniors, but as the newspapers also strive to be read by other age groups, they cannot focus exclusively on seniors. Thus, they are actors in more than one network, which makes the situation more complex and challenging.[11]

However, the ANT served as a starting point for describing the generational divide from a new perspective, which takes the effects of a situation into account, but does not hunt for causes – and the effects are mostly unexpected (Mol, 2010, p. 261).

[10] According to Herring (2008) the description or construction of generational issues is often not done by the generation concerned, but by others. Thus, it is biased and may lead to descriptions, which contain much information about the author's perspective, not about the generation in question. Or – referring to Wittgenstein – both construct a perspective, but one's own construction about oneself is usually more coherent (Lütterfelds 1995).

[11] I decided to use the example of the newspapers' program here to illustrate the potential complexity of networks and situations. The example would have been much longer if I had tried to describe the complexity of the role of seniors as actors within this network. Even so, the important point is that inconsistencies of goals will not only affect the program and the antiprogram, but also different goals of one single actor.

The overall goal of this paper was to describe the potentials and problems of changing media. However, these instabilities illustrate points of departure for producing activity, as the actors are challenged to do something, whether adopting or rejecting the changes. This applies to both younger and older generations and manifests itself e.g., in access to and skills of certain kinds of media. The implication for the above-mentioned project is that seniors as well as children need to be confronted with the new possibilities media bring along for taking over active roles within the senior-children-technology network. The challenge for the development of the intergenerational online activities is to inspire activity and to overcome the reversed generational divide. The basis is already made within the project, as it integrates both parties and requires joint activity. Thus, the perspective of forming and constituting a network allows the actors not only to deal with instabilities but also to tap their full potential.

Finally, the paper aimed to stress that the generational divide need not be negative *per se*, as it accentuates the active role of seniors, youths and technology. Loges and Jung (2001) phrased the active role of seniors vividly: "Older people may have lower Internet connectedness because they don't want higher Internet connectedness" (Loges and Jung 2001, p. 559). This statement illustrates perfectly the core of the ANT and its appropriateness for describing the interaction between seniors and media, as it allows and also requires activity of all actors.

7 Acknowledgements

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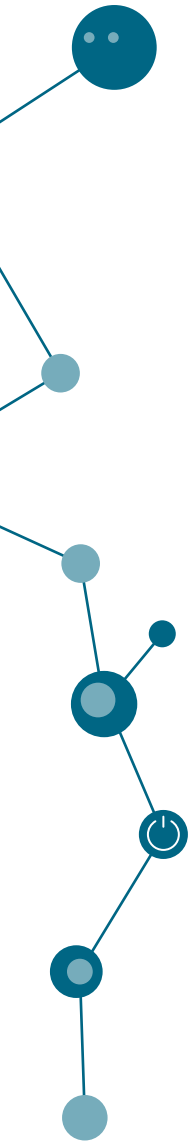

Human-Computer Non-Interaction: The Activity of Non-Use

Abstract. Presumably, technology non-use is not an activity. However, in reference to Actor-Network Theory we argue that non-use may be considered an activity. For instance, rejecting or disregarding technology requires activity of human actors, who undermine the goal of non-human actors (such as technology) of being used. In this paper we present some aspects of Actor-Network Theory that we think are relevant in this context and describe what they may contribute to better understand non-use. Afterwards, we illustrate some examples of non-use, followed by a discussion why we consider non-use an activity.

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Human-Computer Non-Interaction:
The Activity of Non-Use

1 Introduction

Working in HCI, much of our "raison d'être" is the fact that people use technology. Although HCI strives to support people by making technology usable and enabling desirable experiences, we struggle with people not using technology. We rather target helping people to use technology in order to prevent them from experiencing disadvantages through the non-use, such as extra costs if one does not use ATMs but wants to talk to a bank clerk, or if people need to work with technology on the job, being a precondition to function in the professional world.

While those motifs certainly justify a focus on use instead of non-use, they involve the danger of perceiving persons, who do not use technology, as in need of something. Thereby, users' *active* choice of not using technology is often neglected. In this paper, we will provide a theoretical background for discussing technology non-use (which recently got attention in research, e.g., [1, 9]) based on Actor-Network Theory (ANT), as it allows to focus on agency independent of actual use. After briefly outlining the theory, we will describe examples of technology non-use and how the perspective differs as soon as we consider non-use an activity.

2 Theoretical Background

In ANT (e.g., [2, 5, 7]), both humans (e.g., a user) and non-humans (e.g., technology) are actors as soon as they influence another actor. A symmetric network (or *monad*, as Latour calls them nowadays [6]) is formed in case of agency between them, but only for the purpose of the specific activity [5]. Networks consist of associations that have to be established and negotiated, which is important, but difficult. Thereby, the relations within the

network are gradually defined and characterized, e.g., as collaboration, clash, addition, tension, exclusion, etc. [8].

A relevant notion of ANT is the constant negotiation of actors in forming a network. Latour suggests to "paradoxically take all the uncertainties, hesitations, dislocations, and puzzlements as our foundation" ([5], p. 47) Non-use as a form of uncertainty is thus a valid starting point for an analysis from an ANT perspective, i.e., inquiring about various actors' activities. ANT's concept of 'program of action' allows to finally describe non-use as an activity. Latour refers to actors having a goal or a function [4]. As the former rather relates to human actors, the latter is rather associated with non-human actors. Both kinds of actors can be described as programs of actions, thereby putting all actors on the same level. Thus, programatic behavior concerns not only human actors, but also non-human ones.

For instance, a technology's program might be to convince human actors to use it. If the human actors have an objection against this program, they automatically form an antiprogram, independent from the reasons they do so (e.g., not wanting or needing the technology, or not being able to use it). In ANT, the notion of a goal does not require a motif or motivation; the motifs might come from a designer trying to *inscribe* a specific behavior into it, which in turn tries to *prescribe* another actor's (e.g., user's) behavior [4]. Still, it is the technology that in the end influences the human actor, whether to use it or not to use it, but not the designer. The essential aspect is that the technology is also attributed agency, even if a human actor does not use it in a specific way.

The starting point for an analysis in ANT has traditionally been a *setting*, i.e., a definition of the network that is of interest for a given phenomena (as otherwise networks are

potentially infinite), including the identification of all relevant actors. Recently, Latour changed from talking about actor-networks to talking about monads [6], wherein the perspective on the network plays a crucial role. This means that an analysis of a phenomenon is started from a specific actor, from which the network is established. In case of the technology as an actor, this perspective allows to address non-use in a very specific way, i.e., from the program of the technology, the antiprogram (i.e., the non-users' agency) can be observed and described, and the constant negotiations between the two become visible.

Relevance of ANT for technology non-use

Understanding users: considering them as active in non-use as well, they are given a voice in choosing whether to use a technology or not

Identifying reasons: looking at actor-networks from a technology perspective, but still looking at the consequences on how the technology in non-use, researchers will be able to identify reasons for non-use

Understanding materials: designers will be able to address the reasons for non-use through under- standing the agency of the interactive artifact or the digital and physical material that is used for the interactive artifact

Figure 1: Relevance of ANT

Finally, the negotiations may result in the non-human actor's program succeeding (e.g., the technology is used), or the human actor's antiprogram being stronger (e.g., not using the technology). And, there is a third possibility, i.e., creating a new goal that corresponds to neither of the actor's programs of action. In the next section, we will discuss examples of how non-use might differ according to the results of these constant negotiations. If we consider activity of actors (and finally agency within networks) as the mode of inquiry to better understand a given phenomenon, we will be able to better understand the non-use, since the focus is not only on the users not using a technology, but also on designers and researchers accepting that people may not use a technology, even if they do their best to support them (see Fig. 1).

3 Examples of Technology Non-Use

Considering the interplay between human and non-human actors as a constant struggle between program of actions and antiprograms, agency becomes visible, which is exemplified in the two following examples.

Example 1. If a technology is rejected by humans, the program of the technology is not strong enough. For instance, online newspapers are there to be read by human actors. If we consider older adults, they often refuse these media, their activity of rejection is rigid (for further details see [3]). Furthermore, the program of traditional printed newspapers may be stronger, resulting in a successful program of action. Finally, there is a third possibility. The struggle between the online newspaper's program and the seniors' antiprogram may lead to the creation of a new goal, for instance, a new technology adapted to their needs or including a further actor, e.g., the older adults' children using the technology to read out the newspapers.

Example 2. Another example would be a factory with workers not using an interface that aims to support their decision process of what item to process next. Instead, they base their decision on previous experiences. Again, the interface's program of action does not succeed. The technology (non-human actor in this network), follows a program, i.e., to be used by the operators to read the order of items to process.

Though inscribing a specific activity into a technology, it is not the designer of the technology that evokes activity, it is the technology that the user interacts with. This perspective may be disconcerting, but it allows analyzing situations without too many preconditions and histories.

With ANT, we may analyze four aspects:

- The program
- The antiprogram
- The constant struggle and negotiation between them
- The outcome of the negotiation:
  - use
  - non-use
  - emergence of a new goal

Figure 2:
Foci of Analysis

The Activity of Human-Computer Non-Interaction. When considering rejection as an antiprogram, it is also the activity of the human actor's of non-using the technology, that we will look at in depth. In the factory example, we may analyze what it is that lets the workers rely on their own valuation than the one provided by the technology, while even consciously contravening the rules. We may find a variety of answers, such as distrust in technology or in the origin of the information that is displayed on the interface (e.g., not trusting a person being responsible for providing this information), or a feeling of power when not following regulations, etc. We also perceive the border between program and antiprogram clearly, non-use thus becomes a relevant topic of inquiry. Non-use may facilitate a better understanding of what we need to change in the design of interactive artifacts, or what we *cannot* change (see Fig 2).

A further dimension in considering non-use an activity is that technology may affect human actors also in case of non-use, even if they do not "actively" reject or refuse the technology. Taking social media (e.g., Facebook) as an example, and its relation to non-users, its program evokes activity also in non-use. Non-users are also part of the social media that are established virtually; people are represented that are not part. The social media's program influences them through talking with social media users or other non-users. The program of action thus reaches actors also without negotiating with their antiprogram, as they are not rejecting or struggling with it.

4 Conclusion

In this paper we argued that exploring Human-Computer Non-Interaction may re-focus our attention to the new goals that are emerging in technology non-use. However, we are aware

that the scope of this paper has its limitations. We only considered those moments of non-use, where people potentially have access to the technology. Non-use in terms of not being able to afford technology, or living in a part of the world, where certain technologies are actually not available, is not sufficiently covered by our perspective. Still, we think that for many issues that HCI is addressing, an analysis in an ANT sense may be helpful. And we will in future study in detail how to cope with further dimensions of technology non-use.

We do not claim that the findings we gather through taking an ANT perspective cannot be gathered in other ways as well. However, starting an analysis of users from a technology point of view may include both actors equally into the analysis, emphasizing the *hybrid* actor-networks [4] of human and non-human actors that may lead to the identification of attributes and competencies that one actor alone would not have or reveal (e.g., establishing a new goal that is combining the actors' competencies, considering non-users as active).

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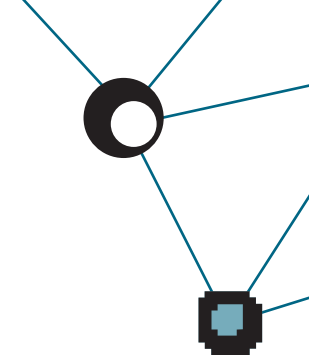

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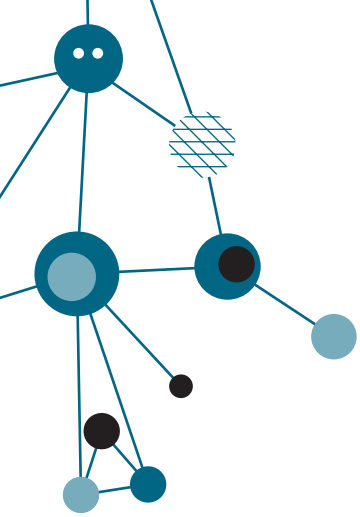

Materials, Materiality, and Media

Abstract. In HCI, and especially in interaction design, the material aspect of interactions is currently emphasized. Nevertheless, it is challenging to theoretically frame the variety of digital or immaterial, and physical materials. In order to contribute to this materiality discourse, we reflect on McLuhan's work on media analysis and on Latour's Actor-Network Theory in this paper. Both emphasize the active role of the material – be it media or any other kind of non-human actors – in the interplay with the human. Thus, we establish junctures between their findings and materials, as used in interaction design in HCI. We discuss McLuhan's claim to focus on new sensory effects and ways of interaction brought forth by new media. Furthermore, we illustrate how describing the connections between materials, designers, and users in terms of Latour's Actor-Networks can be beneficial for interaction design. Finally, we discuss the respective methodology and its relation to research through design.

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1 Introduction

In HCI, design materials are getting more and more attention. At CHI 2012, a panel was held on *"Material Interactions" – From Atoms & Bits to Entangled Practices* outlining different perspectives on materials [51]. The panelists provided heterogeneous approaches to an understanding of materials. Hiroshi Ishii talked about his vision of tangible interfaces and respective properties of the materials. Paul Dourish referred to the complexity of the interplay between current materials and design in HCI. Anna Vallgårda outlined her understanding of computational composites as design materials. While Petra Sundström emphasized the crafting aspects of working with digital materials, Daniela Rosner referred to the cultural histories embedded in technology. Tobie Kerridge focused on public engagement. Finally, Mark Rolston provided an industrial point of view on creative usage of materials. The presented notions of materials were thus manifold. On one hand, the design practice with both digital and physical materials was discussed, which finally aims at providing rich user experiences. On the other hand, the theoretical point of view was emphasized. However, a lack of shared terminology and framing, which would facilitate the discussion about materials in HCI, was recognized.

In order to strengthen this framing, we reflect on two theories from other disciplines, i.e., McLuhan's media analysis and Latour's Actor-Network Theory. Both have focused on the interplay between humans and artifacts and provided a theoretical understanding within their disciplines. The reason for reflecting on these very theories is their explicit emphasis on the active role not only of humans, but also of artifacts. This emphasis complies with the current notion in interaction design that material properties and qualities have an underestimated influence on the design of interactive artifacts.

First, we will refer to Marshall McLuhan's theoretical work on media (e.g., [33]). McLuhan studied the relation between media, humans, and society, and focused especially on sensory effects and transitions from one medium to another. One of his arguments is that media are not only transmitting information, but are information themselves. This will be the starting point for our theoretical reflection, as materials in HCI are also considered to be more than solely "the stuff that things are made of" [19, p. 1]. Thus, we aim to find out whether McLuhan's further inferences on media effects are also true for materials in HCI.

Second, we will describe Bruno Latour's Actor-Network Theory (ANT; e.g., [26]), a sociological theory. This theory understands human and non-human artifacts as actors that form a network. As long as an actor influences another person or artifact, the network not only exists, but also changes continuously. Considering materials as actors might help us to describe and understand their *active* role in the interplay with the user, as well as with the designer.

Our aim is to reflect on McLuhan's and Latour's work in order to identify what they can contribute to strengthen the theoretical framing of materials in the HCI design realm. According to Jung and Stolterman [22], design in general is the materialization of meanings into an artifact form. While the design process in HCI focuses on the communication with the users and their needs (i.e., a conversation based on words, actions, or objects [43]), the design process of traditional design disciplines (e.g., product or graphic design), is rather characterized by crafting particular materials [22]. Fernaeus and Sundström [12] provide several reasons why material knowledge is underestimated when it comes to interactive system design in HCI. For instance, there is the illusion that the digital allows building everything. Furthermore, the complexity of digital material makes it hard to

show, share, and fully understand it. Fernaeus and Sundström [12], as well as Jung and Stolterman [22], argue to nevertheless "integrate a designerly approach in an analytical HCI approach" [22, p. 403], taking the properties of the materials explicitly into account; or as Hallnäs and Redström put it: "Interaction design is product- and systems design where computational technology is a basic design material" [16, p. 24].

These notions emphasize the importance of understanding the effects of the complex digital material on designers and users. Therefore, we will reflect on McLuhan's work on media and their sensory effects and on Latour's ANT, which offers an instrument to describe the dynamic nature of (non-human) materials and their interplay with other (human) actors. Both McLuhan and Latour highly value the *material* (be it media or any other non-human artifact) and its influence. While McLuhan emphasizes the effects of media and the respective consequences for the design, Latour provides methodological possibilities to describe the complex interplay between the artifact and the human.

In order to identify the potential of those two perspectives for the materiality discussion in interaction design, we will initially depict definitions of materials, materiality, and media and explore their similarities and differences. A reflection on McLuhan's and Latour's work will follow, including some already existing connections to HCI, and parallels to the materiality discourse. Finally, we will discuss our main question, i.e., what elements McLuhan and Latour can provide for a theoretical framing of materials in interaction design.

Towards Materials and Materiality 2

Ingold [19] defines materials for the anthropology realm: "I mean by materials the stuff that things are made of" [19, p. 1] (or according to Schön material objects "are just what they are" [42, p. 9]). However, in HCI things are not only made of materials, they might also be *represented* by further materials. When for example users manipulate content, they interact not directly with it, but through input and output modalities, like computer screens, keyboards or mice (i.e., materials for interacting with materials). Interaction design thus works with the content *and* the representation, and both content and representation can be digital (which means here virtual or *immaterial* material) or physical materials. These multidimensional aspects of materials become *tangible* in a design perspective, When designing computational things the material is somehow absent and only conceptually present [16].

Vallgårda and Redström [48] propose to think of computational composites, i.e., computation needs to be combined with other materials, to become a material itself which can be used in design practice. Furthermore, computational materials are *coming to be* over time and in context, i.e., they cannot be reduced to the terms of being or doing, but must be understood as constantly in movement [3]. Consequently, several temporal combinations of physical or digital content with physical or digital representations can be the basis for interaction design to work with. The designer is in progressive relationships with the material, i.e., in conversation, "where she is getting some response back from the medium" [43]. Herein, Schön [43] emphasizes the designers' reflection on action (i.e., pausing to think back over what has been done), and reflection in action (i.e., reflecting on the design without stopping).

Having clarified what we understand by materials in HCI's design, we will now proceed with the term materiality. Ingold [19] states it as: "To understand materiality, it seems, we need to get as far away from materials as possible" [19, p. 2]. Although Ingold relates this argument to anthropology, what he is referring to is similar to HCI. It is about the abstract discussion of materiality without considering the properties of the individual materials. Ingold even poses the question whether materiality was the academic perversion of materials and their properties. In our opinion it is though an abstract term, but not a purposeless one. Similar to the distinction between method and methodology, we understand materiality as the theoretical discourse about materials. This includes all illustrations and discussions of materials in HCI, like their roles in design processes, their forms, functions, ontologies, etc. Thus, under the umbrella of the materiality discourse we are talking about materials when we refer to what things are made of or represented by. On basis of this understanding of materials and materiality, we will proceed by exploring how the term media relates to materials.

3 From Materials to Media

The term media is used in various ways and in various disciplines. Most often, it is used as an expression for means of communication (e.g., [34]), especially in relation to social media. The primary purpose of (social) media is to speed up and increase the likelihood of communication, facilitate coordination of actions, especially with changing interaction partners and finally to allow complex cooperation. Thus, media are more than technical instrumentalizations, as they also include natural languages or writing systems [41]. However, besides the exchange of information in a dialogue, interaction with information can also be a monologue, i.e., an individual perception and reflection [17].

As information is principally dematerialized [9], it needs a material to manifest in order to provide humans a way to perceive this information. The information can be regarded as the content and the manifestation, like the media, is the representation of the content. Thus, media can be any material that allows to interact with the information, and in HCI it will most often be the material interaction design works with. Although not defined explicitly, the term media has often been used in this way in HCI, e.g., by Ames and Naaman [1] or Carter and Mankoff [6].

As McLuhan focused on media analysis throughout his work, we will reflect on it in the following. After illustrating his connections to HCI, we will discuss his notion of media and consider relevant aspects in detail.

Marshall McLuhan's Media Analysis 4

Marshall McLuhan (1911-1980) was a Canadian English Professor, who focused on media analysis, and many of his articles relate to media education [13]. McLuhan has been related to HCI several times, mainly in reference to his book "Understanding Media: the extensions of man" [32]. This is not surprising, as McLuhan describes his interpretation of 26 different types of media in one chapter each. His discussions from the spoken word to photography to automation allow for immediate connections to any related subject (see as examples [4, 7, 23, 50]).

In 2011, McLuhan would have had celebrated his 100th birthday, which motivated several discussions about his work. Although considered ambivalently in academia, e.g., being a charlatan through neglecting the need for evidence (see e.g., [2] or [36]), there were many events for resurrecting his ideas. One

of those events was a conference entitled *re-touching McLuhan*, which dealt with McLuhan's take on sensory effects of electronic media, and his legacy on artistic and digital cultural practice [39]. It focused on questions of tactile sensing and embodiment, and aimed to link McLuhan's work with today's media reality. In comparison, we will reflect on McLuhan's basic ideas in order to identify connection points to interaction materials and materiality.

4.1 Overview of McLuhan's Work

One of McLuhan's most attention-getting books (with Quentin Fiore as co-author) is about the medium being the message. Put very briefly, McLuhan's basic idea is that the medium influences if not determines its effect on the individuals. While one could argue that he is just another technology determinist, Friesen and Hug [13] respond that, although McLuhan would see media "coming before" other considerations, it does not mean that media found or give rise to social, cultural and historical phenomena. However, McLuhan considers the content as having a subordinate role in messages. Instead, by stressing the importance of the media, he argues, the chance of perceiving and influencing the impact of new technologies on humans is increased, and the revolutionary environmental transformations can be extensively used [31].

Stadler [44] argues that the medium-content distinction is related to the figure-ground discussion from Gestalt psychology. It is assumed that perception is based on both the figure, on which we focus, *and* the ground, which appears unstructured in the background. The boundary is perceived as a shape belonging to the figure, while the ground appears to be shapeless. Nevertheless, the ground is essential for perception. According to McLuhan, the media are like the ground, they are the shapeless

environment of the content, but they are pervasively influencing perception and impressions. This is also strongly related to what Fallman [10] refers to as the non-neutrality of technology, i.e., technologies not being neutral means for realizing human ends, as they actively shape the users' experiences of the world; and they not only influence the users' experiences, but also the designers' ways of designing. While Fallman emphasizes that technology is actively influencing human's experiences, McLuhan even considers media, and especially electronic technology, as extensions of the human.

You've got to remember that my definition of media is broad; it includes any technology whatever that creates extensions of the human body and senses, from clothing to the computer. [31]

Again, the medium is the message, as not the content is extending the human senses, but the medium itself (e.g., the phone being an extension of the ear). Furthermore, McLuhan separates four stages of cultural history: a primitive tribal culture, an audile culture, using the oral technology of speech, the "Gutenberg Galaxy", i.e., a visual culture, using the mechanical technology of printing, and finally the electronic age of television and computers [18]. His claim is that the media, which were prominent in the different ages, did not necessarily address all human senses. As a consequence, the deprived senses were affected negatively, and the humans unlearned to perceive with all their senses comprehensively. For instance, the audile culture extended the auditive sense, but left behind the visual or tactile sense.

But it is necessary to understand the power and thrust of technologies to isolate the senses and thus to hypnotize society. [...] Every new technology thus diminishes sense interplay and consciousness, precisely in the new area of novelty where a kind of identification of viewer and object occurs. [30, p. 272]

McLuhan argues that the media of the electronic age have the capability to affect and transform all human senses through activating a sensual interplay, whereas for example the manuscript culture in the Gutenberg Galaxy extended a single sense, i.e., the visual sense. Addressing solely for example the visual sense would be associated with linear continuity, uniformity, abstraction, and individualization, and a culture dominated by visuality would be characterized by separation, distance, alienation and the dissociation of sensibility [18]. The argument is that media, which characterize certain societies or cultures, affect the whole human perception. As an example, McLuhan referred to the television, which at McLuhan's times requested the viewer to actively participate in filling in vague and blurry images [31]. Media, which require such a strong involvement through providing slight granularity (like the electronic age), McLuhan called "cool" media, opposed to "hot" media, which provide enough details to not require strong involvement, like the radio [32].

4.2 Media Analysis and Materials

McLuhan's understanding of human involvement with media illustrates that the media, i.e., the representing material or the ground surrounding a figure, essentially impress and affect the humans. Furthermore, according to McLuhan, past media ages influence the subsequent ones. In order to discuss what this means for interaction design, we will reflect on those aspects in detail in the following.

Sensory Impressions and Effects. Friesen and Hug [13] emphasize McLuhan's distinction between sensory impressions and sensory effects; while the first are what a medium can provide (e.g., releasing sound waves), the latter is the sense obtained, i.e., the sensory impact (e.g., acoustic perception). Friesen and

Figure 1: Can you hear the bang? Multiple sensory effects through visual impression (based on [33, p. 111f]).

Hug furthermore refer to Aristotle and his notion of a common sense, which combines all senses. Not the unique senses, but the movement, rest, number, and magnitude become important parts of the perception.

Figure 1 illustrates the distinction between sensory effects and sensory impressions. It is in the style of a page in McLuhan's book *The Medium is the Massage*, showing a graph in comic style. While the sensory impression is constituted of color and contrast, the sensory effect goes beyond the physical reality. Looking at the picture might also result in *hearing* the bang, or even *feeling* it. The picture is perceived dynamically, as the reader is engaged with several senses.

Also the book title expresses the distinction of impressions and effects. It was supposed to be *The Medium is the Message*, but due to a compositor's error, it got *The medium is the Massage*. After recognizing the error, McLuhan was delighted, as it even more expressed what he wanted to say, i.e., the media affect more senses than the mode of presentation would suggest, like being a massage to the senses [13]. Friesen and Hug [13] emphasize that "An imbalance of the senses induced by media can deprive one of rationality or consciousness" [13, p. 91]. Similarly, Ullmer and Ishii [47] argue that GUIs represent information in an almost entirely visual form, which would neglect the various possibilities to address human senses. Ishii [20] expresses concerns that:

Our visual and auditory sense organs are steeped in the sea of digital information, but our bodies remain imprisoned in the physical world. [20, p. XV]

Also Goodman and Rosner [15] recognized the importance of addressing various senses with digital tools. They investigated how to combine handwork experiences, like knitting or gardening, with digital tools. They emphasized that, especially for handwork, the sensory sensitivity is crucial, be it a physical or digital activity. While Ullmer and Ishii [47] as well as Goodmann and Rosner [15] implicitly assign the responsibility of addressing various senses to the design of interactions, Friesen and Hug [13] argue for training the senses and perception in education in order to re-establish sensual interplay and unity. Both perspectives are related to McLuhan's concerns about people's sensory capabilities. McLuhan assumes that in different media cultures sensory capabilities are brought forth or inhibited by the media. Furthermore, the effects of preceding cultures often continue also in the age of new media. As an example, manuscript culture (i.e., the Gutenberg Galaxy) addressed primarily the visual sense.

Although the electronic age offers the possibility for various sensory experiences through multimediality, there are behavioral or perceptual leftovers from the manuscript culture. "They [people] suspect the ear: they don't trust it" [33, p. 117]. This means that things that are visible, and preferably constant, are more likely to be considered as real [5]. McLuhan and Fiore argue that people sometimes would not understand purely verbal concepts, as seeing things would ensure a certain feeling of safety. There would be evidences in the language, like speaking of visionaries or seers when talking about wise people [33]. This leftover can also be found in Dourish's [8] description of coding signals in interactive systems. He argues that extracting information content from a medium requires the ability to decode signals, which "[...] typically arises as variety of issues around the topic of 'visibility'" [8, p. 165]. Dourish refers to the visibility of the activities from one person to another across time and space, or the system's response to a user's activity. Having put the term visibility in quotation marks himself, leads us to the assumption that the term does not perfectly fit; although it could be a coincidence, this might still implicitly address the lack of appropriate terms for expressing the sensory effects of new media and subsequently of new materials. Thus, turning towards new materials, new media or environments not only requires explicit processes, but also new ways to express them.

Through sensitively making use of new interaction possibilities, which the electronic age provides, and establishing new ways of experiencing the interaction, design can help overcome the sensory deprivations. This also relates to McLuhan's claim that new mediatic environments require new ways of interaction, which will be discussed in detail in the following section.

The Old and the New. According to McLuhan and Fiore [33], new media require new ways of dealing with them, and new perspectives to understand their effects.

The main obstacle to a clear understanding of the effects of the new media is our deeply embedded habit of regarding all phenomena from a fixed point of view. [33, p. 68]

They emphasize that the interplay between old and new environments would be problematic and confusing, as the new media would be forced to do the work of the old. People would rather stick to an asynchronous action-reaction mode, which has different time patterns than what the electronic age would suggest; action and reaction would occur almost at the same time. Today, this is still true for e.g., some newspapers, which are provided online and issued on a daily basis, instead of being distributed continuously. However, there is a transition from the rather "static" newspaper to continuous news exchange, including the possibility for direct feedback in form of comments to the newspaper entries. This complies with McLuhan's and Fiore's argument that media, and especially electric technology, reshape and restructure patterns of social interdependence and every aspect of our personal life [33]. A more subtle but similar perspective is provided by Dourish [9], who refers to a transformative materiality of digital networks. Digital technologies intentionally or accidentally shape and modify physical or social environments, like WiFi networks shaping public spaces.

Following McLuhan's claim to deal with new environments in new ways, one could ask whether the combination of the physical and the digital would be contradictory then, as the physical is what we traditionally dealt with, and the digital is the new environment's material. However, designers' awareness of the

constitution of the materials and the various ways to combine and work with them, will meet McLuhan's claim.

So far, we reflected on several aspects McLuhan referred to, which we consider highly relevant in the context of materials in interaction design. According to McLuhan, media, which can be interpreted as materials representing content, are pervasively influencing human perception and impressions. However, sensory impressions are not necessarily equal to sensory effects. While impressions are what the medium (the material) provides, the effect is rather the sense obtained [13]. Consequently, new media and materials require new ways of designing them in order to overcome perceptual leftovers from former media ages and to enable rich sensory effects. In the following we will thus focus on the effects of interactive media in detail.

Affecting Artifacts: Interaction Design 5

In order to differentiate more clearly between the effects of materials on the users and the effects on the designers, we refer to Lim et al. [29], who distinguish between user experience, interaction gestalt, and interactive artifact. Lim et al. consider the interactive artifact to have properties, which are not equivalent to the usage qualities that the users experience. The designers' task is thus to bridge this gap by translating interaction attributes (like movement or connectivity) to the interactive artifact properties in order to shape the interaction, i.e., the interaction gestalt. Designers anticipate how a certain gestalt will be experienced by the users. Or as Hallnäs and Redström [16] highlight, interaction design increasingly focuses on what we do with the interactive artifact (which is in their terminology the *act* that defines the intended use of things and systems), rather than the things as such.

According to the model, which Lim et al. propose, the designers *translate and manifest* attributes to the artifacts' properties [29]. Nevertheless, the artifact properties need to play an *active* role in this process, like Fernaeus and Sundström emphasize:

[...] in terms of interaction design, choices made on the technical level of tools and materials are essential not only in the fine-tuning, but also for achieving the fundamental properties of the envisioned design. [12, p. 494]

Thus, artifacts with their (im)material properties sensorily affect both the designers during the act of designing, and also the users while experiencing the artifact. In order to further illustrate the dependencies of materials, designers, and users, we will in the following section reflect on Bruno Latour's Actor-Network Theory (e.g., [26]), which also stresses the *active* role of artifacts.

6 Bruno Latour's Actor-Network Theory (ANT)

Bruno Latour, a French sociologist and anthropologist, was significantly involved in the development of the Actor-Network Theory. ANT describes the interplay between humans, and non-human actors. Non-human actors can be analogue artifacts, technology, or anything else (e.g., describing Pasteur's agriculture discovery of a vaccine against anthrax in terms of ANT was one of Latour's first and most prominent examples).

The term activity is a central one in ANT, i.e., everyone and everything can be an actor as soon as he/she/it evokes an action of someone or something else. Thus, a network of actors emerges, "whenever action is to be redistributed" [27], be it between humans, between human and non-human actors, or solely

between non-human artifacts (e.g., machine-2-machine communication). A behavior can be imposed onto humans by non-human delegates (e.g., technology), which is called *prescription* [25]. Actors are connected as soon as they influence each other, and this happens within a network, which they form in turn. As there are human and non-human actors, Latour calls it a *hybrid* network [24]. A network consists of associations, which have to be established. These associations define the relatedness of the actors within the network, and can be described with the terms collaboration, clash, addition, tension, exclusion, inclusion etc. Associations are also sometimes called tinkering, emphasizing the step-by-step activities performed by the actors [35].

[...] there is not a net and an actor laying down the net, but there is an actor whose definition of the world outlines, traces, delineate, limn, describe, shadow forth, inscroll, file, list, record, mark, or tag a trajectory that is called a network. [24, p. 11]

Consequently, a network is not stable, but constituted by the actions of the actors involved. Besides the emphasis on activity, ANT also includes a methodological claim. Through describing all relations (actions, actors, etc.) in detail, an understanding of a phenomena is developed, theory is thus embedded and extended in empirical practice [28]. The detailed description of networks is the researchers' task, and ANT provides the respective terminology and methods.

In a later section we will illustrate what this methodological claim holds for interaction design research. Prior to this, we will discuss the connection between ANT, HCI, and especially materials in interaction design.

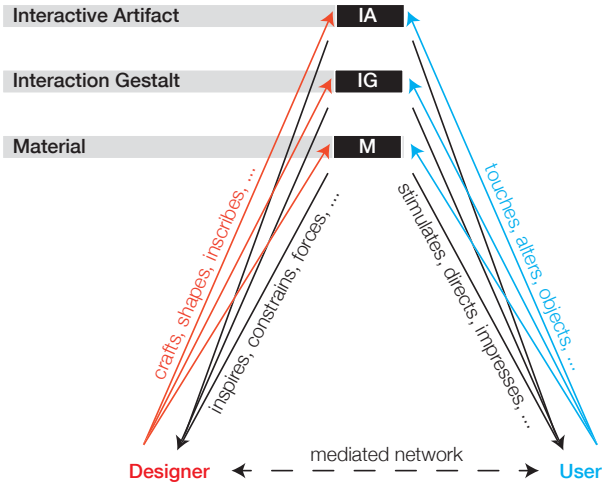

Figure 2: Actor-network between materials, interaction gestalt, interactive artifacts, designers, and users

ANT and Materials. In HCI, there have been several references to ANT or Latour, e.g., [14, 15, 37, 40, 45]. Suchman [45], for example, described among others machine agency referring to ANT. Besides the description of the interplay between users with technology as such, like Suchman used ANT for, we are focusing in the following on the interplay not only between technology and users, but between materials, designers, and users.

If we consider materials and designers as influencing each other and thus forming a network, one might argue that the specific characteristic of HCI, the user perspective, needs to play a central role in this network too. In order to clarify the connections between materials, designers, and users, we again refer to Lim et al. [29]. Lim et al. outline that the designer anticipates how the interaction gestalt (i.e., the shape of the interaction) will be experienced by the users, and considers this in the design. This process of anticipating the users' experiences with the artifact or the interaction gestalt is called *inscription* in ANT. It is the designer's or engineer's effort to influence the user's interaction in a specific way; however, the inscription can succeed or fail.

Figure 2 illustrates this network. It shows that the network consists of different levels, i.e., the material, the interaction gestalt, and the interactive artifact. Furthermore, the designers and the users both are active parts in this network, but they are only connected with each other in a *mediated* way, i.e., only indirectly and asynchronically. The networks are thus of a dynamic nature, they emerge in activity, and are absent in disactivity.

In 2011, Latour held a keynote on network multidimensionality in the digital age at the international seminar on network theory. He related the digital to ANT, and argued that:

[...] the expansion of digitality has enormously increased the material dimension of networks: the more digital, the less virtual and the more material a given activity becomes. [27, p. 8]

What he refers to is the material *representation* of the digital ("Go tell Google engineers that their vast array of servers are just virtual!" [27, p. 8]). When we focus on the network of designers and materials, this means that the dependencies of materials, their properties, and qualities are central in the respective actor-network. Viseu [49] puts it that way:

[...] the objects themselves have competencies which must be taken into account. These competencies give them agency. [49]

The activity of objects (or materials) depends on competencies, and those competencies derive from the objects' properties and qualities. What ANT can thus contribute to a theoretical framing of materials in interaction design is the perspective on the actors and the respective descriptions. In the following, we will bring together Latour's and McLuhan's considerations with interaction design.

7 Interaction Design Linked to McLuhan & Latour

Having reflected on McLuhan's work on media and Latour's ANT, we are now transferring these theoretical notions to interaction design in HCI by sketching the junctures between them. We explicitly emphasize that the following sections do not provide practical implications; they rather illustrate a theoretical framing of materials in interaction design.

7.1 Rich Sensory Effects Through New Media

McLuhan complained that the printed page separated, for example, poetry and music [30]. Following McLuhan's argumentation, materiality needs to be a holistic paradigm of feeling and sensing the material, which allows also subtle peculiarities of materials to be recognized and used in design. As an example in the context of education, the importance of recognizing the "material" as a substantial element in the learning process has been discussed by Friesen and Hug [13]. Friesen and Hug criticize that media are often used for conventional educational purposes, like having instructional media, which take over or complement the traditional role of a teacher. They claim that

Instead, media need to be seen as thoroughly interpenetrating school and classroom, and educational practices and purposes. The implication is that education taken as a whole, needs to be radically re-thought in a sustained manner, from a mediatic perspective. [13, p. 85]

They emphasize the effects of media on educational outcomes by arguing that the properties and qualities of new media cannot be neglected, and suggest to take the sensory effects, as described by McLuhan, as a starting point. Rich sensations that

can be achieved through the usage of specific materials and their interplay, go beyond pure physical stimuli.

In an age of twitchspeed and twitter, multitasking and multimedia, such a radical exploration of alternative sensual orientations and subject constructions in education is both current and compelling. [...] any purchase remaining for thought or practice to engage media and their determinations will be of no small value. [13, p. 99]

In our opinion, this is especially true for interaction design, which also requires a radical exploration of alternative sensations, which can only start in the design by experiencing and playing with the materials. Considering the interplay of senses as a desirable state, which not only affects but also extends humans, spaces evolve to facilitate and understand this interplay. Interaction design faces the difficulty of *designing sensory impressions*, i.e., what the material can provide, in order to *allow sensory effects*. With the complexity of digital and physical material, this is even more difficult, as the material itself sensorily affects the designer in various ways, or as Schön expresses it: "The designer designs not only with the mind but with the body and senses [...]" [42, p. 5]. Consequently, interaction design in HCI needs to assess the sensory effects the material has on the designer, acknowledge the qualities or properties of materials and design the sensory impressions in a way that they result in rich sensory effects for the users. Furthermore, dedicated material studies are necessary in design research to investigate the effects in different contexts, i.e., with different human and non-human actors.

7.2 Rich Ways of Interaction Through New Materials

McLuhan claimed to consider the historical and social context of media, but that does not mean to carry forward traditional ways

of interaction. It rather means that research needs to understand why certain media or materials led to specific ways of interaction in order to consciously identify new ways, which are enabled by new materials. About electric media, McLuhan and Fiore [33] say that they would have an active, exploratory quality, which would involve all senses – to be "with" them. For example, they argue that television demanded different sensory responses than for example printed media. However, the age of the Gutenberg Galaxy predetermined the sensory interaction with the "new" medium television. The same is true for digital materials: Using them in the tradition of physical materials will withhold maxing out the possibilities it would provide due to its immediacy (e.g., direct feedback), dimensionality (e.g., hyperlink structures), and especially multimediality and multimodality (e.g., addressing various senses).

The intertwining of historical contexts and new ways of interaction can be illustrated on basis of Fernaeus et al. [11], who examined the Jacquard Loom. This loom was a system, which was used to produce patterns of fabric in the early 19th century. Fernaeus et al. discussed its qualities in terms of interaction design, like the role of physical materials for interacting with a system, or whole body interaction, which means that the loom explicitly involved the whole body when interacting with it. They assume that:

Some of these [qualities] *may be aspects that we value today but that were probably not considered significant at the time of its original use.* [11, p. 1597]

The argumentation of Fernaeus and colleagues [11] thus includes two implications. First, interaction design should focus on qualities of the material, as the qualities constrain and enable certain ways of interaction. Second, looking into the past can

help us making those subtle processes visible. The perspective of Ferneaus et al. fits McLuhan's claim to understand former ways of interaction, while concurrently recognizing the material's potentials and constraints. Their strong focus on whole body interaction might have delighted McLuhan, as the human senses are addressed in a comprehensive way. They also argue that the Jacquard Loom was a predecessor of modern day computers, as it worked with punched cards which define the patterns of fabric. However, they were criticized by Reeves [38] for not discussing the fundamental difference between analogue and digital computing sufficiently.

Combining Reeves' with Ferneaus and colleagues' findings would finally comply to what McLuhan considered relevant. On the one hand, understanding the ways of interaction in preceding media or technology cultures can help us to provide new ways of interaction. On the other hand, it needs to be acknowledged that the new materials need new ways of interaction, which nevertheless can integrate formerly used interaction techniques. Ishii et al. [21] even go one step further: they propose *Perfect Red*, being what they call *radical atoms*. Perfect Red would be a new design material, which would change dynamically and have a complex set of responsive behaviors. Although Perfect Red is currently only a fictional material, representing a possible substance, Ishii et al. explored the interactions that would be possible with this material. However, in contrast to McLuhan, they begin with the exploration of new ways of interaction even if the corresponding physical material itself has not been invented.

Recognizing that new materials provide new ways of interaction seems to be self-evident at a first glance. However, the various perspectives on how to explore and develop the new ways of interaction as well as how to integrate former ways result in a vast complexity. McLuhan ascribes the ability for creatively

managing this complexity to artists, probably due to the fact that interaction design has not been prominent at his time. He assumes that:

[...] inherent in the artist's creative inspiration is the process of subliminally sniffing out environmental change. It's always been the artist who perceives the alterations in man caused by a new media, who recognizes that the future is the present, and uses his work to prepare the ground for it. [31]

Consequently, the difference between an artist and a designer needs to be the level of consciousness. While the artist might succeed in his work by subliminally apprehending the environmental changes, the designer also needs to explicitly recognize, explore and understand the new environment in terms of digital and physical materials. In HCI, this is formalized by *Research through Design*, both theoretically (e.g., [52, 53]), and practically (e.g., [12, 46]). Fernaeus and Sundström [12] indicate that:

[...] there is no coincidence that the more successful interaction designs are built on deep technical understandings of the specific materials worked with [...]. [12, p. 488]

They rescind McLuhan's concerns that humans are only consciously aware of the environment that has preceded it [31]. One could argue that McLuhan refers to the environment, and not to the specific material, which would make the argument obsolete. Nevertheless, if we consider the environment in McLuhan's sense as the media, or the ground that surrounds the figure, it also encompasses the materials interaction design works with.

Regarding the mediating role of artifacts between humans, McLuhan argued that:

Manuscript culture is conversational if only because the writer and his audience are physically related by the form of publication as performance. [30, p. 84]

This relation can also be described in terms of ANT. As the writer influences the audience, also over time, they form a network. This network would in addition to the writer and the reader consist of further actors, like the text, or the paper form of the manuscript.

Whenever an action is conceived as networky, it has to pay the full prize of its extension, it's composed mainly of voids, it can be interrupted, it is fully dependent on its material conditions [...]. [27, p. 8]

Latour, hereby, refers to the complexity of the networks, bringing along a difficulty in describing them thoroughly. However, the benefit of identifying the network lies in the detailed description of the connection between the actors, which includes also the materials in an active role. In interaction design this means that designers are impressed by the materials in a very different way than users, as they for example are inspired and/or constrained by the potential for crafting them. The users are influenced by the materials (or interaction gestalt, or interactive artifact), which direct them to reach a goal, be it efficient performance and/or having positive user experiences. Nevertheless, the designers and users influence each other indirectly; their network is mediated.

Regarding the designer's role in anticipating or inscribing the users' experiences into the materials or the artifact, Latour refers to blinking text cursors (e.g., in text editors):

As for the computer user input, the cursor might flash forever without the user being there or knowing what to do. There might be an enormous gap between the prescribed user and the user-in-the-flesh [...]. [25, p. 237]

Latour hereby refers to Don Norman's Gulf of Execution, which he considers "[...] an excellent introduction to the study of the tense relations between inscribed and real users" [25, p. 257]. However, Latour expresses regrets that Norman only refers to dysfunctions in the interface with the final user, instead of considering the shaping of the artifact by the engineers or the designers themselves. This is exactly what we can achieve with referring to ANT as theoretical framing; it can provide an instrument for describing the dynamic networks. The material, the designer, and the user have *active* parts in those networks, which do not require a priori definitions of the roles in the development process of any interaction system. Although McLuhan would argue for exclusively taking the *new* material into account, the historical and social contexts need to be described in the networks as well, as long as they affect the current design or usage. This will facilitate understanding the effects of the materials on designers and users, and contribute to consciously explore and comprehend the *new* environment for designing new ways of interaction.

The descriptions of these networks can finally also be regarded as the methodological grounding for interaction design research. For instance, Zimmerman and Forlizzi [52] claimed for research programs, which focus on research through design, to nurture multidisciplinary and cross-disciplinary insights into

design and HCI, creating a body of examples for the community to build on. In order to contribute to that claim, it seems to be promising to take the perspectives of networks in the sense of ANT.

7.4 Doing Research Through Describing Design

Both McLuhan and Latour argue for a descriptive investigation of situations, networks, or interactions. While McLuhan does not follow any paradigm or theory in doing so, Latour grounds his methodological claim in ANT. Fully established descriptions are the method used in ANT, and these descriptions do not need further explanations: "If a description remains in the need of an explanation, it means that it is a bad description" [26, p. 137]. However, he also admits that:

To describe, to be attentive to the concrete state of affairs, to find the uniquely adequate account of a given situation, I myself have always found this incredibly demanding. [26, p. 144]

According to ANT, the more details the description comprises, the better the scientific analysis is, which is expressed similarly in research through design. Zimmerman et al. [54] call for a proper research methodology, realized for example by rigorous documentation of progress and evolution of research through design projects.

Such documentation should preferably cover the whole process from problem framing and the idealized preferred state to the final outcome. [54, p. 316]

Furthermore, research examples, which are describing and examining the intentional choice and use of the research through design approach as a methodology and process would be

needed. However, there is still the discussion of how to formalize research through design (e.g., standards, processes) in order not to restrict "the ability to continually and creatively challenge status quo thinking", which characterizes design research [14]. Gaver [14] argues that convergence cannot be the basis for a theoretical foundation in design, but discursiveness and elaboration, as well as a specific set of detailed design examples. According to Gaver, describing design examples should be the core of design research. ANT's methodological claim thus complies with Gaver's notions of research through design, but also with the need for rigorous documentation of progress and evolution of research through design projects. ANT would explicitly include the *activity* of the involved actors into the descriptions, i.e., of materials, designers and users. It would provide a common way of describing the design examples, and thus facilitate a shared understanding especially in the materiality discourse.

8 Conclusion

The junctures between Latour's and McLuhan's work and interaction design described above have the potential to strengthen the theoretical framing of the materials in interaction design by providing a perspective on materials, which equally integrates the *activity* of materials, designers and users. The strong emphasis on the effects of media on both designers and users allows to explicitly focus on, and design for new ways of interaction. Describing the design process in terms of a network reveals not only the important role of the materials as actors, but also unconscious design assumptions, procedures and constraints, which were induced by former materials or interactions. Research through design already claimed descriptions of design processes as outcome of design research. However, the discussion about how this will lead to theory in interaction design has

not resulted in agreement. If we consider descriptions in ANT's sense being the scientific outcome, the theoretical framing might be strengthened. We are thus convinced that both McLuhan and Latour are valuable references in the materiality discourse, foremost by avoiding a priori assumptions about the role of materials, the designer, or the user to the benefit of describing *activity* caused by either human or non-human actors.

Within this paper, we discussed several theoretical glimpses, which we consider being a basis for further discussions, concerns, and additions. Our prospective work will, for instance, include a discussion of McLuhan's and Latour's work in respect to Hallnäs' and Redström's function-expression circle [16], which has several analogies to McLuhan's media analysis and Latour's actor-networks, as well as a reflection on the idea of becomingness [3] in terms of sensory effects and impressions. This paper aimed at identifying elements for a theoretical framing of materials in interaction design based on Latour and McLuhan in order to facilitate the materiality discourse in HCI; when opening up such a reflection, a variety of topics for discussions and links to related notions emerges, which hopefully not only encourages us to proceed, but also inspires other HCI researchers to contribute to this discourse.

Acknowledgments 9

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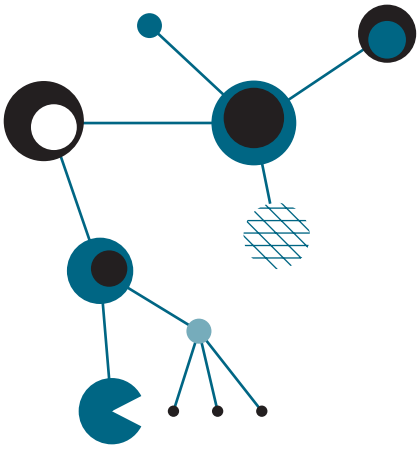

The Multiple Layers of Materiality

Abstract. This is a work-in-progress, in which we theoretically reflect on notions of materiality from Interaction Design research and the scientific field of textual studies to discuss what it means to work with digital materials, and what their materiality is. We found that several notions entail a layered concept of materiality. We will discuss the "ontological immateriality" of the digital and the "phenomenological materiality" that emerges through interaction. Thus, design is *necessarily* engaged with combining materials and experiencing the materialities that emerge from the interactive artifact.

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The Multiple Layers of Materiality

1 Introduction

In Interaction Design (IxD), there is an ongoing debate about materials and materiality (see e.g., [13]). The material used in IxD is characterized by its ability to change between states [10], bringing along a complexity in understanding the dynamics of the material. The goal of IxD is to provide the user with a desired experience, which is enabled by the interactive artifact, or rather the interaction gestalt that emerges between the user's experience and the interactive artifact [6]. The challenge that is inherent to the complexity of these design materials may concern conceiving, refining and communicating design ideas, especially when we talk about immaterial material [7], computational or digital material.[1] Their material properties may be invisible for all practical purposes [9], complicating an effective conversation with the material of software [7, 8]. However, what does material actually mean regarding the digital? What is materiality? What are materialities of the things we are working with and how can we talk about them?

We reflect on notions of materiality in IxD, as well as textual studies, a scientific field that is concerned with the creation and consumption of texts in material form. Our motivation is grounded in what Wardrip-Fruin stated: "When studying a work of digital literature [...] we must operate with some model [...] of the work's elements and structures – one which foregrounds certain aspects while marginalizing others." ([12], p. 164) We aim to reflect on the structure of materials and materiality, approaching a model that supports articulation and communication of the constant interplay of digital and non-digital design material.

[1] The terms "immaterial", "digital" and "computational" materials are often used synonymously in literature. They mainly indicate some form of intangibility of materials, e.g., [7] refer to the immaterial material of software, while [9] refer to radio either as immaterial or digital material.

Layers of Materiality 2

The Hybrid Status of Born-Digital. Regarding digital collections of writers' archives, Kirschenbaum et al. [5] start with the question of what is collected when we refer to digital materials, e.g., is it the physical hardware and storage media, or the binary data it contains? In order to label artifacts that came into being only in a digital way (e.g., writing an email), they refer to born-digital artifacts, in contrast to those that were digitalized (e.g., a scanned paper text). The born-digital artifacts, however, are assumed to have a hybrid status, as they require some form of analogue material to be conceived or collected (Figure 1).

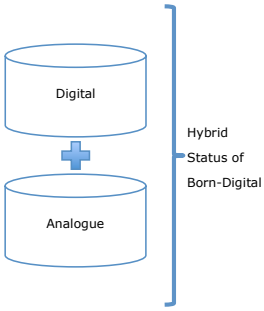

Figure 1:
Hybrid status of born-digital artifacts [5]

Phenomenological Materiality vs. Ontological Immateriality. Drucker [1] argues that electronic media push the examination of form to the limit of its existence as binary code. She raises the question how graphical and visual features of single letters need to be considered as textual "information" in an electronic environment. In electronic media, there is no necessary relation between the material form of input and output, as it is possible to imagine a letter or text outside or independent of any specific embodied form. Referring to Kirschenbaum, she distinguishes between "phenomenological materiality" of the text, and the "ontological immateriality" of its existence [1] (Figure 2). Thus, the information itself is immaterial, but as soon as it is in-the-world, it is a form of materiality. Although it is possible to imagine the *existence* of a digital material (e.g., concept of a letter) independent of any specific form, thinking of what it is may already rely on an embodied form and aesthetics. An interaction (i.e., design and use) with the "pure" digital thus *requires* this specific embodied form.

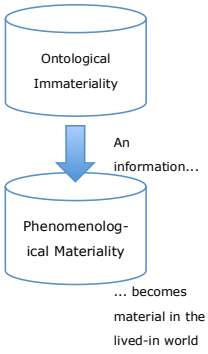

Figure 2:
Materiality vs. Immateriality (Kirschenbaum, as in [1])

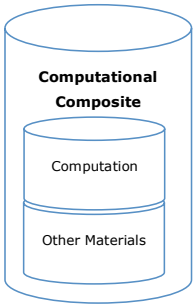

Figure 3:
Computational Composites [11]

Computational Composites. Computational composites [11] offer a material perspective on computers and explain how their changing states may manifest in the physical form of tangible or intangible materials. The computer only gets useful properties if it is combined with other materials, i.e., computations need to be associated with other materials (e.g., physical material) to have specific properties, such as reversibility or connectability [10], and a specific structure. The computational composite's front allows changing the state in the composite through the computed result (the output), while the rear side is the access to the input stream (e.g., algorithms, data) [11] (Figure 3).

Electronic Texts are Cookies. Similarly, Hayles [3] argues that an "[...] electronic text literally does not exist if it is not generated by the appropriate hardware running the appropriate software. [...] an electronic text is a process rather than an object, although objects (like hard- and software) are required to produce it." ([3], p. 79) The digital computer is thus not entirely digital. She considers it having an Oreo cookie-like structure with an analogue bottom, a frothy digital middle (where fragmentations and recombinations take place), and an analogue top ([4]; Figure 4). She emphasizes that it is impossible to create an electronic work without grasping the significance of the work as a materialist production. Materiality is not just an "[...] inert collection of physical properties, but a dynamic quality that *emerges* from the interplay between the text as a physical artifact, its conceptual content, and the interpretive activities of readers and writers. Materiality can thus not be specified in advance; rather, it occupies a borderland [...] joining the physical and mental, the artifact and the user." ([3], p. 72)

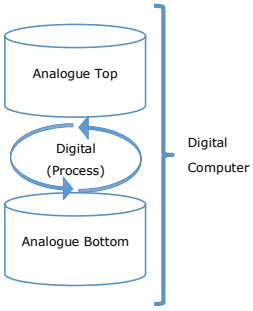

Figure 4:
Oreo-cookie like structure of the digital computer [3]

Interaction Gestalt. We see the concept of the interaction gestalt as a multiple layer concept. According to Lim et al. [6], an interaction is an abstract entity that emerges between the interactive artifact and the user's experiences. Additionally, also the interaction gestalt results from the design [6]. Drawing on this concept, we previously added another layer, i.e., the material [2] (Figure 5). Thus, from a design perspective, three interdependent layers need to be considered: the material, the interactive artifact, and the interaction gestalt.

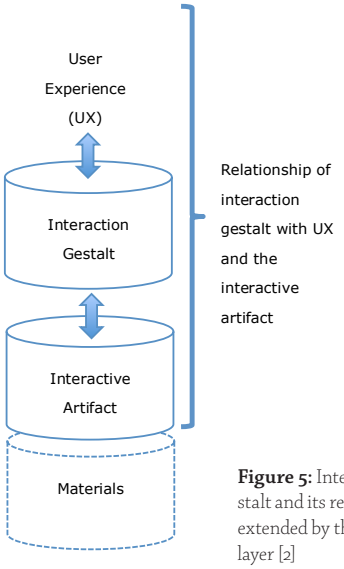

Figure 5: Interaction gestalt and its relations [6]; extended by the material layer [2]

Discussion 3

Through analyzing the above-described notions, we derived two themes. Those are of specific relevance for the conceptualization, articulation and communication regarding digital materials and their materialities.

There is Nothing Entirely Digital. A commonality of the concepts presented in this paper is their reliance on multiple layers that compose the materials worked within IxD. The combination of materials, i.e., the digital (or computation) with an "other material" (analogue) was mentioned in all concepts, as the digital represents an ontological immateriality, which gets its phenomenological materiality through interacting with it. The level of detail in the concepts is though differing, e.g., some concepts argue for analogue bottoms and tops [3] (or fronts and rears [11]) that are

"glued" together by computations [11]. Similarly, considering an electronic text as a process [3] may express this dynamic, state-change inducing property of the digital.

Materials are There, Materialities Emerge. Phenomenological materiality is what we aim at in IxD, if we take Kirschenbaum's distinction as a basis [1]. It is the materiality that is emerging through one's being in the world, which we aim to affect with design. The digital materials, which we are working with, however, seem to not exist as long as they are not combined, added, or enriched with other materials. As such, the "digital" material only exists as ontological immaterial, which gets its phenomenological materiality initially for the designer in the process of defining combinations (computing and adding further materials), to finally allow the user to experience the artifact's and interaction gestalt's emerging materialities.

4 Conclusion

In this work-in-progress, we identified two themes: First, although we may imagine the existence of a digital material, any form of (mental, physical) engagement with and communication about it requires an embodied form. Second, materials is what we work with, materiality is what emerges through design or usage. The perception of digital material is only possible through combinations with other materials, allowing the emergence of materialities in an interaction. Thus, it is crucial for interaction designers to be aware that we can never directly manipulate the digital material. Whenever we design digital or computational artifacts we deal with specific and subjective physical embodiments of the digital.

Acknowledgements 5

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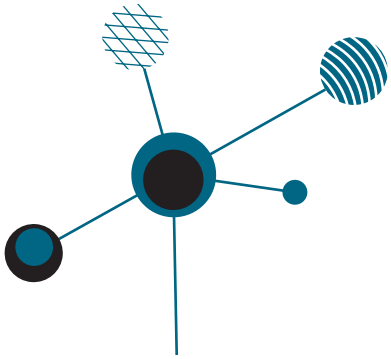
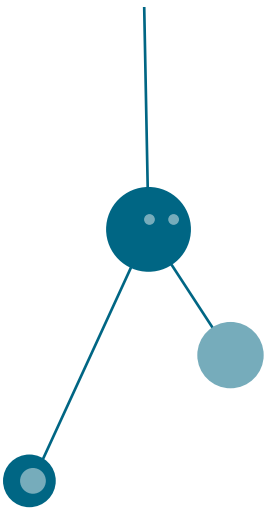


Abstract. The materiality of interactive artifacts concerns, on one hand, design materials and activities, while on the other hand, it is strongly related to the users experiencing the materiality. However, current approaches to investigate the material and the user perspective face several shortcomings, as they focus on either the human or the artifact. In our paper, we describe a materiality-centered data analysis approach that puts the user and the artifact equally in the center of attention. Based on Actor-Network Theory and Bruno Latour's thoughts on monads, we provide examples stemming from interactions in an industrial fabrication plant in order to illustrate the potentials of such a "monadological" approach for accessing materiality from a user and artifact perspective. We show that this approach allows alternating between a human- and an artifact-oriented perspective that finally leads to the identification of material attributes of actors that are less obvious.

Capturing the In-Between of Interactive Artifacts and Users

A Materiality-Centered Approach



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1 Introduction

In 2012, Jung and Stolterman critically reflected on the role of form and materiality in Interaction Design [21]. Although valuing its benefits, they criticized User-Centered Design (UCD) for focusing on functionality that determines the form and aesthetics of an interactive artifact. They propose a new approach, i.e., form-driven interaction design research, in order to emphasize form and materiality of interactive artifacts as part of Interaction Design, not leaving these aspects to engineering and production. Consequently, they claim an artifact-oriented perspective rather than a purely user-centered one [21].

Similarly, Wiberg [44] proposes to study interaction design through a material lens, as materials are the fundamental components of any computational composition. The current *material turn* is characterized by revisiting the core of the subject and acknowledging the material dimension of interaction design, i.e., the materials we relate to and interact with in design and usage of interactive artifacts. In order to stress the importance of material studies [44] (or an orientation towards form and materiality [21]), the agenda of this notion's advocates is explicitly distinct from user-centered perspectives.

Wiberg [44] suggests "materiality" as an analytical lens, but at the same time discerns a lack of systematic studies of methods that allow exploring interaction design research through such a lens. In a User-Centered Design tradition, there would be a variety of such studies, which, however, do not focus on the material aspects. What still unites design and research efforts in user-centered and artifact-oriented studies is the acknowledgement of the relationship between the artifact and the user. Therefore, the notion of materiality is currently advanced and applied in Human-Computer Interaction (HCI) and Interaction

Design, which is – although vaguely – indicating the relevance of material *and* individual aspects characterizing this relationship.

However, how can we capture the perspectives of both users and artifacts for and in design? What approaches to data collection and analysis are appropriate to orient studies towards humans *and* artifacts to capture what is in between them? *How would a materiality-centered approach look like?* In order to answer these questions, we will subsequently outline approaches to investigate human-computer interaction, which focus on users and their requirements. According to an artifact-oriented perspective, we will then shift our focus to related work of materiality, discussing the shortcomings of current approaches to capture the importance of materials used in interactive artifacts and their resulting materiality.

Afterwards, we will provide a methodological proposal that allows an alternating focus on either humans or artifacts (or materials) according to the scope of the respective study. Our methodological proposal is based on Bruno Latour's current refinements on Actor-Network Theory (ANT; e.g., [24]) towards monads [26] as an analytical approach. Therefore, we will give a brief overview of ANT and monads and describe in detail why we think that this notion may help us overcome shortcomings of current approaches, such as separated foci on either humans or artifacts.

In order to clarify its practical value, we will go through several examples of monads (i.e., actor-networks) in the very specific context of a factory, as we have been confronted with a *material* phenomenon there (i.e., the transition from purely physical artifacts to digital-physical composites for the employees to interact with). By illustrating these examples, we demonstrate the potential of monads as an analytical approach for better

understanding materiality as it occurs to users. In the end of the paper, we will discuss potential implications of this materiality-centered approach for research in HCI and Interaction Design.

2 Related Work

2.1 Approaches to Understand Human-Computer Interaction

In order to investigate how users interact with technology, there is a variety of approaches available, each of which has particular opportunities and challenges (e.g., [3, 5, 28, 19]). In earlier days of HCI, the focus was on measuring task-related parameters to find out how well a technology supports a user in the execution of a task. Since then, attention shifted to experience-related aspects [28], taking into account that, for instance, not only efficiency is important, but also the satisfaction of any individual goal. This shift is reflected by the third-wave HCI, which is characterized by its interest in broad use contexts (e.g., home, everyday life) and application types. Accordingly, the user's culture, emotion, and experience are central [6]. The goal of the respective design is not simply how people can get their work done, but how they can create their own meanings and uses for the system [12].

One focus in HCI is on *user requirements*, referring to the consideration of users' needs and capabilities in the design of interactive systems. A growing variety of methods are available to assess these requirements (e.g., to be found in textbooks [3, 7, 23, 28], in descriptions of the application of such methods [30, 31, 34] or method refinements, such as integrating supplementary materials like maps to inform interviews [4]).

Also, the situatedness (e.g., situated action, as coined by Suchman [37]) and contextual embeddedness of interactions (e.g., [12]) are emphasized in user research, which is particularly considered in ethnomethodological approaches, such as ethnography (e.g., [11, 37]) or contextual inquiry (e.g., [5, 19]). For instance, ethnographic approaches are applied to investigate what people do, how they organize action, and interaction in areas that are relevant for system design [10].

Being grounded in social sciences, ethnographic approaches aim to understand the human or the human's agency; in her seminal work on situated action, Suchman already emphasized that every course of action essentially depends upon its material and social circumstances [37]. This means that abstract views on action, apart from the context and situation of the interaction, may fall short in providing an embracing understanding. Additionally, new approaches of ethnography in design engage designers in a critical dialogue that is based on cultural interpretations of everyday settings, activities, and artifacts. [10]

From Materials to Materiality 2.2

The current emphasis on material aspects of artifacts in HCI and Interaction Design (including physical, computational, and digital materials), brings along a variety of discussions related to qualities and properties of materials that affect both the designers (e.g., [14, 33]) and the users of interactive artifacts (e.g., [15]). With physical material, we refer to the constituents of the physical form of things, e.g., their three-dimensional shape (e.g., [40]). Computational material is needed for creating a design's temporal form, i.e., it is an act of programming [40]. What we mean by digital materials is the information that is generated, collected, managed, distributed, and employed [13]. Hence, making and

using interactive artifacts [21] are included in the materials discourse. Making refers to the act of instantiating a design, using either physical or digital materials (e.g., [33]). Using refers to users' practices that, for instance, are changing with the increasing availability of digital materials (e.g., legacy aspects [17]).

Besides the distinction between physical and digital materials, their interplay is also often discussed (e.g., [21, 14]), such as their potentially complementary nature (e.g., [41]). Crabtree and Rodden [9] even talk about a physical-digital divide, which they seek to overcome by hybrid ecologies, i.e., a new class of digital ecology that merges multiple digital and physical environments. Vallgårda and Redström [41] introduced the concept of computational composites, meaning that computations require a complement consisting of other materials to come to expression as materials. Rosner et al. [35] argue that neglecting the digital/physical boundary, but staying with the action, is beneficial, for instance, regarding material traces in design processes.

Regarding methodological approaches to study the materiality of interactions, Wiberg [44] distinguishes four levels of material analysis, i.e., materials, details, texture, and wholeness. All levels are exclusively addressing the act of designing, except for wholeness, which, for instance, also includes contextual studies or ethnography to analyze materials depending on their social, organizational, and cultural context [44]. In this perspective, a user is part of the context a material is used in, putting the main emphasis on material aspects of interactive artifacts.

However, it is not only the material point of view, that is of relevance (i.e., the abstract and ineffable digital stuff actually taking material form [13]), but also the *materiality* of the forms in order to understand their particular material properties and consequences for how people encounter, use, and transform

them [13]. Gross et al. [16] discussed active and influential trends in the theorization of materiality in HCI, providing a critique of contemporary materiality research: (a) physical materials (tangible User Interfaces - TUIs), (b) metaphysical materiality (materiality of computation that is observed indirectly through artifacts that employ it), and (c) tradition communicating, i.e., the materials of craft practice and the materiality of interactions with them.

3 Shortcomings of Current Approaches

In contrast to material studies, user studies (e.g., in a UCD or participatory design tradition) focus on the users' capabilities, needs and requirements (i.e., the functionality that is needed for an interactive artifact to provide). By means of surveys, diaries, interviews, focus groups (e.g., [1, 28]), or ethnographically inspired approaches such as Contextual Inquiry (e.g., [19]) and Design Ethnography (e.g., [11]), the users are studied to capture their individual requirements. Investigations are mainly based on analysis of interactions from the user's perspective, without drawing specific attention to the physical and digital materials constituting an interactive artifact that contribute to the experienced materiality.

While ethnographic approaches acknowledge the material contexts of interactions [37], material approaches concede the user context as relevant aspect of inquiry [44]. Thus, material studies and user studies are not completely neglecting the respective other perspective, rather, they are determined by the lens they are taking. This is certainly not a problem, as long as the perspective matches the research goals: as soon as we, however, target the materiality of interactions, we need to *emphasize and investigate both the user and the artifact at the same time*.

In order to depict the consequences for studying interactions through these two lenses, we distinguish between data collection approaches and data analysis approaches when it comes to materiality. This distinction is based on the assumption that specific approaches have individual potentials and limitations in either taking an artifact- or user-oriented perspective. As an example, if we aim to investigate user's interactions with an ATM, we would rarely observe one user for a longer period of time (e.g., one specific user's repeated withdrawals), as a data collection in a Contextual Inquiry would require. We would rather stay with the ATM, looking at various users at a particular artifact's site. In a UCD tradition, we would then analyze what the users experienced during the interactions, i.e., we would (e.g., by means of affinity diagrams) summarize and cluster what we observed in the user's behavior or her/his subjective opinion. However, the data collection approach would also allow to analyze the data from an artifact-oriented perspective, i.e., analyzing its form and materiality as it appears to the users, leading to an integrated materiality-centered analysis approach.

On the other hand, some artifact-oriented investigations do not allow a way to collect the data without studying the user. For instance, if an interactive artifact is yet to be developed, but we want to uncover what users do without it, we need to study their current situations and how they fulfill their tasks, be it through observations, interviews, or other contextually appropriate data collection methods. Regarding "digital" information (i.e., the data that contains meaning), it is - also in an artifact-oriented perspective - impossible to directly investigate interaction with it. Digital information requires a physical representation (e.g., a computer), and may be processed in parallel by various users. Thus, the artifact itself cannot be observed, it is the user that we are able to study, even in an artifact-oriented perspective. These examples show that data collection (i.e., the actual

assessment via observations, inquiries, etc.) and analysis may not be considered as a unity, but separated steps that are chosen and combined according to a research goal. They also show that data collection depends highly on the circumstances in which we observe[1] a phenomena. Thus, we focus on the analytical strategy to understand both artifacts and humans and their relation.

One approach that explicitly addresses both, humans and technology, is Actor-Network Theory (ANT), which focuses on agency in the relation between users and artifacts. For this reason, ANT was a starting point for our work to suggest a bridging methodological approach. In the following section, we will outline the basic assumptions of ANT, including Latour's recent refinement towards monads [26].

From Actor-Network Theory to Monads 4

Basic Assumptions of ANT and Monads 4.1

Actor-Network Theory has been prominently developed and discussed by Bruno Latour (e.g., [24]), John Law (e.g., [27]) and Michel Callon (e.g., [8]). Heterogeneous examples of applying ANT are available in literature (e.g., on Internet, e-commerce and older adults [38], a door closer [20], or dairy milk [32]). However, there are only few actual application examples in HCI, as the majority of references concerns reflections based on ANT. For instance, Suchman [36] reflected on machine agency, Kumar and Rangaswamy [22] used an ANT approach to discuss the practice of piracy in media, or, in our earlier work, we emphasized the materials' and interactive artifacts' activity that influences users and designers and vice versa [15]. These reflections demonstrate that ANT is a valid theoretical framing in HCI, but as it also

[1] with observe we do not refer to the specific method of observations, but to the more generic approach of data collection by observing the respective phenomena, which may be done through interviews, field observations, etc.

provides a methodological proposal (see the subsequent chapter), we took it as a starting point for our analysis.

ANT's basic assumption is that, in case of any given activity, human and non-human subjects and objects are considered as actors. This can be an (interactive) artifact or any material influencing a human, but also a human affecting an artifact or material. As soon as there is activity between actors, they form a network for this specific activity [24]. ANT is thus not a stable theory of actors, but rather assumes radical indeterminacy. This means that neither the actor's size, nor its psychological make-up or motivation are predetermined [8], be it a human's motivation in using an interactive artifact or a behavior that is inscribed in a non-human actor. Any given phenomenon is described in its actual constitution (e.g., what actors are involved, how they are interacting), but it is not decisive why the actors do certain things. An actor is always defined by its network (i.e. affected by and affecting other actors) and a network is fully defined by its actors [26].

In their latest work, Latour and colleagues take a further stance on ANT by referring to monads [26], a concept that dates back to the philosopher Gottfried Wilhelm Leibniz in the 18th century. In our work, we draw on Bruno Latour's understanding (see e.g., [25, 26]), being aware of the huge preceding scientific discourse. Latour refers to Gabriel Tarde's notion of monads, arguing that there are not individual elements, but monads (i.e., representations, reflections, or interiorisations of a whole set of other elements borrowed from the world around) [25]. This means that the social is characterized of networks rather than of separable individuals.

Drawing on this work, emphasis is put on the difference it makes if a specific perspective (or entry) is taken to a specific actor-network.

A monad is not a part of a whole, but a point of view on all the other entities taken severally and not as a totality. [...] At first the entity is just a dot [...] but then it fills in with more and more elements that specify it more and more until the observer considers that he or she knows enough and begins to take the name of the entity for the entire list. [26, p. 598]

Consequently, a monad is a highly specific point of view on all the other entities present in a dataset, as each monad possesses its own particular perspective of the "whole" [26]. Latour et al. provide the example of preparing a meeting and searching the name of the person to be met on the web. Soon, we will discover many attributes related to the person, finding a network that characterizes the person [26]. However, depending on how we enter a network and how we navigate through it (e.g., through a person, an institution, or an artifact), different networks (i.e., monads) will be visible.

Similar to ANT, the value of applying monadological thinking is not its predictions, as monads also do not aim at forecasting, but at clarifications of provisional wholes.

[...] each entity is entitled to have its own curriculum vitae, that is, its own trajectory through successive attributes. [26, p. 608]

In terms of HCI, following the traces of entities rather aims to understand specific interactions between different actors, than trying to generally explain phenomena in a holistic way. These entities may either be called monads or actor-networks. As for our work, we will use the term monads in order to stress

their specific notion, i.e., being entities whose traces can be followed, but not separated. However, we explicate that we are not drawing on the philosophical discourse, but on the very specific interpretation presented by Latour and colleagues (e.g., [25, 26]).

Due to the pre-assumed equality of human and non-human actors (i.e., the hybrid entities formed by humans and non-humans are in the focus, providing a relationality between monads instead of separated, single actors), we take ANT as a starting point for a methodological discussion on how to integrate human- and artifact-oriented perspectives for approaching materiality. Therefore, we will, subsequently, describe the methodological approach in ANT that allows to alternate between perspectives without neglecting nor favoring one.

4.2 The Methodological Approach

Latour [24] furthermore proposed a method based on ANT. Simply put, he argues for rich, detailed descriptions of actor-networks. The more details such a descriptive investigation has, the better the scientific analysis is [24]. Through tracing activities of hybrid networks (i.e., of human and non-human actors), we can find out how the world is interpreted, reinterpreted, and changed [39]. A description in an ANT's sense is the retrieval of a script (i.e., a scenario or scene that is investigated) from a situation. Descriptions contain definitions of actors (human and non-human) that are endowed with competencies and which make them do things and evaluations of the sanctions that come with the actions taken [20]. Akrich [2], for instance, argues that a description is insufficient if it is solely made from a designer's or a user's perspective. It is rather going back and forth, from the designer to the user, from the user that has been projected by the designer and the real user. In Latour and colleagues' reference

to monads, they again emphasize descriptions of wholes, be it verbal ones or visualizations of keywords [26].

Ethnographic approaches, as described earlier in this paper, may lead to the requested rich descriptions (i.e., the data collection may be similar). Through these rich descriptions, it is assumed that phenomena can be explained and understood. Latour's work on monads [26], however, also affects the data analysis of the rich descriptions. The reference to the perspective on the monad is the crucial moment in the analysis, as the "reality" that unfolds during the analysis is closely related to the perspective, i.e., the actor that we trace through her/his/its network. Then, Latour [26] suggests that after drawing complex overlapping monads, one may begin analyzing (i.e., detecting) the few attributes they share. In order to demonstrate how such an analysis may look, we will provide examples in the following section. Afterwards, we will discuss the results of this analysis and reflect on the methodological potentials and pitfalls connected to such an approach.

5 Monads: Factory Examples

We chose the specific context of a semiconductor factory to draw examples from for three reasons. First, our research group had the chance to intensively research human-computer interactions in a specific factory and its cleanroom in the past four years (e.g., [43]) to understand the different user roles, artifacts, and their interactions. Thus, we have a large body of data to draw on for detailed analysis of phenomena.

Second, we recently accompanied the factory in the transition from a specific, purely physical artifact (i.e., paper) to an interactive, electronic artifact. The factory and specifically its

cleanroom are pervaded with analog and digital technology and interfaces of various kinds, ranging from paper and rather typical screen and keyboard interactions in form of terminals to RFID authentications (i.e., radio-frequency identification, that allows operators to register at the machine they are working with) and many more. The current transition, aimed to abandon the remaining sheets of paper from the cleanroom to better comply with particle contamination standards.

The third reason is less related to the monadological analysis as such. Instead, it is related to the suitability of the examples to reflect on the potentials of the method for HCI research. Obviously, the actors in the examples' networks are humans, computers (in a broad sense) and their interaction, the main concern of any HCI effort. However, the examples not only allow us to look at the interaction between humans and interactive artifacts, but also to study the interaction between humans and non-interactive artifacts. Thus, the examples represent common themes in HCI research and allow studying human- *and* artifact-oriented perspectives in interactions in settings with and without interactive artifacts.

Subsequently, we will briefly outline the context in which the examples are situated in. Afterwards, we describe the data collection, followed by a description of the analysis and the resulting monads.

5.1 The Context and the Phenomena

The context is constituted of a factory's cleanroom, in which wafers are produced. Wafers are very sensitive products that require a multitude of processing steps in various departments until they are completed, which may take several weeks.

Usually, operators do not handle single wafers, but process them in bundles, i.e., wafer lots. Their activities range from loading and unloading machines with the correct lots, operating the machines that process the wafers, transport wafers between places and departments, etc. The cleanroom itself has several specific characteristics, resulting in specific requirements for interactions with interactive systems (e.g., operators need to wear specific cleanroom clothes, there is constant artificial light, no fast movements are allowed to not raise dust, etc.).

To date, the wafer lots have been complemented with a stack of paper (i.e., a control sheet), indicating its production steps. The control sheet is meant to inform the operators and shift leads about processing steps, transfers to other departments, and evaluation stops to see whether the processes led to the correct results. The current efforts to abandon the paper consist of digitalization of the control sheets, which is difficult due to the restricted access to computers and input possibilities for operators. However, the operators need to see the steps to perform and, afterwards, to confirm the execution in order to have the possibility for reconstruction of production processes. As a first attempt, the paper control sheet was recreated electronically in the internal software; however, the need to print one specific page, which requires operators to confirm processing steps, remained.

Accompanying these efforts, we investigated the various purposes of the control sheets (e.g., as asynchronous means of communication between operators, shift leads, etc.). We also investigated digital alternatives separate from recreating the paper control sheet on a screen (being the initial solution that is carried out currently). This, on one hand, satisfies the operators' needs and on the other hand, does not neglect important

information. Within this scope, we were confronted with the user's and the artifact's point of view.

5.2 Data Collection

For this particular research activity, a group of three researchers spent half a day in the cleanroom to collect data about operators' handling of paper. A second half-day observation took place during the transition to paperless interactions, where we focused our investigation on the electronic control sheets. Wafer lots take several weeks to process and operators handle them irregularly. Thus, we decided to observe the same shift in order to better understand the transitions that are not based on differences between shifts. The methodological approach to collecting data was informed by Contextual Inquiries [19], i.e., observations were combined with interview questions to learn from the operators how they work with the wafer lots' control sheets.

Furthermore, we accompanied and interviewed further employees (e.g., who define the processing steps), from whom we learned about the wafer lots' complete journey in the factory. In contrast to the above-mentioned ATM example (where spatially staying with the artifact would be an appropriate data collection approach), we decided in this setting to trace the users, as the control sheets are not continuously used. Thus, concentrating on the employees was the most promising approach. As video and audio recordings are not feasible in the cleanroom (due to ambient noise and required face masks on the operators), notes were taken on cleanroom paper and summarized directly after the observations.

Data Analysis 5.3

Based on the collected data of operators handling the paper and electronic control sheets in the cleanroom, we found Latour's considerations of monads [26] valuable to provide us with different perspectives on the phenomena. Thereby, the data analysis starts by choosing an entry point for a network, which may be any actor. This may, however, be done for multiple actors, if we are interested in different notions and "realities" that constitute different monads to establish different views on the whole. According to the research goal of combining a human-oriented and artifact-oriented perspective in our analysis to arrive at a materiality-centered approach, a minimum number of two monads would be needed in order to be able to alternate between those perspectives. In our examples, we chose human (operators) and non-human (artifacts) actors to start navigating within monads, as those represent the human and artifact-oriented perspectives. As we aim to present a methodological discussion in this paper rather than a results presentation for the specific problem, the monad descriptions are extracts for reasons of clarity; they are not detailed in a sense that we describe all involved actors and activities, but demonstrate the kind of findings and implications that may be derived from such an analysis.

We will show with our exemplary monadological analysis that both artifact-oriented and human-oriented perspectives are possible with the same set of data. Subsequent to the description of the monads, we will address their commonalities and differences to demonstrate what a synopsis of the different perspectives reveals.

5.4 Exemplary Monads

The main aim of the following examples is to illustrate what we may learn from a monadological approach in terms of human- and artifact-oriented perspectives. We have two situations (paper control sheets, electronic control sheets), along which we present the two respective perspectives. Thus, four relevant monads are in the scope of our work, which are addressing the relation between operators and control sheets. In the following paragraphs, the monad examples are described and visually represented in Figure 1 (showing the human- and artifact-oriented monads relating to the paper control sheets) and Figure 2 (illustrating the two respective monads related to the electronic control sheet).

Paper Control Sheets

Human-Oriented Perspective: Beginning with the operator as the entry to the monad (being the primary user), we identify several further actors, such as the paper control sheet, the pen with which the operator confirms having performed the required process, the lot on which the control sheet is placed, another operator that brought the lot with the control sheet to the employee's department, the machine it is processed with, the shift lead who supervises the operator's work, etc. All of these actors have competencies, such as the operator reading and interpreting the steps on the paper control sheet, processing the lot as required, confirming the process; or not processing them, for instance, in case of uncertainties, informing the shift lead, etc. The paper control sheet has the competency of displaying the information, having important information presented in red and the other information in black, being crinkled or presenting illegible handwriting, etc. The evaluation of the sanctions of the actor's actions are revealing whether the lots have been processed properly, i.e.,

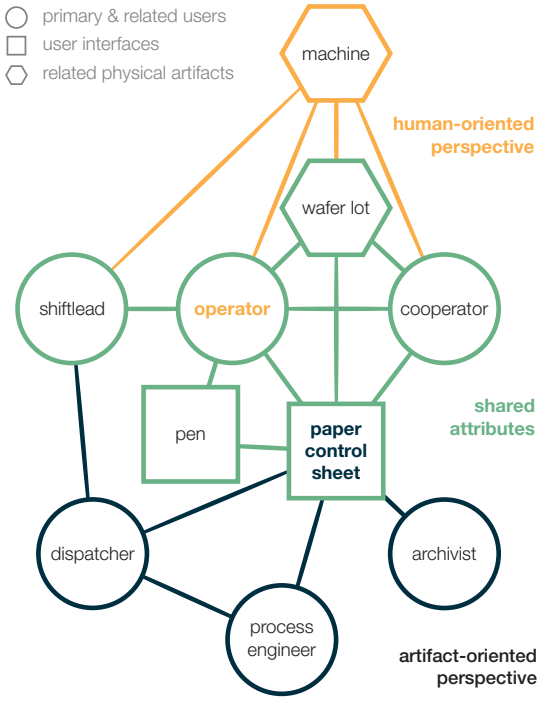

Figure 1: Exemplary excerpt of the analysis regarding the interaction with *paper control sheets*, showing the attributes of two monads (from a human-oriented respectively an artifact-oriented perspective). In order to visualize the different attributes and competencies of actors, we distinguish here between human actors (which may be categorized as primary as well as other users) and non-human actors (user interfaces and related physical artifacts.)

whether the wafers in the lot are as they are supposed to be, and whether the paper control sheets properly identify the procedure (e.g., who did what task when).

Artifact-Oriented Perspective: Taking the paper control sheet as the entry to the monad, we can again identify the actors involved, such as the dispatcher printing the paper control sheet, the lot that carries the paper control sheet, the operator who transported the lot with the paper control sheet to its first processing department, the operator that first processed the lot, the pen that the operator used to confirm a performed step, and also the archivist that archives control sheet for potential later reconstructions of processes. The competencies of the actors are the same as described in the monad before.

By analyzing these two monads, we find several commonalities. Besides operators and the paper control sheet, we identify further actors that the monads share (e.g., pens used to manipulate the paper control sheet). However, we also uncover differences. Only in the artifact-oriented perspective, the employees who are involved in paper creation and archiving become visible. Thereby, attention is given to the chronological course of a paper control sheet, which we would not immediately focus on if we concentrated on one user.

Electronic Control Sheets

Human-Oriented Perspective: The operator is the entry to the monad. What we can draw from the observation is that the lot is less involved in this network as an actor, as there is no physical proximity of the control sheet and the lot, which would require the operator to consider them together. Further actors are the terminal with a screen, where the electronic control sheet is displayed, and the keyboard, which the operator uses to fill in the

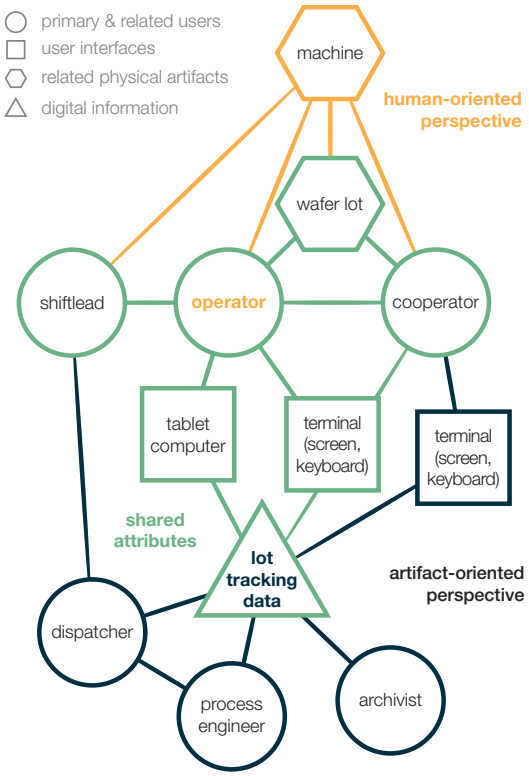

Figure 2: Excerpt of the analysis regarding the interaction with *electronic control sheets*, highlighting differences between an human-oriented and an artifact-oriented perspective. Taking the *lot tracking data* as an entry point to the network unveils how the information is distributed and only indirectly manipulated. This manipulation may happen in parallel, using multiple and varying interfaces. This requires distinguishing between the information (i.e., the lot tracking data) and the representation (i.e., the interfaces). Additional actors (e.g., dispatchers, process engineers, or archivists) are related to or may manipulate the lot tracking data. Their relation to the network can be analyzed, although the interfaces they use are not part of the particular analysis. Contrasting this network to the one presented in Figure 1 unveils that there is no existing relation between the lot and its tracking information.

confirmation information. The competencies of the operator are reading the information on the screen, processing the lot accordingly (or not in case of uncertainties), confirming the process by adding information to the electronic control sheet through the use of the keyboard, etc. The electronic control sheet's competencies are constituted of displaying information via a further device, i.e., a screen, allowing input via a keyboard, and so on. Finally, the evaluation of the sanctions is again the assessment whether the lots have been processed correctly and whether the electronic control sheet allows traceability of the steps performed and the identification of the persons involved.

Artifact-Oriented Perspective: We find terminals (keyboards and computer screens) and data processors being relevant actors. Thus, information is only indirectly manipulated by the operator. Taking this entry to the monad, we focus much more on the digital information (the lot tracking data) than we did in the other monads, as there is no necessary tie between the information and *one specific* representation (e.g., a specific terminal, consisting of screen and keyboard); the information is distributed, as it potentially can be manipulated in parallel through computer screens and keyboards. We need to distinguish between the actors *lot tracking data* and representations of the data (the different terminals), which we were not required to do in the previous monads.

In these two monads, we identify terminals (keyboards and screens) as actors that are visible in both, being central to manipulate the lot processing data. Especially in the artifact-oriented perspective, there is a necessity to consider the lot processing data (the digital information) as an additional actor, which has not been visible before. As we cannot observe it directly (e.g., due to its distribution across various terminals), screens and

keyboards are the specific representations, which enable access to the data.

5.5 Commonalities of all Monads

Analyzing the intersections between all monads, we see that paper control sheets are surrounded by agency, as there are associations to a variety of further actors, e.g., several human actors, as well as the lot tracking data. Attributes that are connected to the paper control sheets are its allowance of asynchronous communication, bounding one specific digital information (i.e., the content) to one specific manifestation (i.e., the paper), having spatial proximity to the lot, whose information is displayed, etc.

Analyzing the monads, we also see that we are often confronted with the data (the digital information) that is developed, manipulated, and archived. What the artifact-oriented views clearly reveal is that the information requires possibilities for manipulation, i.e., an input and output. While this issue has been increasingly discussed in the past few years in HCI and Interaction Design (e.g., Dourish and Mazmanian's discussion of the materiality of information, or digital goods, as they also call it [13]), the same issue may be very self-evident for non-interactive artifacts. Not only does information require some form of physical representation, but also a possibility to interact with it. While in Interaction Design computations are central to enable users' interactions, it is, for instance, the pen, that is required to manipulate the information in purely physical materials.

Furthermore, the operators are associated with a variety of further actors, from human to non-human ones. Similar to the paper control sheets, we may consider them also as overlapping parts in the monads. A further possibility to analyze the data

in a monadological view is to focus on the differences of the monads, which we will describe in the following section.

5.6 Differences in the Four Monads

One major difference in the monads concerns the operators, i.e., the users of the artifacts. Investigating their associations in the monads, we come to understand the changes for them in the transition from paper control sheets to electronic ones. With the paper, they shared the very artifact with others, and reconstructing the lot history was possible for all. There was no possibility to hide information or to display personalized information (e.g., operators may not need the same information than the developers of the information). In contrast, with the electronic control sheet, the information is spatially detached from the lot it refers to, and manipulation is possible synchronically for different users and employees.

In the description of the context, we stated that the factory tried to recreate the physical control sheets in digital form; while this is true for the information as it comes from the information's author, the attributes accompanying the information are distinct. Information that is distributed and worked on in parallel takes different courses than if it sticks to one specific piece of paper. In turn, this implies serious consequences, as the locus of problem solving is connected to the very place the information is to be found ("sticky information" [42]), which potentially means the electronic control is nowhere or everywhere, resulting in a question of responsibility and ownership for the information in case it is distributed.

Design Consequences 5.7

Concluding on the above-presented analysis of human-computer interaction in the cleanroom, we can derive a variety of considerations relevant for design. Again, we only provide exemplary considerations in order to give an impression of the practical relevance such an analysis will bring.

- In the transition from physical to digital lot tracking data, the lot is a less active actor, as there is no physical proximity between the data and the lot. For instance, while in the physical paper setting, operators immediately recognize whether a control sheet is missing; the electronic version is detached and does not indicate any lacking combination of a lot and its tracking data as it is not visible any more. Thus, the two actors do not meet any more, leading to a changing practice when handling the lot and its data.

- Digital data may be handled simultaneously by several users, resulting in potentially overlapping or even conflicting manipulation of data. Whereas input and output mechanisms may be designed appropriately, the data itself has other qualities than it had in combination with the paper control sheet (e.g., being inseparable from the material representing it). We thus need to allow different actors to manipulate the data at the same time, while avoiding conflicts.

In terms of materiality, we identified several qualities of physical and electronic materials that influence the user-artifact-interaction (e.g., distribution, proximity/distance of data and representation). However, some of those only became visible in the synopsis of human- and artifact-oriented perspectives.

6 Monads: Methodological Reflections

The exemplary monadological analysis that we provided in the previous sections show that we alternated between the artifact and the user, between human and non-human actors. In order to determine whether we met our claim that we stated in the beginning of this paper, i.e., through applying a monadological approach we will be able to investigate the materiality to be experienced by the users, we now will reflect on the method and its exemplary results.

6.1 Data Collection

Our data collection approach did not significantly differ from any data collection as it is used, for instance, in Contextual Inquiries [19]. For our monadological analysis, it turned out to be an appropriate approach, allowing us to analyze both user and artifact perspectives in an alternating way. However, we also identified some limitations when it comes to collecting data about digital information. The monads have provided us with an overview of actors and attributes, and we showed that the different entry points to the networks enriched the analysis in various ways. However, if we would like to detail the fourth monad, and especially the attributes that come with the electronic control sheet, the data collection as it was would not be sufficient. This, among others, is due to the observational procedure that we chose for sketching the networks.

Observations and interviews only allow capturing what is visible, which the digital information is not on its own (i.e., any "digital" data). The data basis needs to be something other than data gathered in an observation, such as data logging. However, this will not entirely solve the problem of describing digital

information, neither in an artifact-, nor in a human-oriented analysis, as through data logging alternating between users, technology, and designers will not be possible. Although we can assess the digital information's traces (e.g., who created it, who edited it, where it was distributed to, what points in time it was used or changed, etc.), we cannot observe how it influenced the other actors, like how it affected the user in his work or task solely through data logging. Consequently, a mixture or triangulation of data collection would be needed. Still, this will severely increase the complexity, as, for instance, synchronous and asynchronous activities need to be assessed, which are not directly (e.g., physically, spatially) connecting the actors.

6.2 Data Analysis

One major benefit of analyzing the data based on a monadological approach becomes visible when we, for instance, compare the monads from the human-oriented perspective with those from the artifact-oriented view. In the former, we trace the user through her/his network. We describe how she/he interacts via a terminal with the information. In the latter monad, however, we start with tracing the artifact, i.e., the electronic version of the control sheet. Thereby, we do not have any other possibility than recognizing attributes such as parallelism of manipulation or traceability. These attributes, in turn, will contribute to the experienced materiality of the interactive artifacts and thus comply with our aim by establishing monads. The digital information, as it is detached from one specific representation (as, in our examples, it may be manipulated via all computers in the cleanroom or, almost, the whole factory) is a much more present actor than if we trace the user. In our examples, we could have used a variety of entry points and perspectives, as there is a variety of interfaces that we could look at. However, according

to the context and goals, we chose specific artifacts and users to analyze their attributes, relations and differences. This selection was based on our research aims in this specific context and situation, i.e., to better understand materiality when it comes to paper versus electronic control sheets and, thereby, to generate relationality between these differing monads.

This analysis could have been continued by integrating further levels of detail and/or more actors into the analysis. The more it extends, the more precise the viewpoint of an individual monad becomes [26]. Latour furthermore indicates that the decision on when to stop is determined by the observer's assessment of when to know "enough", as these inquiries could potentially be continued until the whole world is reflected [26]. Acknowledging the exploratory nature of our investigation, we stopped when we were able to relate the monads to each other, finding commonalities and differences that are relevant in future designs in this specific context.

6.3 In Between an Artifact- and User-Oriented Perspective

Hybrid ecologies, as suggested by Crabtree and Rodden [9], which are complemented with human actors, might then be what Latour (e.g., [24]) referred to as hybrid networks, i.e., acting consists of human and non-human aspects, which cannot be separated. By means of a monadological approach, we attempt to bridge artifact- and user-oriented perspectives. While material studies or user requirements investigations on their own fulfill many purposes, they face shortcomings as soon as we consider the materiality of interactive artifacts as an essential part of interactions. Thus, it highly depends on the goal of the respective research.

This is also related to the discussion about the function-expression-circle by Hallnäs and Redström [18]. By staying with the user during data collection *and* analysis, we may oversee the importance of the expression, where, according to Hallnäs and Redström, function resides. Therefore, they suggest to disregard functionality as a starting point and instead work with the experimental design in order to expose aesthetics and aesthetic choices [18]. A monadological analysis allows alternating between perspectives and the resulting realities, thereby neither neglecting expression nor functionality. Through identifying intersections and differences (as demonstrated above), we gather a rich understanding of users, interactive artifacts, and the materiality that comes with the interaction.

Conclusion 7

In this paper, we show that variations of monads (i.e., activities of entities established from a specific perspective, e.g., starting from the user, or starting from the artifact) help to analyze materiality of interactive artifacts. The description of the monads, which were in our case interactions between factory operators and electronic as well as paper control sheets, were valuable to detect differences and commonalities between dissimilar perspectives, as the reality differs depending on what actor is chosen to start navigating through a monad. This allowed us to address the materiality of the interactive artifact to be experienced by the users, without deciding for either a purely human-arienting or an artifact-oriented standpoint, which complies with our research scope to better understand the materiality of physical versus electronic artifacts.

Our suggestion for a materiality-centered approach does not entail step-by-step instructions on how to proceed. It is rather

a conceptual discussion that resulted in the recommendation to researchers and practitioners to take a step back from their analysis and "put on" another orientation to the results. With the examples presented above we aimed to illustrate the benefits of taking another perspective, recommending fellow scholars and practitioners to perform such analytical exercises as well, in order to deepen investigations on the materiality of interactive artifacts and how it is experienced by users.

Certainly, our approach faced shortcomings, mainly related to the decisions upon the extent of data collection and analysis. Choosing the relevant monads and entry points needs to be based on the research aims and, as we are referring to real-world examples, the possibilities within the context. Thus, the main criterion for these choices needs to be the appropriateness in terms of research rigor and goals in relation to the application area. Furthermore, we may arrive at the same knowledge also without referring to ANT and monads. However, explicating the actors and deploying the respective attributes of the entities may support an explicit consideration of different realities within one context or phenomenon. We call our approach a materiality-centered one, acknowledging at the same time however, that it has been an approach to a specific case, i.e., the relation of users to control sheets in a factory. Thus, our future work will comprise further applications, in and beyond factories, to identify the appropriateness of the approach in regards to other HCI related contexts.

For future work, we will additionally detail our investigation of materiality. For instance, we will turn to Lim et al. [29] and their reasonable discussion of interaction gestalt. Lim et al. argue that it is not the interactive artifact (and thus not the material constituting it) that the users experience, but the interaction gestalt, which is the interaction itself or, more precisely,

the shape of a particular interaction [29]. It would be interesting, for instance, to analyze monads from that point of view as well, i.e., considering not only digital actors, but also virtual ones.

Acknowledgments 8

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“The work described here contributes to the theoretical framing of the relations between users and artifacts, designers and materials, and the connections among them. It addresses problems inherent to HCI and Interaction Design by providing a language and terminology that aims to support a comparable, and at the same time distinct, illustration of human-computer relationships.

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