

# Repurposive Appropriation and Creative Technology Use in Human–Computer Interaction

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## Abstract

Although interactive technologies are usually developed with certain purposes of use in mind, their users often adapt them for their own needs. This adaptation process that changes the ways in which the technologies are used is called *appropriation*. Appropriation is both a social and a cognitive process. The social aspects of appropriation have been actively studied in existing research, focusing on the changes of shared practices of use, the ways in which new uses are learned together or from each other, and on the key individuals who invent and propagate new uses. In contrast to this, the cognitive aspects have remained on the margin as a less studied subject.

The purpose of this thesis is to develop a theory for individual users' *repurposive appropriations* that refer to changes specifically in technologies' purposes of use, as opposed to other changes, such as increased efficiency of use or deepening emotional identification. In repurposive appropriation, a user discovers a novel purpose of use for a technology, 'novel' meaning that this purpose was not known by the user at an earlier point of time. The specific focus in this thesis is on individual users' discoveries of *workarounds*: appropriations in which a previously unconsidered technology is used in place of another one that has been applied previously.

This thesis follows an exploratory research approach. Its theoretical basis is in cognitive science, particularly in theories of distributed cognition, problem-solving, and creativity. The empirical basis comes from four studies on systems: three open-ended field experiments on mobile multimedia messaging systems (mGroup, CoMedia, and Comeks) and a web survey on appropriations of digital cameras. These studies shared the same technological domain (piecewise visual content creation and everyday use outside of the institutional context) and addressed only appropriations that did not require reprogramming or other expert adaptation skills. This was the scope also in this thesis.

An analysis of appropriations across the four studies suggests that users appropriate by *mapping* together situational (i.e., technological, social and physical) features of the context. Drawing from theories in cognitive science, three mapping-based cognitive processes are suggested to explain discoveries of workaround-like appropriations. They share a hypothesis that with mapping, users create mental representations called *solution schemas* about novel ways of using technologies.

Users may make mappings by recognizing environmental structures that provide partial solutions to their ongoing or past problems with novel technologies. Alternatively, users may re-represent their present problems on a more generalized level, which enables problems' mapping to analogical solutions schemas. These schemas may point to different technologies than in the original unsuccessful solution schema. As a third alternative, users may find analogies between two technologies that can be used in the same stage in the problem-solving path. This involves a mapping between a familiar but unavailable technology and a present but previously unconsidered technology. Users' existing, especially breadth-oriented technology-related knowledge is suggested to act as an important underlying enabler in all of these three mappings.

The findings provide several design implications for human–computer interaction and research implications for cognitive science.

## Tiivistelmä

Vaikka vuorovaikutteiset teknologiat yleensä kehitetään ennalta mietittyihin käyttötarkoituksiin, käyttäjät usein muokkaavat niitä omiin tarpeisiinsa sopiviksi. Tätä käyttötapoja muuttavaa muokkaamisprosessia kutsutaan *appropriaatioksi*. Appropriatio on sekä sosiaalinen että kognitiivinen prosessi. Sen sosiaalisia piirteitä on tutkittu aktiivisesti, keskittyen teknologian käytön jaettujen käytäntöjen muuttumiseen, uusien käyttötapojen oppimiseen yhdessä tai muiden opastuksella, ja uusia käyttötapoja keksiviin ja levittäviin avainyksilöihin. Sitä vastoin kognitiivisia piirteitä on tutkittu huomattavasti vähemmän.

Tämän väitöskirjan tarkoitus on kehittää käyttäjiin yksilöinä keskittyvä teoria erityisesti *uusia käyttötarkoituksia luovista appropriatioista* (repurposive appropriations). Nämä appropriatiot poikkeavat muista teknologian käytön muutoksista, kuten tehokkaammaksi käyttäjäksi kehittymisestä tai syvenevästä emotionaalisesta suhteesta teknologiaan omassa elämässä. Uusia käyttötarkoituksia luovissa appropriatioissa ‘uutuus’ tarkoittaa, että käyttäjä keksii sellaisen käyttötarkoituksen, joka on ollut hänelle aiemmin tuntematon. Tässä väitöskirjassa keskitytään yksilötasolla erityisesti käyttäjien keksimiin *kiertotapoihin* (workarounds): appropriatioihin, joissa aiemmin kyseiseen tarkoitukseen liittymättömänä pidettyä teknologiaa käytetään sellaisen teknologian tilalla, jota aiemmin on käytetty vastaavissa tilanteissa.

Tämä väitöskirja on tutkimusotteeltaan eksploratiivinen. Teorioiltaan se pohjautuu kognitiotieteeseen, erityisesti hajautetun kognition, ongelmanratkaisun ja luovuuden tutkimukseen. Empiirisenä pohjana on neljä teknologiatutkimusta: kolme avointa kenttätutkimusta langattomista multimediatekniikkajärjestelmistä (mGroup, CoMedia ja Comeks) sekä www-pohjainen kysely digitaalikameroiden appropriatioista. Näitä tutkimuksia yhdisti yhteinen teknologinen perusta (pieninä kokonaisuuksina tuotettu visuaalinen sisältö sekä arkikäyttö institutionaalisen kontekstin ulkopuolella). Ne myös käsittelivät vain appropriatioita, jotka eivät edellytä ohjelmointitaitoa tai muuta teknologian muokkaamiseen liittyvää asiantuntijuutta. Tämän väitöskirjan rajaus on samanlainen.

Väitöskirja ehdottaa, että yksilöiden approprioinnin pohjalla on tilannekohtaisten (teknologisten, sosiaalisten ja fyysisten) tekijöiden yhteen *kytkeminen* (mapping). Kognitiotieteen teorioihin nojaten esitetään kolme kytke-  
mispohjaista kognitiivista prosessia, joilla voidaan selittää kiertotapo-

jen kaltaisia appropriaatioita. Yhteisenä hypoteesina on, että kytkemisessä käyttäjät luovat *ratkaisumalleiksi* (solution schema) kutsuttuja tietoesityksiä uusista käyttötavoista.

Kytkemiset voivat perustua sellaisten ympäristön rakenteiden tunnistamiseen, jotka tarjoavat osittaisia ratkaisumalleja aiemmin kohdattuihin tai käsillä oleviin teknologiaan liittyviin ongelmiin. Toinen vaihtoehto on, että käyttäjät käsitteellistävät ongelman uudella yleisemmällä tavalla, mikä mahdollistaa uusien kytkemisten keksimisen analogioihin perustuen. Kolmas kytkemistapa liittyy kahden teknologian välisen analogian havaitsemiseen. Havainto voi auttaa käyttäjää keksimään keinon korvata ensisijainen (mutta sillä hetkellä puuttuva) teknologia toisella tarjolla olevalla (mutta aiemmin epäolennaisena pidetyllä) teknologialla ilman, että muu ongelmanratkaisuprosessi olennaisesti muuttuu. Väitöskirja ehdottaa, että käyttäjien aiempi, varsinkin leveyssuuntautunut teknologinen asiantuntemus on olennainen näitä kolmea kytkemisprosessia edesauttava tekijä.

Tulokset tarjoavat useita suunnittelusuosituksia ihmisen ja tietokoneen vuorovaikutuksen kehittämiseen ja tutkimukseen sekä lähtökohtia uusiin kognitiotieteellisiin tutkimuksiin.



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My thesis was reviewed by Dr. Michael Muller and Prof. Sampsa Hyysalo. Their attention and criticism revealed several places in which the introductory chapter deserved changes and more thoughtful argumentation. I am also extremely happy to have Prof. David Kirsh as my opponent. Of the people whose work in this domain I am aware of, I cannot think of a better expert on situated cognition and problem-solving.

Research on human–computer interaction is group work wherein no one person’s skills alone are sufficient for high-quality research work. I have benefited from the expertise of many people through co-authoring the papers presented in this thesis: John Evans, Sacha Helfenstein, Tommi Ilmonen, Giulio Jacucci, Pekka Kanerva, Esko Kurvinen, Antti Oulasvirta, Timo Saari, Sauli Tiitta, and Sakari Tamminen. These colleagues’ areas of expertise spanned domains that I would never have dreamt of being able to

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Helsinki, October 2012

Antti Salovaara

## List of original publications

This review is based on the following six original publications. The original articles are referred to in the text by their arabic numerals (1–6).

**Paper 1** : Salovaara, A., Jacucci, G., Oulasvirta, A., Saari, T., Kanerva, P., Kurvinen, E., and Tiitta, S. (2006). Collective creation and sense-making of mobile media. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems (CHI 2006)*, pages 1211–1220, New York, NY. ACM Press.

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<http://doi.acm.org/10.1145/1124772.1124954>

**Paper 2** : Jacucci, G., Oulasvirta, A., Ilmonen, T., Evans, J., and Salovaara, A. (2007). CoMedia: Mobile group media for active spectatorship. In *Proceedings of the SIGCHI Conference on Human Factors in Computing (CHI 2007)*, pages 1273–1282, New York, NY. ACM Press.

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<http://doi.acm.org/10.1145/1240624.1240817>

**Paper 3** : Salovaara, A. (2007). Appropriation of a MMS-based comic creator: From system functionalities to resources for action. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2007)*, pages 1117–1126, New York, NY. ACM Press.

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<http://doi.acm.org/10.1145/1240624.1240794>

**Paper 4** : Salovaara, A. (2008). Inventing new uses for tools: A cognitive foundation for studies on appropriation. *Human Technology*, 4(2):209–228.

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**Paper 5** : Salovaara, A. and Tamminen, S. (2009). Acceptance or appropriation? A design-oriented critique on technology acceptance models. In Saariluoma, P. and Isomäki, H., editors, *Future Interaction Design II*, chapter 8, pages 157–173. Springer, London, UK.

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**Paper 6** : Salovaara, A., Helfenstein, S., and Oulasvirta, A. (2011). Everyday appropriations of information technology: A study of creative uses of digital cameras. *Journal of the American Society for Information Science and Technology*, 62(12):2347–2363.

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## List of abbreviations

|        |   |
|--------|---|
| ACME   | Analogical Mapping by Constraint Satisfaction     |
| ACT-R  | Adaptive Control of Thought–Rational              |
| AST    | Adaptive Structuration Theory                     |
| ASU    | Adaptive system use                               |
| CA     | Conversation Analysis                             |
| CHAT   | Cultural-Historical Activity Theory               |
| CHREST | Chunk Hierarchy and REtrieval STructures          |
| CSCW   | Computer–Supported Cooperative Work               |
| DCog   | Distributed Cognition                             |
| EM     | Ethnomethodology                                  |
| GT     | Grounded Theory                                   |
| HCI    | Human–Computer Interaction                        |
| ICT    | Information and Communication Technology          |
| IS     | Information Systems                               |
| LISA   | Learning and Inference with Schemas and Analogies |
| MMS    | Multimedia Messaging Service                      |
| RQ     | Research question                                 |
| SCog   | Situated Cognition                                |
| SME    | Structure Mapping Engine                          |
| STS    | Science and Technology Studies                    |
| TAM    | Technology acceptance model                       |
| UI     | User interface                                    |



# Chapter 1

## Introduction: What is appropriation?

Although interactive technologies are always designed with some purposes of use in mind, they are also always open for reinterpretation and therefore for a wide array of activities. The way in which a technology becomes adopted and brought into wider use is therefore strongly determined by its users, and not only by its design, the advertised image, teaching and instruction, user manuals, or enculturation into the everyday understanding of common social practices.

In addition to the above-listed means that may be used for communicating the intended purpose of use to a supposedly passive user, users discover new uses for technologies by themselves and apply these to practical *problems*<sup>1</sup> in everyday life. The process in which a user integrates a technology into his or her ongoing practices and may invent new uses is called *appropriation* (e.g., Dourish, 2003, with more precise definitions to be reviewed later in this chapter).

Information and communication technologies<sup>2</sup> (ICTs) with interactive functionalities are particularly suitable for appropriation and therefore are at the focus of this thesis. Information is manipulated – re-represented,

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<sup>1</sup>The term ‘problem’ is here understood in a psychological sense instead of with its common-sense connotation of undesirable situations in one’s life. In the discipline of psychology, it refers to a situation in which ‘an organism has a goal but lacks a clear or well-learned route to the goal’ (Dominowski and Bourne, 1994, p. 23). In this thesis, a problem is a situation in which completion of a task is interrupted because the person does not have a means for moving on in the activity.

<sup>2</sup>The terms ‘technology’ and ‘system’, sometimes also ‘artefact’ and ‘tool’, are used interchangeably in the text. They all refer to interactive information and communication technologies.

adapted, interpreted, combined, produced, and so on – in various ways in one’s day-to-day personal and working life.

As a result, over the past 15 years, appropriation has been gaining increasing attention in technology-oriented research fields such as human–computer interaction (HCI), computer-supported co-operative work (CSCW), information systems (IS), science and technology studies (STS), and sociology of consumption. Appropriation is one of the key phenomena in interactive technology usage and a central issue in system design (Andriessen et al., 2003). Unlike in Taylorian factory work, technologies are nowadays rarely used according to rigid task sequences to serve predetermined goals. Consequently, the understanding of what the context of use is has changed and become more heterogeneous. For example, in modern knowledge work, successful performance may require ability to make use of the available tools in an adaptive manner. Often usefulness depends on the situation, since many problems are ill-structured – i.e., do not have a clearly defined goal state and means of reaching it (Simon, 1973).

Let us consider the example of a user who encounters an error while working on a computer and cannot bypass it. She may decide to call a friend for help. But how does she describe the problem in an understandable way over the telephone? One option is to take screenshots of the computer screen; perhaps paste them into PowerPoint, Keynote, or some other presentation graphics program; and then send them to the friend by e-mail. The friend may be able to access the e-mail at short notice and call back after having inspected the problem. Adoption of this solution requires use of four to five distinct technologies: the original software with which the error occurs, a screenshot tool, e-mail, the telephone, and optionally a presentation program. The combination of using these particular tools for solving problems in computer use, as well as the purposes of the individual programs in the larger process, may be such as the user has never considered before and she may invent it ‘on the fly’. Because of this, technologies should be *appropriable*: usable to serve multiple, also unforeseen, purposes and adaptable to different settings, because the conditions of activities vary from one setting to another. Also, by supporting flexibility, appropriable technologies help users to get the most from their higher cognitive capacities. Because even the most everyday life today involves a considerable amount of technology use, appropriable technologies can have a significant impact on all aspects of life.

Finding out how to create appropriable technologies is, therefore, an important design problem but also a very tough one. A central problem underlying all research on appropriable technologies lies in the relation



that the tool's design has with its user's ability to notice opportunities for use. This formulation calls for more informed psychological and cognitive research into appropriation.

In order to offer opportunities for impromptu solutions, technologies must give room for adaptation and improvisation. How this should be done is a question for which cognitive science can provide a starting point. Humans have always been creative tool-users (Tomasello, 1999), and improvisation in everyday problem-solving is a natural part of human cognitive functioning. For example, research can reveal how perception and action interact during situations of technology use and how existing experience affects the ways in which users evaluate the possibilities for use of technological features in different tasks and problems. Applying cognitive science to the research on appropriation is therefore natural and necessary.

However, as was noted in the list of research fields that share an interest in appropriation, the cognitive viewpoint has not been the only entry point to appropriation's most important questions. The following section presents the existing lines of research, including the different interpretations surrounding the specific meaning of appropriation, and the related findings. The final part of the chapter returns to the central theme of this thesis – repurposive appropriation – and initiates an analysis of the cognitive basis for appropriation.

## 1.1 Interpretations of appropriation

Appropriation has drawn the interest of many fields of research. Each has adopted a slightly different interpretation of the term's primary meaning, which has, in turn, affected the findings that have been presented. These are summarised in Table 1.1 and in the following sections. Also the emphasis placed on appropriation's individual or social characteristics has differed. As the review will attest, within each interpretation, both emphases have usually been addressed, in different studies, but the focus on social characteristics has been more prominent. The common viewpoints will be presented in Section 1.2, which also describes their relationship to the research question of this thesis.

### 1.1.1 Invention of new purposes of use

The interpretation of appropriation through the notion of *purpose of use* is especially commonplace in HCI-related studies. Research within HCI

Table 1.1: Examples of the interpretations of appropriation

| <b>Interpretation</b>               | <b>Field of research</b> | <b>Theory or framework</b>        | <b>Example studies</b>   |
|-------------------------------------|--------------------------|-----------------------------------|--|
| Invention of new purposes of use    | Design                   | –                                 | Dourish (2003); Dix (2007)   |
| Improvisation                       | CSCW                     | Ethno-methodology                 | Brown and Perry (2000); Brown (2000)                               |
| Customisation and adaptation        | End-user computing       | –                                 | Pipek (2005); MacLean et al. (1990)                                |
| Trying new features of technologies | IS                       | –                                 | Loraas and Diaz (2009); Mills and Chin (2007); Sun (2012)          |
| Integration into existing practice  | CSCW                     | –                                 | Balka and Wagner (2006)  |
| — ” —                               | IS                       | Social construction of technology | Fulk (1993)  |
| Renewal of structures of work       | Organisation studies     | Structuration theory              | Orlikowski (1992a); DeSanctis and Poole (1994)                     |
| Making the technology one’s own     | Sociology of consumption | Domestication                     | Silverstone et al. (1992); Sørensen (2006); Williams et al. (2005) |
| — ” —                               | End-user computing       | Sensemaking                       | Bansler and Havn (2006)  |
| — ” —                               | CSCW                     | Activity theory                   | Petersen et al. (2002)   |

strives to advance understanding of humans and technology, thereby resulting in more informed design of new technologies. One widely adopted assumption is that technologies are designed with a set of purposes of use in mind (e.g., Beyer and Holtzblatt, 1998; Sharp et al., 2007). The set of use purposes envisioned determines the basis for evaluating the quality of design. If users are able to carry out the tasks foreseen in an efficient manner, effectively, and find it enjoyable, the design is able to meet its HCI

objectives. Although the attention to the envisioned purposes of use is not always explicitly expressed within HCI, it has sensitised researchers and practitioners in the HCI field to notice whether users deviate from the uses expected. Observations of such behaviour have been one of the reasons for HCI researchers' interest in novel uses and how they emerge. Unexpected uses and changes in technology use are, therefore, an important aspect of HCI-based research on appropriation. To a large extent, this applies also to studies within CSCW, which, as a research field, is close to HCI but focuses specifically on social phenomena surrounding technology use.

Novel purposes of use are rarely invented without a reason. Instead, they emerge as responses to specific situational needs that may have developed gradually over time, or that arise abruptly during a course of action. Appropriations can be understood as technology-based ways to cope with such situations. This is the starting point for studies that endorse multipurposeness in technology's design and use (e.g., Dourish, 2003; Dix, 2007). For example:

Appropriation is the way in which technologies are adopted, adapted and incorporated into working practice. This might involve customisation in the traditional sense (that is, the explicit reconfiguration of the technology in order to suit local needs), but it might also simply involve making use of the technology for purposes beyond those for which it was originally designed, or to serve new ends. (Dourish, 2003, p. 467)

In the most straightforward vein, many HCI and CSCW studies focus on suggesting principles for design of easily appropriable systems. Such suggestions have often been practically oriented and intended to inspire new design thinking without leaning heavily on specific theoretical orientations. They also include suggestions that can be applied when one is designing for both individual and social contexts of use. The principles have been expressed most commonly as adjectives and in other descriptive terms. Dourish (1999) lists five such 'aspects'. *Flexibility* refers to providing the user with more control for customisation of the system, and also openness for application of the system for different kinds of content and purposes. Technologies should also enable *incremental* adjustments, in order to accommodate gradual transformations of use. Because Dourish sees appropriation primarily as a social process, he suggests that designers should also take into account the user *community*, by, for instance, creating features that add *visibility* of user actions between users so that novel practices can be shared (see also Dourish, 1997). Finally, the gradual changes

also require that the system manifest *persistence*, preserving a previous system state, on which later adaptations can be built. Other desirable features include *playfulness* and *exploration*, which are suggested to increase the chances of discovery of novel purposes of use (Perry and Rachovides, 2007; Paper 3). A similar kind of list has been presented by Dix (2007).

In some cases, *ambiguity* supports appropriation. For example, in computer-mediated communication, users need an opportunity to remain unresponsive when they so desire. For example, phone users have been found, in order to avoid losing face in such situations, appropriating the communication system's connectivity problems as a legitimate excuse for not picking up calls (Aoki and Woodruff, 2005; Hancock et al., 2009; Salovaara et al., 2011b).

Designers too can make use of ambiguity. Especially in the design of non-utility-oriented systems, designers can encourage users to explore by making systems vague as to their meaning and possible purposes of use. Ambiguity forces users into making sense of, reflecting upon, and interpreting the system's functionality themselves, thereby possibly arriving at uses that were not expected (Gaver et al., 2003; Sengers and Gaver, 2006).

From a usability point of view, appropriable technologies feature designs in which simplicity and multifunctionality should be in balance. Both of these design goals – simplicity and multifunctionality – have their proponents. When simplicity has been the goal, the systems resemble *information appliances* (Norman, 1999). These are tools that are each designed for one purpose only, for a 'restricted, specialized set of tasks' (p. 61). This specialisation provides good facilitation for the intended tasks but comes with a cost. Users will need lots of appliances in order to address all of the tasks in which ICT can benefit their lives. However, in some cases, users value adaptability. This is visible in the design behaviours that users may engage in when they customise and modify everyday environments to be suitable for their tasks (Wakkary and Maestri, 2007, 2008). Accordingly, at the other end of the spectrum one finds multifunctional technologies, such as tailorable systems (see Subsection 1.1.3), that allow users to adapt their functionality with scripting tools and other adjustments. Multifunctional technologies' benefit lies in their suitability for a wide number of purposes, though with a risk of poor readiness for meeting immediate needs and mediocre suitability for novice users.

In contrast to the above-mentioned approaches with their rather flexible theoretical underpinnings and individual vs. social focus, a more clearly cognitive and individual-oriented way of looking at appropriation is to investigate the changes in the ways in which users interpret and use technol-

ogy. These changes always build on users' existing knowledge. Appropriation takes place when a user perceives an opportunity for using the features of a technology in a new way, where 'new' means that the perception is new for this particular user (Salovaara, 2006). If the new use solves the user's problem, it becomes part of his or her repertoire of uses (Al-Natour and Benbasat, 2009; Paper 4). This interpretation of appropriation will be dealt with in more detail in this thesis, from Section 1.2 onward.

### 1.1.2 Improvisation

Sometimes people need to improvise in order to manage situations smoothly. Improvisations that involve uses of technologies can be considered as appropriations. In sociology, analyses of situation-specific improvisations are often based on findings from ethnomethodology (EM) and conversation analysis (CA) – research fields that study co-construction and maintenance of mutual intelligibility and order in social interaction (Garfinkel, 1967; Heritage, 1984). These closely related research traditions have been important in HCI and CSCW especially in their compelling argument for increasing researchers' attention to situated interaction (Heath and Luff, 2000; Martin and Sommerville, 2004; Suchman, 1987). Writers on EM and CA have argued against the practice of building strict models for human–computer interaction. As an alternative, they advocate focusing on the ways in which contextual resources are applied in interaction, and sequential analyses of actions' implications for later actions. In addition to the actions of co-present parties, and other features of the situation, EM and CA maintain that the contextual resources include rules and norms of acceptable behaviour – e.g., 'when a phone rings, answer it' (Brown and Perry, 2000, p. 623). Users orient to these rules in different ways and are not 'cultural dopes' who would act only 'in compliance with the preestablished and legitimate alternatives of action that the common culture provides'; Garfinkel, 1967, p. 68).

In research on appropriation, the analytical perspective of EM and CA has been used to investigate the ways in which social norms and rules, as embedded in the design of technology, have been oriented to by users in an improvised manner (e.g., Bowers et al., 1995; Button and Harper, 1993). Technologies may be designed to encourage certain organisationally desirable behaviours and constrain others. However, such rigidity in design does not rule out flexibility in technologies' use. For example, in one case, workers were observed entering pieces of data into a system not because it supported information management within the organisation but

primarily because writing a report created an impression of orderliness and professional competence (Brown, 2000, pp. 270–271).

Another approach is to consider technology use as *embodied interaction*. Drawing not only from EM and CA but also from literature on phenomenology (which partly underlies also EM and CA; see, for example, Heritage, 1984), as well as more recent technological developments in tangible and social computing, Dourish (2001) maintains that interaction with technologies, as any human interaction with the world is, are both a social and a physical phenomenon and that this provides a grounding for the meanings that users ascribe to technologies. Dourish emphasises the importance of the user’s direct interaction with the environment instead of one mediated by his or her mental representations. Designers may steer this interaction by designing constraints and expectations related to the system’s use into the system’s feature set. How the features are coupled with various purposes of use is, however, not determined fully by the designer but conditioned by the user’s embodied interactions. To support users’ embodied interactions in technology use also for unforeseen purposes, Dourish suggests that designers should make an attempt to provide resources for action instead of attempting to design for particular tasks only (p. 173).

In summary, the works drawing from EM and CA as well as research drawing from embodied interaction theorise about users’ capabilities of improvising. These studies also encourage designers to become attentive to providing opportunities for users’ improvisations.

### 1.1.3 Customisation and adaptation

Much of this chapter so far has emphasised appropriations’ emergence from novel perceptions or situated improvisations. However, also other forms of discovery of novel uses exist, since, in addition to perceiving, the user can intentionally change the features of the technology, making them more suitable for his or her needs. This can be encouraged by making systems adaptable by the users – for example, by providing scripting tools (Cypher et al., 1993; Henderson and Kyng, 1991; Mørch, 1997; Mørch and Mehandjiev, 2000; Lieberman et al., 2006; Nardi, 1993; Stevens et al., 2009; Wulf et al., 2008).

However, users differ in skill and in their eagerness to write scripts. Eager users can be classified into at least three types (MacLean et al., 1990) that have important social roles in discovery and promotion of novel uses of technology. ‘Tinkerers’ enjoy exploring the system but lack a full operational understanding. ‘Programmers’ possess in-depth understanding

of the system but are rarely available to support ordinary users as they face problems. Additionally, in some cases, a new intermediary role (called ‘handyman’, ‘translator’, ‘gardener’, or ‘mediator’; see Bansler and Havn, 2006; Mackay, 1990; MacLean et al., 1990; Nardi, 1993) emerges to bridge the gap between the technology-savvy and the ordinary users. Mediators often provide ICT-related support, with an official or unofficial mandate from the organisation. By providing help and support, they can also promote good practices. Designers and managers are advised to support users’ progress from the role of an ordinary user to more advanced roles, and to create a tailoring culture that activates users (MacLean et al., 1990). However, studies to date have not identified the individual characteristics that distinguish the tinkerers, programmers, and mediators from other users in technology use. Therefore, how such a key worker would be best supported remains largely unknown.

When one considers the social aspects of sharing novel ways of working, it is important to increase *visibility* and *sharing* of other users’ creations. If the outcomes of appropriations are visible to other users, they propagate more easily (Höök, 2006). Pipek (2005, pp. 62–63) has presented an 11-item list of design principles for tailoring and increased visibility. For example, a system can help users articulate their work practices such that others can learn from them, provide visualisations of past use, and be equipped with tools for exploration and simulation of possible ways of use.

Users may intentionally modify also technologies that are not programmable. For companies, users’ modifications may present a crucial source of new innovative thinking that can be harnessed in further design iterations and new product development (von Hippel, 1988, 2005; Hyysalo, 2004; Hasu, 2001). Sometimes, however, users deviate from companies’ intentions and conflicts arise. Competition for power and the politics of technology use are consequently often involved in emergent uses. The field of science and technology studies has documented many processes in which designers, managers, technology policy leaders, and others with development power have intentionally restricted or banned certain uses or in which users have started using technologies on their own terms (Abu-Lughod, 1989; Eglash, 2004; Mackay and Gillespie, 1992; Schäfer, 2011; Winner, 1980).

#### 1.1.4 Trying new features of technologies

It would seem reasonable to assume that appropriation would be more commonplace among users who are willing to invest time and effort in learning about new features of technology. However, learning about a new

feature does not necessarily entail learning about a novel purpose of use. For example, learning may also be related to more efficient execution of an already familiar task, or to a purpose of use that the user had been aware of but only recently decided to become properly acquainted with. Nevertheless, although studies of feature-related learning and exploration do not explicitly address appropriation, they may provide useful hypotheses on factors that constitute part of the underpinnings of inventions of novel purposes of use specifically.

In contrast to much of the literature cited above, studies in this area have been mostly quantitative in nature and focused on individual users' characteristics instead of the social or physical context. In general, users display the greatest motivation to invest their effort in learning new features when they do not need to focus only on performance and when they also find that learning is not complicated (Loraas and Diaz, 2009). However, they may be unwilling to learn new uses if doing so has side effects for routines that they are not willing to change (Lindley et al., 2009).

Several individual-oriented constructs have been suggested as underlying factors behind a person's interest in exploring individual features of technology or entirely new technologies. These include personal innovativeness in information technology use (Agarwal and Prasad, 1998), micro-computer playfulness (Webster and Martocchio, 1992; Woszczynski et al., 2002), and willingness to try to innovate with IT (Ahuja and Thatcher, 2005). This work uses self-reporting scales for computer use traits, attitudes, or users' goals and has not examined the attributes in relation to actual novel uses.

It appears that only three quantitative studies have been published to date on the relationship between individual user characteristics and users' inventions of new purposes of use. The first one, by Mills and Chin (2007), following Compeau and Higgins (1995), employed self-efficacy theory (Bandura, 1986) to explain creative use. The authors used self-efficacy, general computing knowledge, and belief in one's ability to use computers as the independent predicting variables. These factors explained 62% of the variance in creative uses. However, this work too measured creative technology use with general self-assessments, without measuring actual creative uses.

The second, a very recent study by Sun (2012), addressed 'adaptive system use' (ASU) and its antecedent factors. Here ASU was defined as exploration of new features, substitution of new ways of working for old ones, combination of features in new ways, and appropriation of features for purposes that the user considered not to have been intended by the designers. Sun found that three factors contributed to ASU: novel situations,



discrepancies in interaction with the computer, and deliberate initiative to learn new uses. The study measured these factors on a general level (e.g., with statements such as ‘I applied some features in Microsoft Office to tasks that the features are not meant for’; see p. A3), without reference to concretely stated appropriations, and again on the basis of respondents’ self-assessments.

Finally, the third study, addressing appropriation explicitly, is presented in Paper 6. Its main findings are summarised in the next chapter. This study examined a set of technology use characteristics (reflective use, *ad hoc* use, social use, etc.) as predictors for creative use. The associated measurement of creative use was calculated from responses to questions on a predefined set of non-obvious use purposes.

### 1.1.5 Integration into existing practice

In leisure and work contexts both, systems are often used in joint actions with other people. This presents another kind of aspect of technology appropriation. As was noted above, to be successful and effective, systems and their use need to be *integrated* into the existing social practice in which the technologies are embedded (Dourish, 2003).

Integration into practice is strongly linked to social uses of technology. Studies looking at integration draw from the framework of social construction of technology. Proceeding from this starting point, they maintain that technologies and their configurations are determined not only by technological possibilities but also by social forces (Bijker, 1987; Law, 1987; MacKenzie and Wajcman, 1998). This is apparent in appropriation: users contribute to appropriation by adopting uses, making adaptations, and propagating them further, as well as by restructuring the work processes, work environment, and technologies. These are examples of activities that are necessary if one is to ‘make technology work’ (Balka and Wagner, 2006, p. 229).

Technology-related practices are often also developed from the ground up. Workers usually trust their peers’ opinions more than their managers’ when it comes to formulating opinions about technologies (Fulk, 1993). Such opinions incorporate beliefs about other group members’ knowledge and acceptance of the rules, resources, and capabilities of technology, and about the degree to which the members agree on the ways in which the technological structures should be appropriated (DeSanctis and Poole, 1994). Sometimes workers also create manuals of their own and start organising

informal tutoring groups. These forms of collaboration also have an effect on common opinions (Boudreau and Robey, 2005).

Nambisan et al.'s (1999) organisational management study showed that also organisations are able to affect workers' perceptions of technologies. In the study, employees' awareness of novel purposes of use could be increased through establishment of technology-focused steering committees (e.g., task groups and planning teams) that reinforced workers' exploration intentions. Other successful means were on-site support services (e.g., user fora, user labs, and customer support) that encouraged workers' exploration abilities.

Qualitative longitudinal studies show that often practices of use tend to stagnate on a group level, which leads to a decrease in appropriation (Huysman et al., 2003). However, external thrusts such as discrepancies in the work structures are able to re-stimulate appropriation (Lassila and Brancheau, 1999; Majchrzak et al., 2000; Tyre and Orlikowski, 1994). Also, systems that allow more freedom of use, even at the price of a steeper learning curve, lead to more active appropriation in the long run (Fuller and Dennis, 2009).

### 1.1.6 Renewal of structures of work

Practices of technology use in workplaces are by their very nature socially structured. In the Adaptive Structuration Theory (AST) (e.g., DeSanctis and Poole, 1994), technology is seen as embodying *structural features* (rules, resources, and capabilities offered by the system) and the *spirit* (the intended use of the technology). The AST approach is based on the structuration theory of Giddens (1984; Jones and Karsten, 2008), which brings together two opposing theoretical viewpoints in sociology: that emphasising objective macro-level structures that shape human action and, on the other hand, the view that social reality and structures are products of human actions. Giddens proposes a duality of structure, in which three elements of social interaction – meaning, power, and norms – operate as mediators between the actions and the structures.

In this framework, technology's integration into social practice can be studied as a structuration process; AST posits that structures are embodied in technologies that act as mediators of change. Integration of technology into practice can have two outcomes. Depending on whether the integration takes place in conformance with the spirit, it is appropriated either *faithfully* or *unfaithfully*. Proponents of faithful appropriation maintain that it ensures optimal use of the system for the organisation (e.g., Rüel, 2002; Dennis et al., 2001; Nambisan et al., 1999).

A related proposition, also drawing from Giddens, has been put forward by Orlikowski (1992a). In contrast to AST, this focuses on the role of technology in structuration more neutrally, highlighting its interpretive flexibility (cf. Pinch and Bijker, 1987), without giving precedence only to the faithful uses of technology. This is a justified viewpoint in light of long-term studies showing that also unfaithful appropriations can be beneficial. Through negotiation and mutual changes in both managers' and workers' practices, all appropriations may lead to positive renewals of the structures (Orlikowski, 1992b, 1996; Rodon et al., 2011; Majchrzak et al., 2000; Tyre and Orlikowski, 1994; Lassila and Brancheau, 1999).

Early work by Orlikowski (1992a) presented technologies as embodiments of structures, similarly to AST. However, Orlikowski (2000) later withdrew this assumption. The more recent viewpoint is based on an idea of emergent structures that users *enact* through technology use. This version maintains that structures are virtual and manifested in humans' actions and interactions, as had been proposed already by Giddens (Leonardi and Barley, 2010; Jones and Karsten, 2008, p. 22).

Appropriation is therefore understood as a technology-related form of structuration. It may take place gradually or abruptly. In gradual changes, structures of shared resources are constructed in a piecemeal fashion (Muller et al., 2005). Abrupt appropriations, in turn, take place especially at times of discontinuity and discrepancy. Initiating events include introductions of new technologies, difficulties in carrying out certain tasks, and team reorganisations (Tyre and Orlikowski, 1994; Majchrzak et al., 2000; Lassila and Brancheau, 1999).

The focus on integration and renewal makes the research on appropriation different from studies of *adoption* (e.g., Davis et al., 1989; Davis, 1989; Venkatesh and Davis, 2000; Venkatesh et al., 2003) and *diffusion* (e.g., Rogers, 1995). While adoption refers to the selection of a technology for use (or its rejection), appropriation refers to the adaptations that are necessary for a successful adoption. Also, appropriation does not end with the user's decision to adopt the technology. In fact, many studies of appropriation focus on 'post-adoption behaviours' (Jaspersen et al., 2005). Depending on the success of the appropriation process, a technology may become *non-appropriated* (not adopted at all), *disappropriated* (a technology in which the user loses interest after initial adoption), or *appropriated* (integrated into practice) (Carroll et al., 2003).

Also, studies of adoption are typically focused on quantifications of technology use, often with a single measurement (e.g., of frequency of use). But, because the same technology can be used in different ways by different

people and at different times, the appropriation studies cited in previous subsections also pay more attention to what users actually do and achieve with technology than the studies examining adoption do (see Paper 5 and Section 4.3).

### 1.1.7 Making the technology one's own

Integration of a new technology into one's routines and practices also means that the user becomes more familiar with it. The technology therefore starts to feel more personal and part of one's identity (Carroll et al., 2001; Scifo, 2005). This viewpoint is especially common in sociological studies of *domestication* whose foci are on both technologies' functional processes (i.e., those related to their purposes of use) and symbolic processes (i.e., to do with meanings ascribed to them). Early work on domestication (e.g., Silverstone et al., 1992) in the 1990s addressed media consumption in domestic settings, particularly in households' practices of television use. Researchers emphasised that the impact of technology on household routines is far from a deterministic matter (Berker et al., 2006). Instead, the household is an arena in which technology use involves both pragmatic and moral transactions between its members. Four interrelated non-deterministic processes – appropriation, objectification, incorporation, and conversion (e.g., Haddon, 2007, p. 26) – are described, referring to the different ways in which the transactions render an originally unfamiliar technology personal and 'domesticated' (Silverstone et al., 1992). In the terminology of this literature, appropriation denotes the ways in which technological artefacts achieve their significance through ownership. The phenomena related to the purposes for which technology is used are captured within *conversion*.

Another strand of domestication research has paid attention to designer–user relations in technology development processes (Sørensen, 2006; Williams et al., 2005). Drawing from the social shaping of technology approach (e.g., Pinch and Bijker, 1987) and actor–network theory (e.g., Latour, 1988), this literature objects to the deterministic view in which technology has well-defined impacts on people and society. Researchers have shown that designer–user relations in development projects include mutual social learning that shapes technology's meanings and purposes of use (Williams et al., 2005, p. 7).

Another possibility is to view relation-building with a technology as *sensemaking*. According to Weick (1995), sensemaking involves seven properties: a person's identity, retrospection, enactment of experiences as narratives, social context and those who are involved therein, ongoing shaping

and reaction to the environment, extraction of cues from the environment, and favouring of plausible explanations over accuracy. Open-ended technologies require more sensemaking than do other technologies before they can be adapted to changing conditions of use. In organisations, sensemaking may become one of the mediators' responsibilities (Bansler and Havn, 2006).

The third viewpoint on 'making technology one's own' comes from Cultural-Historical Activity Theory (CHAT), which looks at HCI from a developmental and systemic perspective. Technology-mediated activity relies on cultural-historically developed tools and practices. The unit of analysis is the evolving activity system that consists of a subject, a mediating instrument (a tool), and an object of activity. The tool can be physical (e.g., a hammer) or intangible (e.g., a set of rules, or any other symbolic expression or system, including natural language). The same applies for the object. It can be a material thing (e.g., a hand-crafted item) or an intangible concept (e.g., a plan; see Bardram, 1997). The social environment in which the subject is embedded – the community – introduces two additional mediating relationships: the rules that define the subject's relation to the community and the division of labour that describes how the community acts upon the object collectively (Engeström, 1987; Kuutti, 1997). The CHAT framework allows for analyses that take into account both individual-oriented and social processes involving physical and symbolic entities alike. Technology appropriation is seen as a merging of new tools into the activity system, transformation of tool use and how these tools mediate users' interaction with the objects of their actions (i.e., what the user wants to achieve). Gradually, through being used, the tool finds a natural place in the person's individual repertoire of actions (e.g., Waycott, 2004). This requires the system's design to support learning along several dimensions: how the technology is used, what its functions are, what its purposes of use might be, and how the user is to explore its use further (Petersen et al., 2002).

## 1.2 The scope and the research question

The viewpoints presented in the review have certain elements in common:

- The user is seen as an active actor who integrates, adapts, and interprets technology to make it suitable for his or her own purposes.
- The changes in technology use are at the focal point of appropriation. They occur when users integrate technology into existing practices,

or when their uses deviate from the most common use patterns. Deviations can denote different things, such as temporary improvisations, development of new uses that become new resources for action, or uses that the designer did not consider when developing the system.

- Appropriation refers to two things, with the interpretation depending on the context in which the word is used: the process (how the novel aspects of technology-related practices emerge) and the outcome (what the emergent uses are).

However, the review also shows that the literature on appropriation is incomplete with respect to some central issues. The following elements have been poorly addressed:

1. *Repurposing* – changes of use that are specifically related to uses of technology for novel purposes. The interpretations of ‘appropriation’ have been varied in previous literature. As was pointed out in the review, the majority of appropriation-related studies consider the change in technology use as related to social practices alongside concepts of integration (Subsection 1.1.5), active modification (Subsection 1.1.3), renewal (Subsection 1.1.6), and making technology one’s own (Subsection 1.1.7). While addressing several interpretations of change, the associated arguments have not been developed such that they address change in the purpose of use. Whilst such change has been one of the main interests within HCI research (see Subsection 1.1.1), it lacks an underlying theory.
2. *The individual user* – a contrast to previous research, in which social processes have been accorded the dominant role. While social processes have received a lot of interest, appropriation by an individual has been addressed in only a few studies. The design-oriented papers (Subsection 1.1.1) pay attention to individual-oriented issues but without presenting empirical studies that look at individuals. Findings in end-user computing literature (Subsection 1.1.3), in turn, have noted the importance of technology-savvy key individuals as sources of novel use practices, but no in-depth studies have been published on the factors through which one could fruitfully address the relationship of technology savviness to the ability to appropriate actively. The studies of individual users’ interests in trying out new technology features (Subsection 1.1.4), on the other hand, have been individual-oriented, but they have focused on learning in a rather general sense and not on appropriation specifically. Finally, there are a number

of suitable theoretical frameworks (e.g., ethnomethodology, conversation analysis, cultural-historical activity theory, sensemaking, and embodied interaction; see Subsections 1.1.2 and 1.1.7) suitable for more detailed analysis of individuals' appropriation too, but the review shows that only a few studies exist wherein these frameworks have been applied empirically to individuals' appropriation.

This thesis focuses on these two poorly addressed issues. However, the relationship between the social context and an individual's action and cognitive processes is complex, and applying focus on an individual introduces the threat of important aspects of appropriation being neglected. For example, individuals' knowledge is to a large extent acquired from and alongside other people. In addition, many situations in which technology is used are embedded in an activity in which also other people play an important role.

Regardless of the obvious importance of the user's past and present social context, it is also sensible to assume that individual users' cognitive processes too play an important role in appropriation. All groups of people are composed of individuals who bring something personal to their joint activities. When they use technology, they mediate the practices that have been socially developed, and on some occasions they may transform these by finding new purposes of use. An individual's role as an independent appropriator is important, especially when the technologies involve one user's interactions at a time. The uses of technology studied in this thesis – mobile multimedia messaging, mobile comic-strip creation, and digital photography (see Subsection 1.2.2) – have this characteristic. In addition, as the theory-building in Chapter 3 indicates, application of theories with their origins in cognitive science and psychology may yield understanding that has not yet been considered.

A specific emphasis on individual users was not chosen in advance when the work for this thesis was begun. Instead, it evolved during the first three empirical case studies presented in the thesis (i.e., Papers 1, 2, and 3). The decision to focus on individuals and repurposing, as conceptualised in this introductory chapter, was based on the observation that the existing literature had not addressed them as much as it has social processes and other interpretations of appropriation. Also, narrowing the scope in later studies (Paper 6) made the possible contribution of the thesis more salient.

The following sections define the central concept – repurposive appropriation – explored in this thesis, provide further scoping, and present the research question.

### 1.2.1 A definition of repurposive appropriation

Repurposive appropriation denotes the following:

**Definition 1** (Repurposive appropriation).

In repurposive appropriation, a user or a group of users discovers a novel purpose of use for a technology, ‘novel’ denoting that this use was not known by the user or the user group at some earlier time. Although repurposive appropriation entails a change in technology use, not all changes are repurposive. For example, integration of a new technology into existing practice is repurposive only if the technology’s purpose of use also changes to something that the users did not originally envision. Increased mastery in technology’s manipulation is not repurposive, because it does not change the technology’s purpose of use. Neither is adopting a new purpose of use by learning about it from others (e.g., through observation or by being taught) repurposive appropriation, because then the discovery is not actually made by the user or group of users in question.

This definition is agnostic of the concepts of ‘intended use’ (cf. de Souza, 2005) and ‘faithful appropriation’ (cf. Chin et al., 2001). These notions refer to the purposes that a designer, a design team, or the managers thereof have assumed for the technology. The user, however, may not be aware of such purposes. In fact, the intended use may actually have many meanings, since designers and managers may differ in their intentions. Communicating the intended use to the user is also confounded by many other factors: physical limitations on transforming the design ideas into concrete features; lack of time and other resources for design and production; and messages about the intended use that are presented by peers and in public opinion, advertising, user manuals, and tutoring. In addition, whatever the features are, they rarely predetermine their purposes of use fully.

The concept ‘intention’ is, therefore, often imprecise, and comparison to actual usage is problematic. The definition presented directly above for repurposive appropriation avoids this problem. Repurposive appropriation is always a change in relation to the user’s previous understanding of the purposes of use. When comparisons are needed, the focus can stay on the user and his or her interpretations only; the designer’s intentions are relevant only to the extent that the user is aware of them. Therefore, this thesis does not apply the concept of intended use. In addition, while the thesis focuses on individuals, the definition applies to repurposive appropriations



both by an individual and by a group. The distinctive criterion is that the novel use is novel for all parties involved, be they one user or more.

In this thesis, repurposive appropriation is divided into the following two categories:

**Workarounds:** discoveries in which a previously unrelated tool is used in a task in place of a typical tool that in this case is unavailable or deemed unnecessarily laborious to use. For example, a digital camera may be used for ‘scanning’ physical documents when a scanner is not available.

**Discoveries of novel activities:** discoveries that lead to a completely new activity for which no need existed before. For example, the invention of ‘scratching’ in New York in the late 1970s opened up the possibility of using turntables for creating new kinds of compositions in hip-hop music (see Goldberg, 2004).

### 1.2.2 Scope: Workarounds in piecewise visual content creation

As stated in Section 1.2, this thesis focuses on repurposive appropriations made by an *individual*. This approach addresses learning of a novel use wherein the individual directly has a significant role in the discovery. It follows that such forms of learning as mimicry or instruction-following will not be within the scope of the thesis. The reason is that in those cases the discoveries are made by people other than the one whose technology use is at the focus of analysis. Co-discovery with other users, however, is addressed to some extent, insofar as the analytical focus remains on that user who comes up with something related to an idea of a novel use. The importance of other users who may provide starting points for such discoveries will be addressed in the context of situational features of the repurposive appropriation process (see Subsection 2.5.1). Given that the social context is important in appropriation, its relation to individual users’ repurposive appropriation will be elaborated upon in addition, in the discussion (Section 4.4).

The specific technological use context that is addressed in this work is *piecewise visual content creation*. This scoping stems from the empirical studies that addressed collocated mobile group messaging (Papers 1 and 2), comic-style mobile messaging (Paper 3), and digital camera use (Paper 6). The term ‘piecewise visual content creation’ is used in this thesis to refer to technologies for creating visual content in a piecewise manner, message by

message or image by image. This makes their use *episodic*, meaning that the use can be segmented into temporally bounded processes (e.g., from taking a camera phone in one's hand and starting to compose a message to sending the message and putting the phone away). These segments, or episodes, were numerous in the studies' data. The shared unit of analysis made it possible to focus on the contextual factors of use on the same level across all of the technologies studied.

Piecewise visual content creation is well suited to a psychologically oriented analysis and associated theory. In creation of a piece of content, the visual format of the medium requires that the user attend to the surrounding environment in order to find material for the message. This interaction with the environment is a process involving exploration and planning. In addition, the user's prior experience of similar content creation situations can be expected to affect the way in which the content creation process unfolds. In Chapter 3, these characteristics will be brought together in a common model through interpretation of repurposive appropriation as recognition of the environment's structures and as problem-solving in which expertise plays a significant role.

Furthermore, all of the technologies in the empirical studies were used in *everyday life* instead of work settings. This was beneficial, since researching individual users' repurposive appropriation would have been more difficult in workplace contexts. Therefore, the analysis of social forces (rules, shared practices, co-authorship, etc.) could be de-emphasised. Also, the focus on digital cameras and systems in mobile phones ensured that in most cases the systems were operated by only a single user. Accordingly, the unit of analysis could be more easily limited to an individual user.

Thus, the technologies under study were well suited to research on individual users' repurposive appropriation. However, while both workarounds and discoveries of novel activities were given the focus in the first three studies (Papers 1, 2, and 3), observations of the latter were rare. Subsequently, *the thesis focuses specifically on workarounds*. This scoping was also employed already in the planning of the fourth empirical study (Paper 6), which, therefore, addressed only workaround-like appropriations.

However, as a counterpoint to these specifications that narrow the thesis's scope of applicability, the repurposive appropriations studied here do not presuppose reprogramming (see Subsection 1.1.3) or physical redesign (e.g., 'do-it-yourself' work) by the user. Throughout the thesis, the focus remains on such repurposive appropriations as any user can perform without needing to apply special tools or programming skills.

### 1.2.3 The research question

In view of the scoping above, the goal of this thesis is to *develop a theoretical hypothesis as to the cognitive processes in individuals' workaround-like repurposive appropriations.*

Satisfying this research goal requires specification of the relationship between the features of the activity context and the individual's cognitive processes in that context. Addressing the physical and technological features of the context is particularly relevant, since interaction with technologies always has a physical dimension in the form of button presses, pointing, movement, etc., which are oriented toward making use of technological features. Empirical studies of repurposive appropriation are needed, for description of the relationship between context and cognitive processes. Any hypothesis proposed must be compatible with observations of repurposive appropriations in natural settings. The papers in this thesis therefore present three field experiments (described in Papers 1, 2, and 3) that generated empirical data and served as a basis for a model describing the required relationship between the context and cognitive processes (see Subsection 2.5.1). The theoretical work was then based on this foundation.

Furthermore, the cognitive processes need to be described and explained in relation to other psychological and cognitive theories. Chapter 3 reviews psychological theories that can be used to explain repurposive appropriation. They link repurposive appropriation with higher cognitive functions such as problem-solving, creativity, and thinking. The chapter presents these alternatives, analyses their strengths and weaknesses, and bases its development of theory on those that are strongest. The goal is in *theory development for the moments when users perceive a novel opportunity for action.*

The answer given for the research question has three limitations, some of which have already been mentioned. The theoretical hypotheses' empirical evaluation is not part of the thesis. Also, this work does not address the relationship of repurposive appropriation to lower-level cognitive functions such as memory or attention that support higher cognitive functions (e.g., problem-solving). The reason for imposing this limitation is related to the exploratory goal of the thesis and is explained in more detail in Section 2.1. Additionally, although repurposive appropriation is a process that builds on previous appropriations and experiences of technology use, this thesis does not address the cyclical and developmental nature of longer-term appropriation processes.



# Chapter 2

## Empirical studies

Four exploratory empirical studies were carried out for better understanding the phenomena in repurposive appropriation and supporting the development of theory on its underlying processes. The following sections present the research strategies adopted in these studies and an overview of each. This consideration is concluded with a summary of the limitations of the research strategy chosen.

### 2.1 Research strategy

McGrath's research strategy circumplex (1981; see Figure 2.1) can be used to deliberate on one's research methods in different research settings. The circumplex has two dimensions: universal vs. particular concern and obtrusive vs. unobtrusive research operation. These dimensions define four quadrants (I–IV) of research methodology and eight possible research strategies.

McGrath maintained that when planning research, the researcher should consider the weaknesses and strengths of different methods. He presented three mutually exclusive *desiderata* (*A–C*) that characterise good research: *A*) generalisability, which is greatest in sample-based surveys and computer simulations; *B*) precision, at its highest in laboratory experiments; and *C*) realism, highest in field studies. The dilemma for the researcher is that these desiderata are located at maximally distant positions along the circumplex's circumference, so no study can excel in addressing all of them. Also, an attempt to satisfy two desiderata makes the study particularly weak with respect to the third desideratum. For example, a researcher who focuses on precision (*B*) and realism (*C*) is likely to select field experiments or experimental simulations as the research strategy.

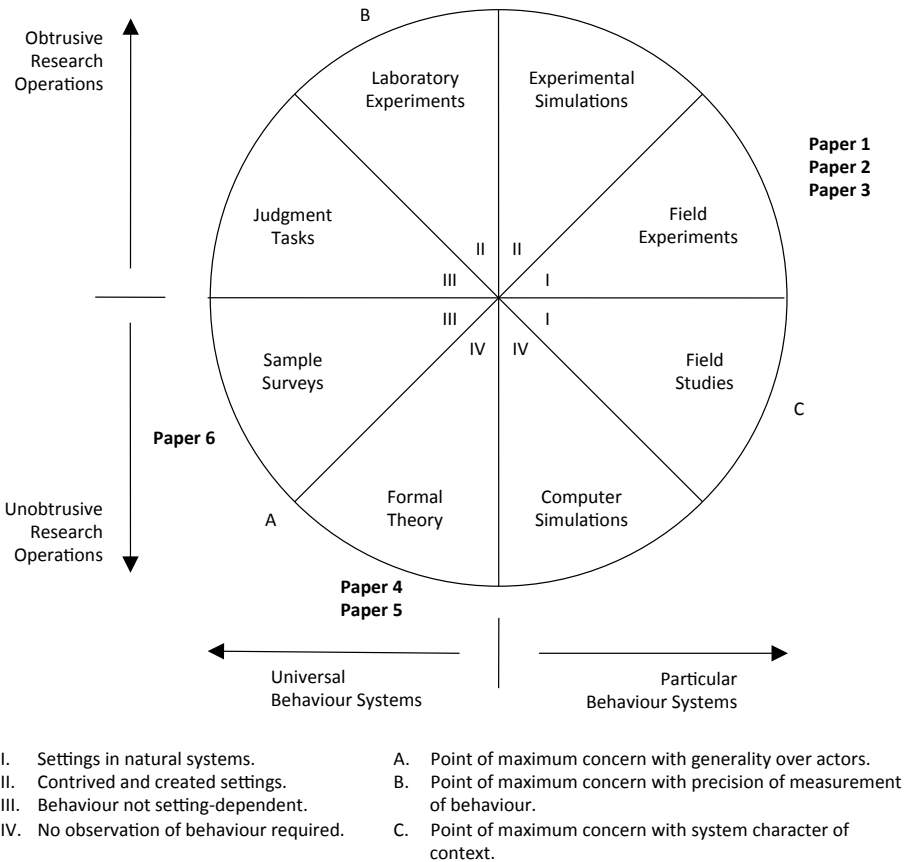


Figure 2.1: Research strategy circumplex (adapted from McGrath, 1981, p. 183) with the studies of this thesis placed in the respective octants.

However, since these are methods in which either the sample size is small or the context does not permit exercising better control of the phenomenon, such methods are of relatively low generalisability (*A*). Generalisability, in turn, would be best obtained by means of sample surveys. As a result, no research strategy can be considered better than another *per se*. McGrath maintains that, instead of embarking on one method, the researcher should contemplate the strengths and weaknesses of each strategy and choose the one that seems best for the task at hand. Also, studies should be considered as a series, such that different strategies would be adopted in different parts of the series, thereby addressing the three desiderata in a mutually strengthening manner.

As was concluded in Section 1.2, no existing theory from Section 1.1 could be applied for the present research question. Given this, the studies for this thesis had to be designed to provide data suitable for exploration and generation of new endogenous theoretical hypotheses. This led to a decision to start the research by focusing on desideratum *C* with a goal of collecting contextually rich data and desideratum *A* with a goal of developing theoretical hypotheses that could be generalised. The most important limitation with this strategy was that it did not address desideratum *B* (precision) and consequently did not include controlled experiments.

With these choices, the methodology for the studies was not typical of studies in cognitive science or psychology. Open-ended descriptive studies were carried out although they produce indirect and uncertain data with respect to cognitive processes. Because mental processes are not directly observable, their research would have required controlled studies on concurrently occurring repurposive appropriation processes.

However, the research goal for this thesis was to develop theoretical hypotheses on cognitive processes involved in repurposive appropriation. The open-ended methodology was chosen because it was felt that the phenomenon required it. Repurposive appropriation was seen as being heavily embedded in the surrounding context. Starting the research with a controlled method and with precision (*B*) as the primary desideratum would have entailed a risk of disregarding something crucial by embracing a research design of questionable ecological validity.

The cost of choosing open-ended studies and realism as the starting points is that the interpretive steps from observations to theoretical conclusions were likely to be long and therefore to produce uncertain and potentially erroneous information on the target phenomenon. In Chapter 3, where hypotheses are developed for repurposive appropriation, alleviation of this problem is sought through a review of competing theories and choice of the most salient ones at each stage. It is important to confirm findings later with experimentally controlled further studies. Such studies will be proposed in Section 3.5, and the limitations mentioned here will be addressed further in the discussion, in Section 4.1.

### 2.1.1 Realism

As stated above, despite its importance for system design, repurposive appropriation is a little-studied subject. Existing literature therefore does not provide strong suggestions on where to direct one's research. Also, repurposive appropriation is a phenomenon occurring in a natural context in

Table 2.1: Research strategies applied in the studies for this thesis

| Paper | Research strategy | Research setting   | Method  |
|-------|-------------------|--|---|
| 1     | Field experiment  | Mobile multimedia messaging in a group ( $n = 13$ )                | Technology intervention, <i>in situ</i> observation, post-study interviews, logging |
| 2     | Field experiment  | Mobile multimedia messaging in a group ( $n = 8$ )                 | Technology intervention, <i>in situ</i> observation, post-study interviews, logging |
| 3     | Field experiment  | Mobile multimedia messaging in a group ( $n = 8$ )                 | Technology intervention, <i>in situ</i> observation, periodic interviews, logging   |
| 4     | Formal theory     | –  | Theory-building   |
| 5     | Formal theory     | Technology acceptance models                                       | Critical analysis of ontological foundations  |
| 6     | Sample survey     | Digital camera use (pilots $n = 33+25$ , final study $n = 2,379$ ) | Web-based survey  |

which a multitude of characteristics of everyday life can play a role. There is no *a priori* knowledge as to which contextual, social, and personal characteristics are more important than others in repurposive appropriation.

Because of the paucity of existing firm research findings, the first three studies presented in this thesis (see Table 2.1) were carried out by means of an open and exploratory research strategy and naturalistic data collection. The goal was to address desideratum *C* (i.e., realism) by observing repurposive appropriations and appropriation processes *in situ* and narrowing the research focus until more understanding about the phenomenon had been gained.

A good-quality open-ended field experiment in HCI requires that the collection of data about technology use be carefully and comprehensively executed. If possible, the data should be rich with examples of the topic of interest. This can be challenging if the phenomenon occurs unpredictably. Also, the behaviour observed should be as close to natural as possible, even if obtrusive methods such as videotaping and interviewing may be necessary in the data collection.



In the present studies (Papers 1, 2, and 3), these requirements were addressed by carrying out *technology interventions* with mobile communication technology prototypes. Through being designed and implemented by the research team itself (Papers 1 and 2) or in close co-operation with the developers (paper 3), they could be equipped with comprehensive data logging features both at device level and on the server. This made it possible to collect very high-quality information about the communications that took place via that media channel. To complement data logging, the other research methods consisted of participant observation using video cameras (Papers 1 and 2) and periodic interviews (Paper 3). The challenge that repurposive appropriations may occur only rarely was alleviated via study of prototypes of possible future communication tools. The participants could not have experienced similar communication opportunities before, which meant that the users had not yet developed routinised use practices for the technologies. This increased the probability that novel uses could be observed.

### 2.1.2 Generalisability

While open-ended studies are useful in contextualising the topic of interest and in revealing relations to other phenomena, their problem is that they provide fewer opportunities for generalisation beyond the scope of a small group of users or for more general theory-building. This was true also in the above-mentioned field experiments.

Remedies for this weakness were sought in Papers 4, 5, and 6, situated in opposite octants in the research strategy circumplex (see Figure 2.1, above). These three papers were aimed at singling out generally applicable theoretical starting points (desideratum *A*) for repurposive appropriation.

Paper 4 presents a theoretical model for repurposive appropriation, drawing from ecological psychology, particularly schema-based mental representations and Neisser's (1976) perceptual cycle. Schema-like representations are one of the building blocks in the theoretical hypotheses presented in Chapter 3.

Paper 5 offers critical comment on technology acceptance model (TAM; e.g., Davis et al. 1989; Davis 1989; Venkatesh and Davis 2000; Venkatesh et al. 2003) research. TAMs represent a theoretical viewpoint and assumptions that are in opposition with the central assumptions of repurposive appropriation research. Paper 5 criticises these models for poor sensitivity to the purposes of use that users have for technology. If the variation in the individual purposes is not known, the utility of studying what features

lead to a technology being accepted by the users becomes debatable. The arguments raised in the paper are discussed in Subsection 4.3.

Finally, Paper 6 is a quantitative survey-based comparison of eight distinct individual-oriented factors that could explain users' propensity for discovering workarounds and adopting the discovered uses for their recurrent use practice. The purpose of the study was to identify those explanatory factors that are most important for repurposive appropriation. The technology under research was digital cameras. The findings are presented in Section 2.4.

Also this thesis belongs to the formal theory octant. It presents hypotheses (see Chapter 3) addressing the underlying cognitive constructs and processes of repurposive appropriation. It also provides a basis for controlled empirical studies that would maximise the heretofore unaddressed desideratum *B* (i.e., precision).

The following sections present the field experiments conducted as part of the thesis research, presenting the technologies studied, overviews of the data collection methods, and the main findings about repurposive appropriation. As was already noted in Section 1.2, the first three studies – of mGroup, CoMedia, and Comeks – did not limit their focus to addressing individual users' repurposive appropriation. Instead, they examined repurposive appropriation in a group of users. The difference between the research question of this thesis and the aims of these three studies reflects the change that took place during the dissertation process. In a later stage, the focus was narrowed to the decision to study the individual's repurposive appropriation, as is evident in Papers 4–6. The more general focus of Papers 1–3 can be considered also as a factor that may increase the ecological validity of the thesis, in that they provided data for conceptualising the various contextual features, including the social ones.

The purpose of this chapter of the thesis is to develop understanding of an overarching outcome across all of the empirical papers. The result is presented in Figure 2.8, at the end of the chapter, after the summaries of the case studies.

## 2.2 Collocated mobile group messaging: mGroup and CoMedia

Mobile phone applications mGroup and CoMedia were prototypes for rich computer-mediated interaction among members of a geographically distributed group. Their use was studied in open-ended field experiments

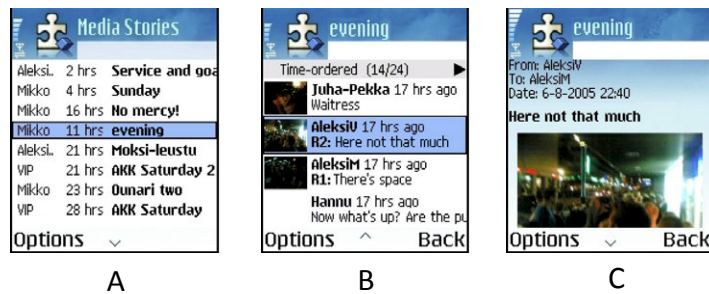


Figure 2.2: mGroup's user interface: the list of media stories (A), messages and replies in a story (B), and a view of a single message (C).



Figure 2.3: CoMedia's user interface. Unlike that of mGroup, the interface provides awareness information on all of its screens. The ticker box at the top of the screen informs about the other online users in the system (A), in the same media story (B), and in the same message (C). The users' online statuses were described by means of member icons and on a dedicated screen (D).

during Neste Rally events in 2005 and 2006. Neste Rally is part of World Rally Championships competition and one of the largest public events in the Nordic region. It brings hundreds of thousands of people to central Finland each August to spectate as cars speed along gravel roads. Spectators usually attend the event in groups. Traffic jams caused by the many spectators often force a group to split and watch the competition from different locations. This increases the need to co-ordinate and communicate.

Figures 2.2 and 2.3 present the user interfaces of the two systems. Users could send messages with images (in CoMedia, also video and sound) to each other. These messages were gathered into message threads called 'me-

dia stories' that the users could create as needed. CoMedia was a successor of mGroup and featured also a Web interface, an event guide, and real-time awareness cues related to other participants' activities in the system. The research goal in both pieces of research was to study emergent situated interactions and communication patterns with and through the devices, and the resulting repurposive appropriations.

### **The method**

The method – *in situ observation* – made use of a hidden observer who had real-time access to all the traffic in the communication channel. Two observers in the field used video cameras to record user behaviour and were supported by a third researcher, who monitored messaging at the server (Salovaara et al., 2006b). When a participant sent a message, the hidden observer notified the field researchers with a mobile text message. The observers in the field could then prepare themselves for videotaping the behaviour. Conveniently for this research method, typically mGroup's and CoMedia's messages arrived on the users' phones with a delay of several minutes, because of the low mobile data traffic bandwidth in the rural countryside. Delivery of a mobile text message was not hampered by such delays.

The *in situ* observation was complemented with qualitative content analysis and post-study interviews about messages. Interviews were useful especially in contextualising those message exchanges that had taken place when the two observer-researchers were not present (i.e., at night and in system use on the days before the rally event).

### **Repurposive appropriations**

There were 230 and 164 messages created and sent in the mGroup and CoMedia study, respectively. Analyses in both of the Papers (1 and 2) focused on repurposive appropriations mostly on the group level. With mGroup, the groups appropriated the media stories for co-ordination of activities, maintaining awareness of each other, and for constructing small-scale events of their own through messaging (e.g., a story listing group members' bets for the winner of the rally). The CoMedia study showed similar group-level repurposive appropriations: on-site reporting, keeping up to date on each other's undertakings, remote spectating, co-ordinating and making plans, reliving and knowing what others have done, and joking.

Figure 2.4 presents a sequence of message exchanges from which many features of the messaging context can be discerned. Although the sequence

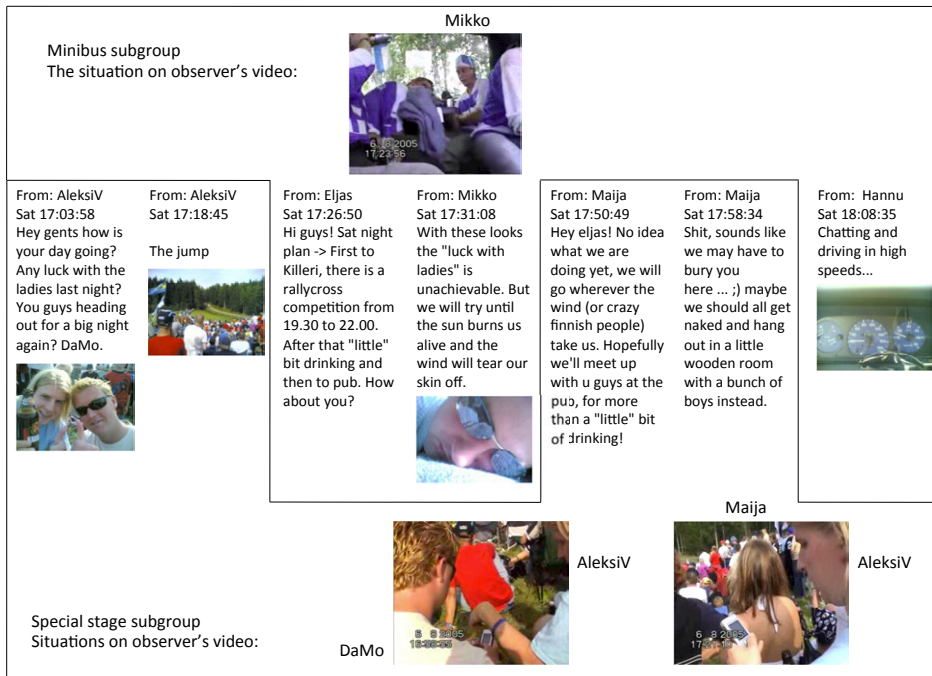


Figure 2.4: Two subgroups maintaining awareness of each other's actions in mGroup field experiments. The message stream is presented in the middle.

does not exemplify repurposive appropriation, it shows how the message creation is interleaved with other social activities at both ends (at a rally stage and on a minibus). It is assumed that the same situational features are present also in situations in which users appropriate.

Figure 2.4 shows that several situational features (e.g., a sleeping friend and the speedometer dials) could affect the way in which messages were composed and how the communication unfolded. Furthermore, the messages were created collectively, in joint agreement by the people co-present. Therefore, both the *social* and the *physical features* of the surroundings provided inspiration for messaging content.

In addition, in other messaging situations also *technological* features, such as video capture, could be sources of inspiration. The participants in the CoMedia study consisted of amateur rally drivers and mechanics. They explained that they could better appreciate the rally drivers' skills if they could not only see bits of the road but also hear the sounds of the engines in a video clip. The video capture and the participants' expertise in rally

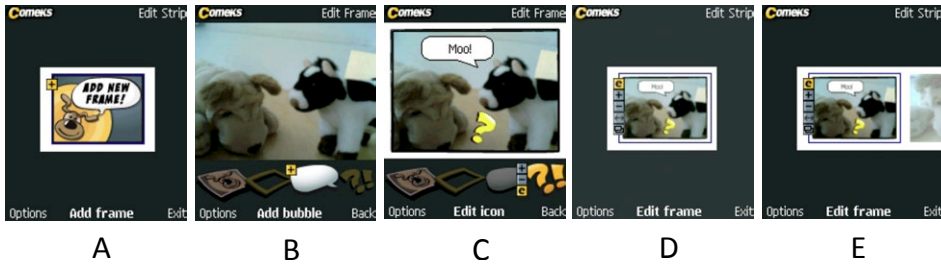


Figure 2.5: Screenshots of comic-strip creation using Comeks: start screen (A); screen after insertion of an image (B); what the user sees after having added a white border, a speech bubble, and an icon (C); and when the system is ready for another slide (D). When multiple frames have been created, they are shown in a sequence (E).

driving made video clips an efficient form of communication. The importance of different kinds of situational features is discussed at more length in Section 2.5, which summarises the findings of the empirical studies.

The benefit of *in situ* observation was in its ability to capture the physical context, the users' behaviour, and the social setting surrounding the piecewise visual content creation process. On the other hand, the method was resource-heavy, requiring continuous participation from three researchers and making it infeasible to observe those repurposive appropriations that developed slowly. Also, the observers had limited options for intervening and enquiring about the ongoing activities, because sometimes it was feared that doing so would interrupt participants' activities and hinder further actions related to repurposive appropriations.

### 2.3 Comic-style mobile messaging: Comeks

Comeks was a specialised multimedia message composer for mobile phones. Its idea was conceived by the author and was developed into a commercial product by Bulbon Ltd. Comeks could be used to create expressive, comic-style multimedia messages in a tailor-made Multimedia Messaging Service (MMS) editor. The design goals were to improve the possibilities for annotating images in an MMS message, creating stories, and making messaging more entertaining. The main screens of the Comeks user interface are presented in Figure 2.5.

## Method

Informed by research method experiences in the mGroup and CoMedia studies, the Comeks study was based on *periodic interviewing* instead of direct observation. The phones in the field experiment had ContextPhone logging software installed (Raento et al., 2005), providing unobtrusive logging of the phones' use and their near-real-time monitoring on the server side. At approximately three-week intervals, the messages of each user were collected together and one-to-one cued-recall interviews were held to discuss the messages. The goal with this periodical process was that interviews would take place when the memories of messaging situations were still fresh. In total, the eight participants were interviewed 24 times over the course of nine weeks. In that time, the participants sent 90 messages with Comeks. The interviews focused on (i) the situations in which the messages had been created, (ii) why a message had been created in such-and-such a way, (iii) why the message had these particular recipients, and (iv) (in the case of a received message) what the reactions to it and the subsequent actions had been.

## Repurposive appropriations

Repurposive appropriations of Comeks were studied by focusing on individual users and were observed on three levels: (i) increased mastery (i.e., appropriations of the application's features for more expressive message creation)<sup>1</sup>, (ii) replacement of existing communication channels with Comeks, and (iii) new communicative acts. Level ii corresponded mostly to workarounds, while level iii was closest to discoveries of novel activities.

In addition to generating data on the physical and social features of the message creation context (as in the mGroup and CoMedia studies), the Comeks study provided information about the use of individual technological features. Figure 2.6 presents workaround appropriations related to textual annotation techniques. When annotating images and adding speech bubbles, users often ran out of empty space in the frames because they did not want to occlude parts of the underlying images. During the first three weeks of the study, they discovered three workarounds to cope with this problem: using transparent bubbles, squeezing the images to make space on the sides, and complementing Comeks with a standard MMS editor. With

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<sup>1</sup>Increased mastery was classified as appropriation in the associated paper, but it is not in this thesis, where a stricter definition has been adopted (see Subsection 1.2.1). Therefore, the occurrences of increased mastery have not been included in the analysis in this chapter.

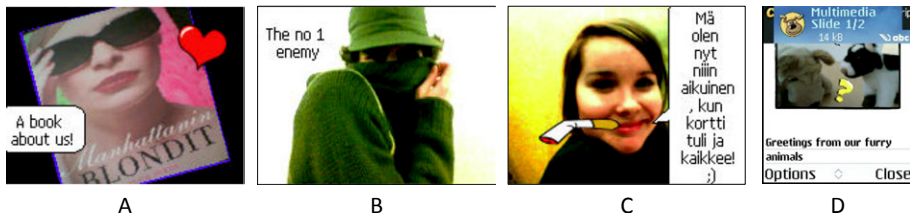


Figure 2.6: Comeks’s standard annotation feature (A) and three repurposive appropriations that enabled writing more text in the messages (B–D). Option D was based on a hack: use of a standard MMS editor’s text fields at the time of sending the message when the standard editor took control of the actions. Users discovered this extension without Comeks developers’ intention.

the aid of the data, the origins of these appropriations could be traced back to individual participants and messages that first featured these solutions. When participants learned the new techniques from each other’s messages, these techniques became part of their message composition processes as well and were used alongside the previously mastered techniques. A particularly rich way of combining these techniques is presented in Figure 2.7’s third comic strip.

In the study, repurposive appropriations resulted not only from novel uses of technological features (as exemplified above) but also from observations of features in the physical environment and social interactions that could serve as elements in messages. Examples of creative use of such situational features could be seen already in the mGroup study (e.g., the message chain in Figure 2.4), but this phenomenon was more evident in the Comeks study. The first two comic strips in Figure 2.7 show an early message exchange between two participants from the second week of the study. These messages provided inspiration for more messages later. The latter included an exchange of similar thematically related stories a few weeks later and four collaboratively created comic stories. These socially created messages led to a discovery of a novel social pastime and a topic about which both the participants involved and the recipients spoke recurrently in the interviews. The third story in Figure 2.7 is an example of these jointly created messages.

Compared to the mGroup and CoMedia studies’ *in situ* observation, periodic interviewing improved the possibilities for comparing the changes in an individual participant’s usage to those of the rest of the group. Also, the



Oskari to Eva, 23 Dec. 2005:



Eva to Oskari, 23 Dec. 2005:



Eva to all participants, 13 Jan. 2006:

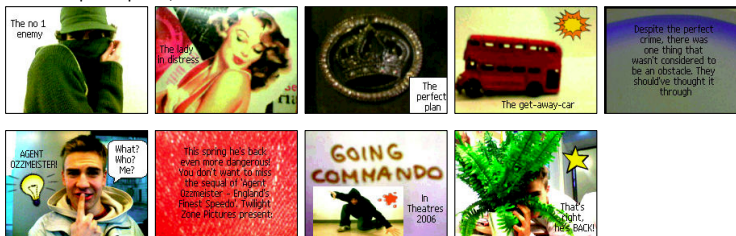


Figure 2.7: Messages between two participants in the Comeks study.

duration of the study could be extended, which rendered a greater variety of repurposive appropriations observable. On the other hand, periodic interviewing remained dependent on the system's overall success and popularity among the participant group. In addition, although interviewing improved the access to users' underlying reasons for repurposive appropriations, the data were collected after the fact. Participants' reports on their past actions are likely to feature retrospective generalisations and rationalisations as well as be based on false memories. The analysis could not therefore be brought to the level of cognitive processes and strong individual-oriented theoretical hypotheses. Naturally, the analysis of the message creation context too may contain errors, for the same reason. This problem, related to the deliberate decision to focus on realism in the research strategy, was discussed in Section 2.1.

However, the interview excerpts do make it possible to identify some of the primary *sources of influence* in the piecewise visual content creation<sup>2</sup> process. An analysis of influences was carried out as part of the study, although its results are not presented in Paper 3.

<sup>2</sup>For a definition of piecewise visual content creation, which served as the overall framing of activities studied in this thesis, see Subsection 1.2.2.

Table 2.2: Classification of sources of influence in piecewise visual content creation, based on an analysis of Comeks data, where the abbreviations in brackets are used in an interview excerpt later in this section

| <b>Code</b>                     | <b>Description</b>  |
|---------------------------------|---|
| Technological<br>(tech)         | Features of Comeks and the mobile phone that enabled or constrained possible message-creating actions. Examples of Comeks's features in Figure 2.6 are the space constraint in each message frame, the speech bubble feature, the image squeezing feature, and Comeks's use of the phone's standard MMS editor at the time of message delivery. Technological features constituted a heterogeneous set of properties, not always intentionally implemented, and could also be other physical or interaction-linked factors that became relevant for the participants in certain contexts and tasks.         |
| Suggestions<br>(sugg)           | Message composition ideas learned from other participants, either directly through their participation in the message creation process or indirectly from composition ideas in other participants' messages.  |
| Environmental<br>(env'l)        | Physical features <i>and the people</i> the participant considered to be material for a message or that/whom he or she had to attend to when planning or carrying out the message creation. Physical features included objects and the environment that could be used as image content or that changed the possibilities for taking pictures (e.g., lighting). In the case of people, the difference from suggestions (i.e., the previous item) is that here the other people were passive contributors who did not participate in the message creation in other ways than by acting as the user requested. |
| Working<br>content<br>(content) | Features of the unfinished content created within Comeks, including also images captured with the mobile phone's camera where there was an intention to use them in Comeks messages.  |
| Purpose                         | The intended final form of the message and its purpose (e.g., sending a piece of information to another person, performing artistic expression, spending time together by composing a message, or combining these). In the excerpt presented below, the portions tagged with 'purpose' refer to the development of an idea of a film trailer comic strip.   |
| Plan                            | The steps considered for production of the desired content.   |

The analysis was based on interview excerpts and message content, proceeded in a bottom-up fashion, and was informed by grounded theory (GT) methodology (Glaser and Strauss, 1967). A rigorous GT analysis applies a *constant comparative method* by which tentative theoretical hypotheses are repeatedly refined via gathering of further data. These data are deliberately sampled for critical evaluation of the present hypotheses. As the analysis progresses, the coding of the content proceeds to increasingly sophisticated levels (open, axial, selective, and theoretical coding; see Strauss and Corbin, 1990) as the theoretical hypotheses get stronger. Rigorously applied GT interleaves the data collection and the analysis. This strengthens theory development because then the new data are better suited to the evaluation of existing hypotheses.

In the present study, GT's different levels of coding were not strictly followed, because the task had already been set as classification of the message creation process's sources of influence. Also, the nine-week trial period had already elapsed, so data collection could not be interleaved with analysis. However, the constant comparative method was used in the development of such codes for the sources of influence as would be applicable to all message creation situations that the participants had described in the interviews.

The following results emerged from the analysis. From the user, piecewise visual content creation required sometimes complex deliberation between the message composition plan and the various sources of influence, which included the opportunities afforded by Comeks, the physical and social environment that could be used as a resource for photographs, the ideas learned from the other participants, and the content of the unfinished message. The participants appeared to attempt to match these sources of influence against their ongoing message creation plan. The opposite was also seen; the technological, physical, and social influences affected the message creation plan. The classification of different sources of influence is presented in Table 2.2, and its use is illustrated by presentation of how the creator of Figure 2.7's third strip (Eva) describes the strip's creation to the researcher (R) in the following, previously unpublished interview excerpt. The sources of influence and the points at which she describes her overall composition plan are indicated with codes along the side in the excerpt.<sup>3</sup>

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<sup>3</sup>For the sake of clarity, the tag 'tech' has been omitted from places that would indicate Comeks's camera feature (e.g., 'I'd take some photos'). Without this omission, the code would appear so frequently in the excerpt that it would compromise the readability of the other codes and the places to which they are referring.

- R: At what stage did you get an idea for this? I mean, it probably took many days for you to create this.
- env'l Eva: It started with a chat with Oskari. Then he said that this thing we were talking about was stupid because I was such a bore, and then I grabbed that flower [see the last frame of the third message in Fig. 2.7] in my hand and in front of his face, although he was still talking to me. That was kind of a joke. That was when we were creating that sneezing message [see second message in Fig. 2.7] together. So I put that flower there and said ‘don’t disturb me’. Then, I think, Oskari said: ‘Hey hey, I still have something to say.’ I was like: ‘Yeah, yeah, make that kind of a secret spy look’ [...].
- purpose R: When you said that, did you already have an idea of wanting to create that kind of long comic?
- plan Eva: First I just thought that I’d take some photos of those situations [...]. That Oskari is a kind of secret agent but in fact a more comical kind of agent. [...]
- env'l, purpose R: Then you propped up some situations?
- plan Eva: Yeah, a bit, but this one’s the only one that made it to the final one. Then I wanted to take some shots related to Asif. I wanted to have that scarf just like that. That became mega-good, that shot. Then I thought: ‘This’s going to be the bad guy!’ [...]. Then I took a photo of a bus; that’s my keychain [...]. I did not plan what to do with it back then [...]. Then a bit later I thought, any kind of a story is fine, and that there has to be a woman. It’s from my bag, this photo of the lady.  
[...]
- env'l, content purpose Then I was in a Swedish class, and I wrote– it was green, that pen– I wrote on the back of some shop receipt that going commando text. And then I changed it a bit, swapped the colours, so that it became red, that text. And at the previous break I had taken a shot of Oskari when I had said: ‘Try to look like a ninja.’
- env'l, purpose [...]
- R: Then there’s still this buckle.

|         |      |   |
|---------|------|---|
| env'l   | Eva: | Yes, it is from this <u>bag</u> . So I had all of these ready, and I think I went to do some shopping downtown, and that one's from Forum's H&M. When you enter, there's a <u>blue lamp</u> in the ceiling. This one was blue, so I took it there.  |
| env'l   |      | [...]   |
| content |      | <u>First I just took the photos</u> [...]. Then I went to another shop, JC, and there was a <u>special-bargain note</u> , and this one was red there. <u>I made it even a bit brighter red</u> [...]. But also these ones, I first, I just <u>tried to find some single-colour</u> , like not-many-colours, photo.  |
| env'l   |      |   |
| tech    |      |   |
| plan    |      |   |
|         |      | ...   |
| purpose |      | That <u>twilight-zone pictures</u> idea came when I chatted with one friend over the Net. I told her about my day [probably asking for suggestion for the strip], and then she replied. The idea totally reached out like [a creature] from a drain, unrelated to everything, and <u>she wrote 'twilight zone'</u> . And then I was like 'Ahh, sounds good!'. |
| sugg    |      |   |

The excerpt shows how content creation was shaped by the user's plan for the message composition; by the state of the unfinished message; and by her attention to the technological, social, and environmental features. These features provided opportunities for, and constraints to, the plan's completion.

The excerpt may appear to be weak on examples of repurposive appropriation. However, both the environment and the technological features were appropriated for new purposes in this process. Also, two repurposive appropriations of technological features took place during this message creation. Eva's description reveals that she collected the photographs first in the phone's image gallery, from which she transferred them to Comeks for final message composition. For Eva, this was the first time using the phone's image gallery with Comeks. Previously, she had always shot the images by using Comeks's inbuilt camera functionality, which offers fewer possibilities for gathering image material for message creation. Another sign of repurposive appropriation was that this message involved extensive use of different speech bubble styles to make suitable space for text.

According to the analysis, a finished message was a result of an *adaptation* to the possibilities and constraints in the environment and the technological features. The findings are consistent with, and specify further, those on the piecewise visual content creation process in the mGroup and CoMedia studies. The converging evidence from the three studies (Papers 1, 2, and 3) points toward a hypothesis that the technological, social,

environmental, and content-specific features listed in Table 2.2 play an important role in all piecewise visual content creation. This hypothesis will be expanded upon in Subsection 2.5.1.

## 2.4 Everyday use of digital cameras

The results from the previous studies were focused on the immediate context of repurposive appropriation but did not inform about its antecedent factors in a systematic way. The *Web-based survey* study of digital camera uses (Paper 6,  $n = 2,379$ ) was carried out to address this issue. Instead of remaining within the research strategy that seeks only to maximise realism, the study in question focused on complementing the findings with generalisable results (see Section 2.1).

The Web-based survey searched for factors that would explain the differences between digital camera users' repurposive appropriation levels. With this goal, it resembled von Hippel's (2005) surveys that investigated predictive factors of lead-user innovations. The foci, however, were different here: von Hippel measured, for example, modifications to original equipment in different sports communities and identified lead users on the basis of differences in respondents' community involvement. The present study, in contrast, addressed new uses that did not require modifications, and the predictors were tied to individual users' differences in technology usage.

In the study presented in Paper 6, factors belonged to three groups of variables: *demographic background*, *level of experience*, and *orientation to photography*. Demographic background variables consisted of factors not related to photography: the respondent's gender, age, education level, and income, as well as whether the respondent had pets, children, and/or grandchildren. Experience factors consisted of general-level photography-related factors: use tenures and frequencies for film, digital, and phone cameras, as well as whether camera use was or had been part of the respondent's work, hobbies, or studies. Orientations consisted of eight factors that described the respondent as a camera user. On the basis of a factor analysis, the number of factors was decreased to six in the final analysis: self-reflexivity, use reflexivity, spontaneity, exploration, technology cognizance, and consultancy (i.e., social use). The definitions of these are provided in Table 2.4. Together, these three groups of variables served as predictors in regression and other types of analyses of the data.

Two measures of appropriation were used as dependent variables in the analysis: (i) the level of *personal discovery*, which denoted the respondent's

Table 2.4: Six digital camera usage orientations measured in Paper 6

| <b>Orientation</b>    | <b>Description</b>   |
|-----------------------|--|
| Self-reflexivity      | Increased sense of self-criticism with respect to photography and camera use skills.   |
| Use reflexivity       | Reflection on the success of one's photos, immediately after shooting or afterward.  |
| Spontaneity           | Taking photos spontaneously in a spurt of action, without always thinking before acting.   |
| Exploration           | Exploration of new manners and directions of photography.  |
| Technology cognizance | Having an accurate understanding of how a digital camera works and how its features can be combined with other technologies and tools. |
| Consultancy           | Learning new ways of use from others through teaching, observation, or exchange of ideas.  |

own role versus the social basis of discovery, ranging from discoveries completely on one's own to mimicry of others, and (ii) the extent of *adoption* of the creative use, which ranged from no further use at all to habitual continuous application of the novel use at a later time. Values for both were calculated from respondents' answers to questions pertaining to discoveries and long-term uses of eight workaround-like digital camera appropriations: mirror, map, note-taking tool, scanner, memory/storage, lamp, instruction tool, and periscope. Their descriptions are provided in Table 2.5.

The level of personal discovery was calculated on the basis of the levels of contribution that the respondents had had in the discoveries of the eight workarounds, ranging from no contribution (e.g., the respondent had been instructed to use her digital camera as a scanner) to full contribution (e.g., the respondent had discovered the use as a scanner all by herself without other people's presence). The overall personal discovery level was obtained by taking an average of the eight workaround-specific personal discovery levels. However, because not all respondents had employed all eight workarounds and some did not remember the situations in which they had learnt these uses, the average was taken only from those workarounds of which the respondent had a memory. Details of the operationalisation and data collection are provided in Paper 6.

Compared to the operationalisation of personal discovery, calculation of the level of adoption was considerably simpler, since all respondents could

Table 2.5: Eight digital camera workarounds studied in Paper 6

| <b>Workaround</b>  | <b>Description</b>   |
|--------------------|--|
| Mirror             | Pointing the camera toward oneself – to see how one’s face looks, for example.                         |
| Map                | Taking a photo of a map and using that photo in place of a paper map.                                  |
| Note-taking device | Using the camera for taking notes when the content is highly visual (e.g., when shopping for clothes). |
| Scanner            | Capturing printouts and text as images with a camera.  |
| Memory/storage     | Plugging the camera into a computer for use similar to that of a USB memory stick.                     |
| Lamp               | Exploiting the camera as a light source.   |
| Instruction device | Using a sequence of photos to provide step-by-step instructions.                                       |
| Periscope          | Inspecting places that are otherwise inaccessible to human vision but where a camera can enter.        |

indicate whether they were frequently using each of the eight workarounds. Also in this case, the overall level of adoption was obtained by taking an average of the workaround-specific values.

To summarise, in the regression analyses, three groups of variables (demographic background, level of experience, and orientation to photography) were used to predict two measures of appropriation (discovery of a novel use and its long-term adoption). The purpose of the study was to compare the predictive variables in the three groups against each other in order to identify those that are important for repurposive appropriation. The next subsection presents the results of these analyses and three other research questions addressed in the study.

### **Frequency of repurposive appropriation and its antecedent factors**

In all, five research questions (RQs) were pursued, with the following findings emerging:

RQ1 *How common are repurposive appropriations?* On average, 48% of the respondents had employed each workaround once or more often.



Table 2.6: Operationalisation of the technology cognizance construct (Cronbach's  $\alpha = .85$ ) in the Web-based digital camera survey

| Description   | Likert statement   |
|---|--|
| Comprehensive studying of features                    | I have acquainted myself with, more or less, every feature of my camera(s).  |
| Understanding of cause and effect                     | I know how to adjust the settings of a camera such that the photos are usually of good quality.                                      |
| Awareness of the good and bad sides of the device     | I know the most important technological strengths and weaknesses of my camera(s).  |
| Formats   | I know which storage formats to use in response to different needs for image quality and file size.                                  |
| Data transfer between devices                         | I transfer images between different devices (computers, cameras, and other storage devices) frequently.                              |
| Use of photos in conjunction with other digital media | I use the photos that I have taken embedded in other media (with text, in presentations, via graphics programs, on Web pages, etc.). |
| Command of other electronic devices                   | I am used to using and taking up different electronic devices.   |

RQ2 *How frequently are the repurposive appropriations learned individually?* The study suggests that most users can be classified as either people who learn all of the repurposive appropriations socially from others or users who discover them independently, without any help from others. Personal discovery of a repurposive appropriation was slightly more common than learning it from others (20.3% vs. 16.0%). The other respondents either did not remember how the discoveries had been made, had never made these discoveries, or the circumstances of the discovery were unclassifiable.

RQ3 *Which individual characteristics predict personal discovery?* This question was answered by means of logistic regression analysis. Demographics, photography-related orientations, and experience together reached a Nagelkerke's pseudo- $R^2$  of .21 for predicting an individual user's personal discovery. The orientations were found to be more predictive than the experience-related factors. Technology cognizance (see its operationalisation in Table 2.6) was the single most important predictor, having the same importance as all of the experience-

related factors put together. The minimal set of characteristics having a predictive fit not statistically different from the best possible model consisted of technology cognizance, gender (male), exploration-orientation, use frequency for digital cameras, use tenure for digital cameras, and income, in decreasing order of importance.

- RQ4 *Which individual characteristics predict long-term adoption of a repurposive appropriation?* A sequential linear regression model explained 34% of the variance in adoption. The orientation and experience groups proved equally important, with  $R^2$  change = .20 and  $R^2$  change = .18, respectively. Here, use frequency for phone cameras, orientation to technology cognizance, exploration-orientation, gender, and use tenure for digital cameras were the variables with the best prediction, again from greatest to least influence. This five-variable model's adjusted  $R^2$  was .32.
- RQ5 *Which type of discovery predicts adoption to long-term use?* Personal discovery had a small but positive effect (average Kendall's  $\tau$  correlation: .28) on a creative use becoming part of the user's permanent use practice.

Therefore, given the answers to RQ3 and RQ4, the study indicated that technology cognizance may be the single most important factor in both the discovery and the adoption of creative uses. This thesis makes an assumption that if respondents report that they have invested effort in learning the functions of the technology, they have probably acquired a different understanding of the technology (i.e., technology cognizance) than the other respondents have. This would imply that their mental representations of the technology are different. Drawing conclusions about users' mental representations on the basis of their retrospective accounts is problematic, however. This will be examined further in the summary of all the empirical findings (Section 2.5).

### **Situations and processes of workaround appropriations**

The Web-based survey study did not merely generate quantitative data, however. The pilot studies ( $n = 33$  and  $25$ ) preceding the final study included two open-ended questions about situations and discovery processes of repurposive appropriations. The participants provided 110 free-form descriptions of their inventions of seven uncommon uses (the eighth use in the final study – the periscope – was added after the pilots). Providing

answers in these fields was optional. These open-ended questions were not present in the final study, because asking respondents to answer them could have proved too laborious. It was feared that many participants would have lost interest in completing the questionnaire or would have provided only very general answers had the open-ended questions been asked.

A qualitative content analysis (Silverman, 1993) of the contents carried out by the author suggests several situational factors that can initiate a repurposive appropriation process leading to discoveries of workarounds. Table 2.7 shows these results. The ‘immediate need’ category was much more heavily populated than the others, suggesting that, at least with respect to digital cameras, most workaround-like appropriations are discovered in the actual situations wherein the solutions are needed. While the other categories feature fewer examples, they are still important, because they hint about a qualitatively different, more serendipitous discovery mechanism. Accordingly, the situations that stimulate the workaround appropriation described in Table 2.7 can be grouped into the following two larger categories:

**Bridging:** The user notices a technological feature that presents a path from the current situation to the goal state. In the data, often the paths were very short, so the effectiveness could be immediately appreciated. The repurposive appropriations belonging to ‘immediate needs’ and ‘dormant needs’ were mostly bridgings.

**Abduction:** The user notices that interaction with a technology produces an outcome or a side effect that is suitable for solving an unexpected problem<sup>4</sup>. In the data, these were problems that had never faced the user before. Repurposive appropriations resulting from abductive reasoning could be found in the categories ‘playful exploration’, ‘cued by design,’ and ‘accidental discovery’.

Importantly, both methods – bridging and abduction – are examples of *mapping*. Mapping refers to a situation in which a person finds a solution

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<sup>4</sup>In formal logic, abduction is an inference of the type ‘if  $p \Rightarrow q$  and  $q$  is true, then  $p$  is also true’. This kind of reasoning is formally invalid, because it does not take into account the possibility that  $q$  may hold for other reasons than  $p$ . Therefore, abduction resembles guessing and hypothesis-building. It holds a central role especially in Peircean pragmatism, in which it is used to describe the process of idea generation (Peirce, 1902, paragraphs 188–189; Paavola, 2006). In this thesis, the term is used *atheoretically*, without a theoretical commitment to Peirce’s writings or pragmatism. Rather, here it denotes a situation in which the user, after observing an outcome, comes to imagine a problem that this outcome would be able to solve.

Table 2.7: Situations that give rise to workaround appropriations

| <b>Reason</b>        | <b>Freq.</b> | <b>Example situation (what the situation was / how the discovery was made)</b>   |
|----------------------|--------------|--|
| Immediate need       | 62           | ‘I was shopping and was thinking at the same time about what to cook for dinner. There was a cookbook for sale in the shop. I looked up a nice-looking (and simple) dish, and, because I didn’t want to buy that book, I took a picture of the recipe. Then I went around the shop, picking up the ingredients with the picture as my guide, and cooked the food at home.’ / ‘First, I felt bad because I hadn’t taken a pen with me, but then I remembered that my new phone had a camera and I decided to try it.’ (Use as a note-taking tool) |
| Dormant need         | 2            | ‘I think it was in Antwerp and we had to find our way back to the car, and I happened to notice a stand with a map of the city.’ / ‘This just came to mind as it also had happened that we had forgotten the map in our car.’ (Use as a map)   |
| Playful exploration  | 6            | ‘Drowsy on a Saturday afternoon’ / ‘I played with my wife’s new phone; I set my grinning face as its background image.’ (Use as a mirror)  |
| Cued by design       | 2            | ‘The Sony Ericsson k700i has a small mirror right under the lens, so I tried it right away when I played with the phone the first time.’ (Use as a mirror; no description of the situation was provided)   |
| Accidental discovery | 2            | ‘With a clamshell phone, it is irritatingly simple to make a phone take a photo of you and see it on the front display.’ / ‘I discovered this use because this happens accidentally every week or even more often.’ (Use as a mirror)  |
| Social learning      | 4            | ‘I was shopping for new eyeglasses.’ / ‘My sister suggested doing that.’ (Use as a mirror)   |
| Unclassifiable       | 30           | –  |

to a problem by recognising a pattern in the problem-solving situation that fits a pattern in another, relevant piece of knowledge. This definition will be refined further in the next chapter. Mapping helps the user discover

the solution by finding a novel way of using technology for a present or hypothetical problem (bridging and abduction, respectively).

These hypotheses are not without their problems, however. Here, the thesis makes an assumption about users' mental representations and cognitive processes on the basis of retrospective self-report data. This leads to the same validity-related limitations as in the Comeks study. As such, respondents' retrospective accounts of their repurposive appropriation processes are unreliable sources of information on users' cognitive processes. In addition, although technology cognizance had the greatest predictive fit with repurposive appropriation (RQ3) in the Web-based survey, it does not necessarily follow that the actively appropriating people had really acquired a better understanding of technology than the average users had. Both of these conclusions require further empirical research. The theory that follows is based on the assumption that these hypotheses hold and will not be refuted altogether later.

Table 2.7 also lists a 'social learning' category. However, since the focus of this thesis is on individual users' repurposive appropriation processes and also the data have been gathered with that purpose, this category will not be analysed further.

## 2.5 Implications for theory

Although the empirical works presented in this section were originally carried out as separate self-contained studies, our analysis has pointed toward three common implications. First, the field experiments with mGroup, Co-Media, and Comeks presented how the features of the technology and the environment affected the piecewise visual content creation processes. This observation applied to all message creation situations generally. Therefore, repurposive appropriation, as a special case of such content creation processes, is affected by the same technological and environmental features. Second, the Web-based survey provided hypotheses on antecedent factors of repurposive appropriation and identified technology cognizance as the factor with the greatest significance in prediction. Third, the pilot studies for the Web-based survey provided data on situational needs that give impetus to repurposive appropriation. When the needs were grouped together, they pointed to two qualitatively different repurposive appropriation processes (bridging and abduction).

These implications are dealt with in the following sections.

### 2.5.1 Repurposive appropriation requires adaptation to the situational features

All of the empirical studies pointed out that the creation of a piece of multimedia content (a message or a photograph) is affected both by the visual material in the surroundings and by the features of the technology. This can be modelled as follows. In piecewise visual content creation, the user develops and maintains a plan for composing a piece of content, using the environment and the features of the technology as resources. This plan may need adaptation during the process, including also changes in the purpose of the final content. The user adapts the plan on the basis of his or her evaluation of the progress, suggestions provided by others, and his or her observations of the environment.

For instance, during the process in which Eva created the film trailer story (see Figure 2.7), she noticed that a picture of her friend hiding behind a scarf made him look like a villain. This observation sparked a change in her plan for the message's narrative and led to further explorations and adaptations of the plan. Similarly, in the example of playful exploration with a digital camera that led to a repurposive appropriation (see Table 2.7), the respondent discovered the new use for a camera after initially having in mind a plan to create a funny picture of himself. However, the result – a grinning face – led him to think of using the camera as a mirror. Here the original form for the content (an amusing image) was transformed into a utility-oriented format, on the basis of interaction with the features and from appreciation for the resulting image in the process.

Content creation therefore requires *adaptation* to the situation and attention to its content creation opportunities. The elements of this process are illustrated in Figure 2.8's situated content creation process. It is reasonable to assume that repurposive appropriations that arise within piecewise visual content creation will also follow the mechanisms of the situated content creation process. The *situational features* that affect the process have been given focus already in this section (e.g., in the classification of Table 2.2). Found in the above-mentioned figure's bottom row, they are of four types:

**Working content:** The piece of content that the user is creating in the piecewise visual content creation task. Working content is typically incomplete, and this incompleteness is an important source of problems that the user sets out to solve before being able to consider the piece of content finished. Examples of working content in this chap-

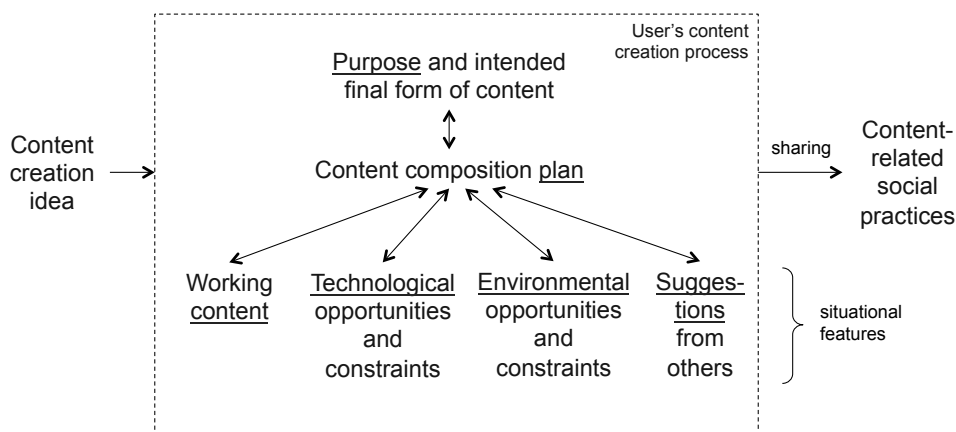


Figure 2.8: Situated content creation process. The underlined words denote the related codes in Table 2.2.

ter's studies are mobile multimedia messages, mobile comic strips, and photos taken with a digital camera.

**Technological features:** Features that the user interacts with in order to manipulate the working content. The technological features provide both opportunities and constraints to the user with respect to the content creation goal.

**Environmental features:** Features to do with the background of the activity, including physical and digital properties that also provide opportunities and constraints affecting action for the use. Under the classification in Table 2.2, these features also include other people, if they only act as props and do not actively suggest changes to the purpose or the composition of the piece of content. Environmental features are usually at the periphery of the user's attention unless a problem emerges and the user starts to search for a solution, or a serendipitous observation brings them to the focus of attention.

**Suggestions from others:** Actively expressed influences on the content or its purpose, originating from other people.

These features and the situated content creation model will be used as the foundation for a model of the repurposive appropriation process in the next chapter.

### 2.5.2 Two kinds of mappings underlie repurposive appropriations

Section 2.4 introduced two processes – bridging and abductive reasoning – by which repurposive appropriations may be discovered. Bridging refers to finding a match between the features of the current situation and the surrounding resources, which aids in solving a problem or at least coming closer to completion of a solution. Abduction, on the other hand, is triggered by paying attention to something different from the ordinary. Both processes are examples of mapping, which is one of the key concepts in the psychology of problem-solving.

### 2.5.3 Repurposive appropriation depends on existing knowledge

The third major finding from the empirical studies has to do with the important role that users' understanding of the technology appears to play in repurposive appropriation. The study of digital camera use (see Section 2.4 and Paper 6) suggests that technology cognizance is the most important factor explaining both the discovery and the adoption of creative uses. The technology cognizance construct was composed of practices of studying the features of the camera comprehensively, awareness of the connectivity of the camera to other digital services and systems, and understanding of the effects that different shooting settings have on the resulting image (see Table 2.6 and Salovaara et al., 2011a, p. 2362).

## 2.6 Reliability and validity

The findings presented above stemmed from *in situ* observations of novel communication technology use as well as self-report data from a Web-based survey. In the absence of existing theory on individual users' repurposive appropriations, the research strategy (see Section 2.1) was to explore the phenomenon from multiple angles, deliberately accepting the fact that some parts of the resulting hypotheses do not have extensive empirical grounding. The threats to reliability and validity are presented below.

### 2.6.1 Field experiments

The studies involving mGroup, CoMedia, and Comeks were planned so as to maximise realism, with possible compromise between precision and generalisability. As for validity, the qualitative methods that were applied –



technology interventions using *in situ* observation and periodic interviewing – support good ecological validity and are suitable for this strategy, provided that the duration of the studies is long enough. An extended duration increases the likelihood of observing normal user behaviour instead of only experiences of first-day excitement. This requirement was met better as the work progressed from one study to the next: from four days (mGroup) to 10 days, of which the last four were actively studied (CoMedia), to, finally, nine weeks (Comeks).

With respect to reliability, researcher involvement always influences the participants, especially when observation-based methods are applied (i.e., field experiments in HCI are easily subject to the Hawthorne effect; see Adair, 1984 and also Brown et al., 2011). Also, participants may deviate from the truth in their answers, not always deliberately so much as on account of poor recall and unawareness of their cognitive processes (cf. Nisbett and Wilson, 1977). Much in these threats is dependent on the habitus of the researcher as well as the extent to which he or she has treated the participants with appreciation, winning their trust. In addition, participants in technology intervention studies are likely to feel obliged to use the technology in question, for the sake of social desirability and politeness to the researcher, thus causing higher-than-natural usage statistics. The same applies to assessments of the quality of the technology.

In the studies of mGroup, CoMedia, and Comeks, it is indeed possible that the participants used the systems more actively than would be normal and behaved in a contrived manner in order to present themselves in a good light. However, the goal of the studies was not to evaluate systems' acceptance and the associated user satisfaction but to learn about emerging repurposive appropriations. This goal was never revealed to the participants before the concluding interview. The focus on an aspect of use other than acceptance increased the reliability of the studies, because the participants were not aware of the true expectations of the researchers. It is, however, possible that, because the participants were unable to invent any uses for the systems, they tried them for multiple purposes only to prove to researchers that they had at least done something with the systems. Thus more repurposive appropriations may have emerged than would have been natural. However, there were no signs pointing to this occurring in the studies.

The main outcome from the three studies was the model of situated content creation (Figure 2.8). It is unlikely that the researcher's presence or the short experiment durations would have biased this model, made it incomplete, or populated it with the wrong elements.

## 2.6.2 The Web-based survey

The Web-based survey study of digital cameras had a different set of threats to validity and reliability. In Web-based surveys, problems with validity arise in relation to the limitations of the data collection: the topic of interest must be verbalisable and often formulated in easy-to-answer questions. Therefore, Web-based surveys are rarely suitable for studying temporal events, for example, or anything to do with physical action in any great detail. The questions presented in surveys are frequently based on a research model wherein there is an intention to investigate relationships between individual variables. If the model is causal and contains independent and dependent variables (as was the case with Paper 6), the causality is, in fact, only a theoretical assumption; the data in isolation will be only correlational. In this case, the validity depends on the validity of the model.

In the Web-based survey considered here, the research questions were chosen so as to be verbalised and presented as forced-choice questions and statements. The questions' validity was improved through two pilot studies and collection of peer critique from colleagues. However, explicit means for ensuring the validity of the Web survey overall (e.g., methodological triangulation; see Fielding and Fielding, 1986) were not employed. The validity of individual theoretical constructs within the context of the questionnaire was improved by means of exploratory factor analysis with attention to the loadings.

As for reliability, Web-based surveys suffer from their reliance on retrospective self-report data whereas concurrently collected data would be more reliable. There is always (see Czaja and Blair, 2005) a possibility that the users (i) may not (or cannot) report what they really think, or are. They (ii) may also answer by using idealisations, generalisations, or abstractions, and they (iii) may provide false answers because of weak memories (Nisbett and Wilson, 1977). All this may take place without an explicit intention of being untruthful. Threat iii was addressed through asking the respondents to report also how well they felt they remembered the moments when they had discovered the purpose of use in question (see the tree-structured questionnaire design in Paper 6, p. 2352).

Threats i and ii remain, however. The first was not addressed explicitly in the study; this would have required methodological triangulation, which, as stated above, was not part of the study's design. With respect to threat ii, it may be that in the course of filling in the survey's first four pages, the respondents constructed a self-image of themselves as photographers. This could have affected respondents' answers to Likert items on the questionnaire's fifth page that addressed possible antecedent factors of repurposive

appropriation. Active photographers may have presented themselves as more proficient than they really are. However, *post hoc* tests of differences in self-reported expertise (with levels of expertise ranging from novice to professional, in four steps) revealed differences in neither discovery (RQ3) nor adoption (RQ4) of workarounds (Paper 6). Therefore, while the threat remains, the most straightforward analyses showed no signs of error.

Statistical analyses present their own threats to reliability, mostly related to tests that are unsuitable for the data. Paper 6 applied non-parametric ordinal regression and variable dichotomisation in order to mitigate the U-shaped distribution of answers for the personal discovery variable. The statements related to independent variables, in turn, were iterated over two pilot studies. In the analysis, the data were explored via factor analyses and grouped within new constructs in cases in which Cronbach's alphas did not yield acceptable levels and when the grouping was theoretically motivated.

Finally, as mentioned above, the Web-based survey method brings its own threats to reliability. One is a badly constructed sampling frame that prevents true generalisability of the findings to the whole population. Paper 6 justified the lack of a proper sampling frame with the fact that digital cameras are an everyday technology for which the sampling frame would cover the entire population of Finland. Probability sampling from such a frame was impossible. The problems arising from self-selection convenience sampling were compensated for by use of a large number of participants ( $n = 2,379$ ), which made it possible to perform analyses also of subsets of data, this way addressing some of the threats in the post-study analysis stage. Another Web-based-survey-specific threat is low respondent commitment: respondents quickly lose interest in an Internet survey. With our Web-based survey, this was countered with a prize draw for 15 gift cards (worth 20 EUR each) from among the respondents who filled in the entire questionnaire. The breakoff rate was 22%. There was no method of assessing how the results would have changed had all respondents filled in the questionnaire completely.

### 2.6.3 Implications of the studies

The implications presented in Section 2.5 can also be analysed for their validity and reliability. For example, they can be too far-reaching, biased, or invalid in some other ways. With respect to the model for piecewise visual content creation (Subsection 2.5.1), a claim was made that repurposive appropriation would be bounded by the same factors as other content

creation situations. It is possible that this claim may not hold. The possibility can only be addressed by subjecting the model to evaluation with new empirical data in future research.

Subsection 2.5.2 suggests that discoveries of repurposive appropriations will typically be prompted through two distinct kinds of cognitive processes, both of which can be seen as mapping. This hypothesis receives support from psychological literature in the following chapter. However, confirmatory theoretical evidence does not satisfy the requirements of rigorous evaluation; that would necessitate comparison of the hypothesis with competing theories, followed by an empirical evaluation. Such an evaluation will not be provided in this thesis. Therefore, also this theoretical step from data to theory will require future research.

In addition, while the studies presented here have led to a hypothesis about mapping-based repurposive appropriations, that does not prove that other cognitive processes leading to repurposive appropriations could not exist. Further empirical research is needed for identification of additional processes. However, exclusiveness of these two processes (i.e., their being the only ones resulting in repurposive appropriations) was not actually suggested in Subsection 2.5.2.

In Subsection 2.5.3, we claim that repurposive appropriation is dependent on the user's existing knowledge, and the more effort or time the user has devoted to learning how the technology operates and can be used in combination with other technologies, the more likely it is that the user appropriates. This claim is based on the finding that technology cognizance was the most important predicting variable for discovery of novel digital camera uses. This claim, however, may not be valid with all technologies, or the relation may not be as straightforward as the claim assumes.

Finally, the statistical support for technology cognizance's overall importance was rather tentative. The pseudo- $R^2$  value for the research model's predictive capacity for the personal discovery variable was rather low (.21). Removing technology cognizance from the set of predictors reduced the pseudo- $R^2$  by only .03, to .18. However, this decline was larger than what resulted from removal of all variables of use tenure (measured in years) and use frequency of different camera types (six variables in total). Therefore, while the hypothesis of the importance of technology cognizance is tentative and it appears that many additional factors remain to be uncovered, it is nonetheless a stronger component than any other factors studied. This thesis takes a deliberate risk here by adopting the assumption that technology cognizance plays a significant role in repurposive appropriation.

The purpose of this thesis is to develop starting points for a cognitive theory of repurposive appropriation. Given this exploratory goal, the threats to validity are not as critical as they would be in theory-testing, for example. In this case, the coherence of the theoretically oriented hypotheses and their compatibility with empirical findings are the central criteria for validity. The next chapter shows how the findings from all of the empirical studies when considered together can be integrated into coherent theoretical hypotheses addressing cognitive processes of repurposive appropriation.



## Chapter 3

# Cognition in repurposive appropriation

This chapter takes the previous section's theoretical implications as a starting point for exploration of a cognitive theory of repurposive appropriation. The chapter starts by presenting a model for repurposive appropriation and substantiates it with knowledge from relevant fields in psychology and cognitive science. These elaborations are summarised at the end of the chapter as starting points for a theory of repurposive appropriation. In contrast to the previous chapter, which was based on data from empirical case studies (Papers 1, 2, 3, and 6), this chapter draws from existing literature. The goal is to work toward a theory for individual repurposive appropriation. Because the material for the theory development in this part of the work is not empirical in nature, no empirical evaluation of the theory will be presented either. However, Section 3.5 provides suggestions for such research designs.

Figure 3.1 presents a model that is directly based on the situated piecewise visual content creation model of the previous chapter (i.e., Figure 2.8). There are two differences between the previous chapter's model and the present one. First, the class '*suggestions from others*' has been omitted from the situational features. While the previous model described the situational influences of piecewise visual content creation generally, the model shown here has to do with repurposive appropriation by an individual user. As defined in Table 2.2, suggestions denote recommendations made by others regarding the purpose or composition of the content. Therefore, because this thesis focuses on the discoveries of an individual, solutions provided by other people through suggestions will be omitted. However, in a parallel with Table 2.2, the influences from other people, as long as they are not

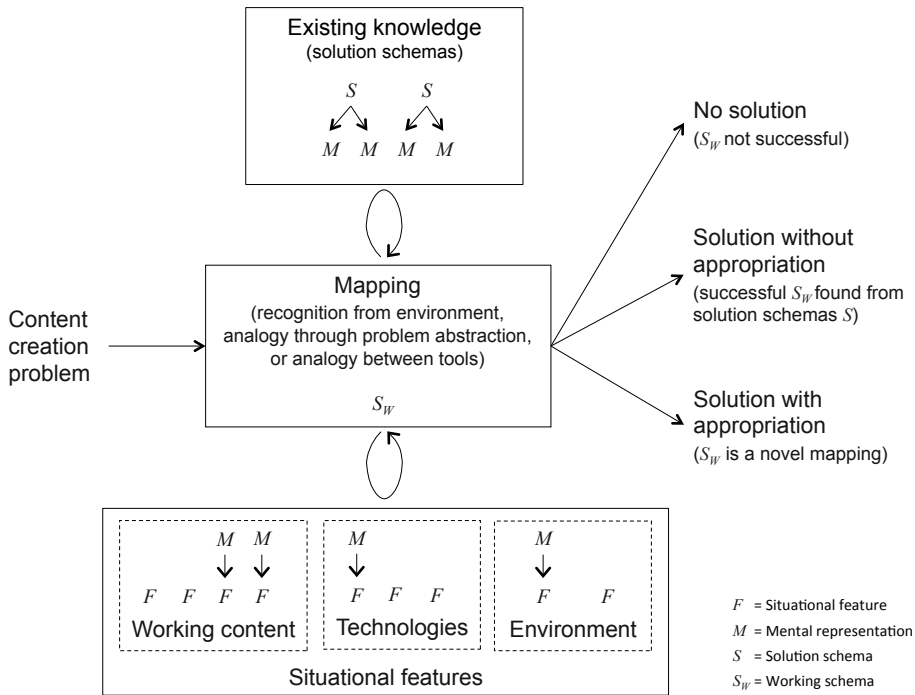


Figure 3.1: The cognitive process of repurposive appropriation in piecewise visual content creation. A hypothetical user solves the problems in creation of a piece of content by mapping situational features of the setting (bottom) to her existing knowledge of possible content creation solutions (top), representing her solution attempt in the working schema ( $S_W$ ). She may discover a novel use for the technologies if the resultant mapping is novel.

direct suggestions to repurpose the technology, remain in the model as a sub-class of environmental situational features.

The second difference from the previous chapter's model is that Figure 3.1 applies cognitive terminology in the model. Piecewise visual content creation is seen as a *problem-solving process* in which the user's problem is to find a satisfying composition for the working content (e.g., an unfinished message). In order to succeed in this, the user applies the features of the environment and technologies while also interactively consulting existing knowledge in the course of the search for a satisfying configuration.

In short, the model suggests that repurposive appropriation is based on processing of *mental representations* (denoted with  $M$  and  $S$  in the figure). They are both the user's interpretations of the external features ( $F$ ) and



pieces of knowledge in his or her memory about issues that are relevant in content creation (e.g., compositional alternatives and methods by which content can be manipulated).

When creating a piece of content, the user adapts (see Subsection 2.5.1) to the situational features through a *mapping process*. The model suggests three distinct types of mapping. The first one (recognition from the environment) refers to finding a set of correspondences between the situational features and the user's representation of a possible solution. The second and third type (i.e., analogy through problem abstraction and analogy between tools, respectively) use the same definition for mapping as the literature on analogical problem-solving. There, mapping is defined as a process in which a person establishes 'a set of systematic correspondences that serve to align the elements of the source and target' (Holyoak, 2005, pp. 117–118) analogs.

The ongoing problem-solving solution is represented in an unfinished *working schema* ( $S_W$ ). It ties together the situational features' ( $F$ ) representations ( $M$ ) and a description of the problem. The three mapping processes change  $S_W$  in different ways.  $S_W$  may become one of the existing *solution schemas* ( $S$ ) if the problem-solving is completed successfully. Solution schemas represent known ways to carry out tasks. They are large network-like mental representations.

The situational features ( $F$ ), in turn, are properties of the working content, the environment, and the technologies. The user can interact with these features in the problem-solving process. Only a subset of these features is known to the user, and of these features, only a few are attended to when the user solves a problem. In Figure 3.1, the unattended and unknown features are visualised as  $F$ s that do not have  $M$ s linked to them.

This chapter first presents the ontological premises behind the model (Section 3.1) and then addresses each of Figure 3.1's components in turn: situational features (Section 3.2), mapping (Section 3.3), and existing knowledge (Section 3.4). In the final part of the chapter, Section 3.5 addresses what is necessary for turning the model into a theory of repurposive appropriation.

## 3.1 Premises

The model rests on two ontological premises. First, it is assumed that repurposive appropriation is based on processing of symbolic mental representations. Second, it is assumed that the outcomes of this processing

– the appropriations – are also represented as complex mental representations that describe how situational features can be manipulated to solve problems. These premises are presented in the following two subsections.

### 3.1.1 Repurposive appropriation as processing of symbolic representations

Two competing representation-related frameworks are available for explaining repurposive appropriation processes. As is evident from Figure 3.1, this thesis suggests that discoveries need to be explained with theories of problem-solving and processing of symbolic representations. This will be referred to as the *symbolic viewpoint*. Its competitor will be termed the non-representational viewpoint.

#### **A competing hypothesis: The non-representational viewpoint**

From the non-representational viewpoint, one would explain repurposive appropriation without a reference to symbolic processing and suggest direct interaction with the physical surroundings. This viewpoint belongs to a class of theories referred to here as the *situated viewpoint*. We describe this first.

The situated viewpoint does not form a completely coherent and non-contradictory paradigm for cognition, but an outline of its explanation for repurposive appropriation can be presented as follows. From this viewpoint, when a user carries out tasks that are familiar, he or she is not consciously aware of the interaction with the tools and the object of activity. Instead, the tools are, in Heidegger's terms, 'ready-to-hand', and their use is unproblematic. In situations such as that of repurposive appropriation, unproblematic interaction is interrupted and the tools become 'present-at-hand', invoking processes of planning and sensemaking of the situation (cf. Winograd and Flores, 1986).

At this point, the different theories applying the situated viewpoint diverge in their opinions as to the role of symbolic representations in human behaviour. One opinion is that humans may switch temporarily to a symbolic mode and generate internal representations of problematic situations and plans. The plan may serve as a resource for further actions, which again are carried out in direct interaction with the environment (Suchman, 1987). This alternative therefore does not deny the role of symbolic representations in human behaviour altogether. However, it shows how representations are dependent on the circumstances in which they are invoked. The thesis is intended to be in line with this formulation of the situated viewpoint.

The alternative, the *non-representational viewpoint*, in contrast, states that internal representations, planning, and use of symbolic representations are unnecessary theoretical constructs (e.g., Brooks, 1991; Varela et al., 1993). Many factors are behind the non-representational viewpoint's rejection of the hypothesis as to the existence of symbolic representations. For example, a number of artificial intelligence systems have been developed that do not have representational states yet nevertheless exhibit intelligent behaviour. Hence, it seems that representations are not necessary for intelligent action, which raises the possibility that representations may not be needed in other explanations of cognitive activities either (van Gelder, 1998). Second, mental representations appear to be uneconomical: if an agent has an opportunity to use the world as its model, why would there be a complicated mechanism that translates observations into symbolic form before any intelligent behaviour becomes possible (Beer, 2003; Brooks, 1991)? Third, representation-based systems have been claimed to exhibit poor performance. Early work on artificial intelligence showed that intelligent robots relying on representations often failed to solve real-world problems because their internal models of the environment were brittle and lacked robustness in the face of changing circumstances. Also, many real-world problems are intractable and, because of their size, cannot be represented with a problem space (e.g., Agre and Chapman, 1987). These are a few of the reasons for which some researchers of artificial intelligence and philosophy have rejected the existence of symbolic representations in human cognition.

At most, these theorists argue, the theories of action and perception should be based on sensorimotor representations (e.g., van Gelder, 1998; Thelen and Smith, 1994). To explain human behaviour with representations, the non-representational viewpoint states that the user uses the external world directly as his or her model. The physical properties of the world provide *affordances* for action that are perceived directly, without interpretation (Gibson, 1979).

A non-representational theory can be used to explain some repurposive appropriations. For instance, when a user encounters a need to keep a door open, she may perceive that a screwdriver can be stuck between the door and the door frame. In this case, by its shape and movability, the screwdriver affords its remaining in that position. This results in repurposive appropriation of a screwdriver as a door-stopper. Some theorists suggest that human cognition should be based on theories of this type of direct interaction with the environment (e.g., Brooks, 1991).

Shapiro summarises the claims in the following definition:

**Definition 2** (Argument for representational scepticism).

1. Representations are stand-ins for actual objects.
2. An agent is in continuous contact with the objects with which it needs to interact.
3. If an agent is in continuous contact with the objects with which it needs to interact, it doesn't require stand-ins for these objects.

Therefore, an agent has no need for representational states that stand-in for actual objects. (Shapiro, 2011, p. 150)

Repurposive appropriation is, however, a phenomenon that cannot be explained fully without a reference to mental representations. The non-representational viewpoint could possibly be defensible if one were to focus only on repurposive appropriations that are discovered in the face of an immediate need and that involve perceptions of physical properties (as in the screwdriver example above). It could then be that interactive technologies' functions could be explored directly, without internal symbolic representations. But the non-representational viewpoint cannot be maintained when other kinds of repurposive appropriations are considered. First, the discoveries resulting from dormant needs (see Table 2.7) take place in situations in which the user is not in continuous contact with all of the features that are needed for a successful solution to a problem. Therefore, the user must have had a memory (i.e., an internal representation) of the technology and other features, in order to notice the opportunity for a novel technology use.

Second, also during continuous interaction, some users appear to be better than others at discovering novel opportunities for action. A plausible explanation is that the more actively appropriating users have capabilities that the other users do not. Paper 6 suggests that the most feasible explanation lies in the difference in knowledge (i.e., technology cognizance) of the technological features and their effect. Much of that knowledge is symbolic; it is not directly observable in the world.

It is, therefore, more likely that *the user processes symbolic mental representations in repurposive appropriation*. As a result, this thesis subscribes to the situated viewpoint but not in its non-representational form.

### The symbolic viewpoint

The conclusion that repurposive appropriation is probably based on symbol processing implies that this thesis subscribes to the so-called *physical sym-*

*bol system hypothesis* of human cognition (Newell and Simon, 1976; Newell, 1980; Vera and Simon, 1993) in its explanation for repurposive appropriation. According to this hypothesis, intelligent action can only be based on processing of symbols (Newell and Simon, 1976) and, secondly, these symbols and their processing can be implemented physically. The human brain is said to be an example of such a physical system<sup>1</sup>.

The symbol system hypothesis that is subscribed to here follows the one presented by Vera and Simon (1993), who emphasise that symbolic representations can be unconscious and operate also at low levels of the cognitive architecture (e.g., as commands for muscles; cf. p. 18). The thesis, therefore, does not assume that representations would be encoded in an inner, symbol-like ‘language of thought’ (cf. Fodor, 1975). Consistent with Vera and Simon’s hypothesis, the hypothesis here is that in repurposive appropriation, perceptions of the features (denoted with  $F$  in Figure 3.1) of the surrounding world are processed and represented as symbols, which, in turn, are used in information processing. Similarly, the existing knowledge too is symbolically represented. However, as will be shown in the discussion that follows, the model presented in this chapter does not require that symbolic representations be processed without interaction with the surrounding environment. On the contrary, the suggestion is that in repurposive appropriation, the situational features and the existing knowledge interact with each other in the mapping process.

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<sup>1</sup>However, the brain is also a connectionistic sub-symbolic system. Research-based knowledge of how symbolic representations are implemented in the brain is still tentative and inconclusive (e.g., Dumas and Hummel, 2005; Eysenck and Keane, 2000). Detailing how even simple pieces of propositional knowledge (e.g., generic templates such as `eats(cat, fish)`) can be implemented neurally has been theoretically challenging, although progress has been made (e.g., Dumas and Hummel, 2005; Botvinick and Plaut, 2004). For repurposive appropriation, the symbolic–connectionistic models that address perceptions, actions, and symbols are especially promising. These include Barsalou’s theories of perceptual symbol systems (1999) and realisation of representations as neural simulators of the external object (2009), as well as Hommel et al.’s theory of event coding (2001), which also suggests that perception and action are based on the same representational neural medium. The problem of neural implementation of symbolic representations is not pursued extensively in this thesis (however, see Section 4.2, on computational simulations of repurposive appropriation). As was discussed above, explaining repurposive appropriation without committing ontologically to symbolic representations leads to problems. Repurposive appropriation is a ‘representation-hungry’ (Clark, 1997) problem that theories advocating representational scepticism cannot explain.

### 3.1.2 Repurposive appropriation as creation of solution schemas

The second premise is that as an outcome of repurposive appropriation, the user learns new symbolic representations of technology use that can be described as networks of representations, already referred to as *solution schemas*. The following example of an authentic repurposive appropriation concretises this suggestion. One of the respondents in the Web-based survey (see Paper 6) described her discovery of a digital camera as a note-taking tool as follows (presented already in Table 2.7, on p. 60):

*Question: What was the situation like?* ‘I was shopping and was thinking at the same time about what to cook for dinner. There was a cookbook for sale in the shop. I looked up a nice-looking (and simple) dish, and, because I didn’t want to buy that book, I took a picture of the recipe. Then I went around the shop, picking up the ingredients with the picture as my guide, and cooked the food at home.’

*Question: How was the discovery made?* ‘First, I felt bad because I hadn’t taken a pen with me, but then I remembered that my new phone had a camera and I decided to try it.’

In the terminology of Figure 3.1’s model, the mental processes behind this discovery may have been the following. The quotation contains a sequence of three solution attempts, of which the third was successful and also contained a repurposive appropriation. These solution attempts involved different mappings, depicted in Figure 3.2. The problem-solving proceeded from a need to come up with a plan for dinner. The user recognised that she could look up a recipe in a cookbook that is sold in the shop. This created the content creation problem of storing the recipe somehow for later retrieval. The respondent’s first working schema was initially mapped to an already known solution schema: purchase of the book. However, the respondent did not find this solution successful, because she did not want to spend money on the book. The second version of the working schema too was mapped to an existing solution: using pen and paper (mentioned in the ‘how’ part of the answer). However, this working solution was unsuccessful because the respondent did not find a pen. Finally, the respondent created a working schema with a novel mapping, based on recognition that a feature of another technology – the camera phone – was also suitable for storing information. This working schema proved successful because

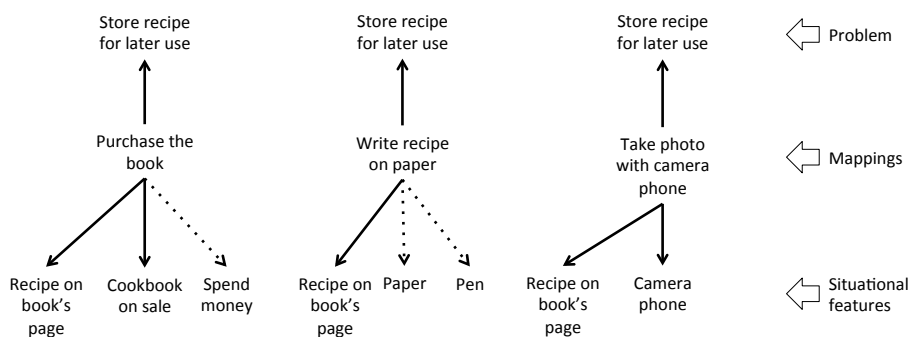


Figure 3.2: Three solutions for storing for later use a recipe in a cook-book that is for sale in a shop. Dotted lines represent features that were unavailable or deemed undesirable, leading to unsuccessful solutions.

it mapped the solution to features that were available in the situation at hand.

The three diagrams in Figure 3.2 illustrate a suggestion as to how re-purposive appropriation can be understood as creation of a novel solution schema. This schema maps the given situational features and one or more actions to a description of how the desired change in the physical world or a digital environment can be achieved. These diagrams are simplifications; their purpose is to illustrate mapping, not to suggest that this respondent's solution schemas in reality would have had exactly the structures that are shown. Also, although they present only single-action solutions (e.g., 'purchase the book'), this does not mean that solution schemas would not contain also sequences of action.

### The structure of solution schemas

Solution schemas, by linking different elements together, are complex mental representations. They are similar to frames (Minsky, 1975), scripts (Schank and Abelson, 1977), memory organisation packets (Schank, 1982), and templates (Gobet and Simon, 1996), all of which are concepts presented in the literature for describing complex mental organisations of knowledge. Such representations share the property that they can be expressed as relational propositional networks (e.g., Paivio, 1990, p. 30).

More precise suggestion than this cannot be made as to the structure of solution schemas. The only feasible requirement is that these schemas

would have a mapping-like structure in (i) linking situational features together and (ii) representing actions that operate on these elements. Psychological literature has established that mental representations can be divided into *procedural* and *declarative* representations (e.g., McNamara, 1994; Eysenck and Keane, 2000). Procedural representations refer to knowledge of how tasks and actions are carried out, while declarative representations refer to knowledge that can be verbalised, visualised, or declared in some other way (McNamara, 1994, p. 86). Within declarative knowledge, the main dividing line is between *analogical* and *symbolic* representations (or visual and verbal representations; see Paivio, 1990). Analogical representations preserve the structure of the object that they represent (e.g., what a camera looks like). Symbolic representations have to do with information that does not have physical dimensions or a visual form (e.g., the rules for deciding when to use the flash when taking a photograph). Solution schemas appear to have characteristics of both procedural and declarative representations.

### **Interaction with the situational features**

Solution schemas and situational features (see the next section) are in close interaction. On one hand, features provide possibilities for serendipitous novel mappings that give rise to new solution schemas. On the other hand, solution schemas direct the user's attention to features in the environment. Schön (1983) has called these reciprocal interactive problem-solving actions *move-testing experiments*. With moves, the problem-solver makes attempts to frame the problem-solving situation. With tests, he or she verifies the assumptions. It has been found that interactiveness helps the solver both (i) make important observations and (ii) evaluate the assumptions he or she has made (Weller et al., 2011).

These two possible outcomes of move-testing – observation-making and evaluation – are similar to the stages in Norman's *action cycle* (1988), which presents humans' interactions with the world as alternation of execution and evaluation. In Norman's model, however, observation-making is de-emphasised.

When Schön's and Norman's descriptions of interaction are considered together, they create a three-part cycle consisting of observation/perception, execution/action, and evaluation/learning. Such a cycle was presented in Paper 4, based on Neisser's *perceptual cycle*. The two models are presented graphically in Figure 3.3. In the cycle shown on the right, the working schema directs exploration (i.e., perception) of the



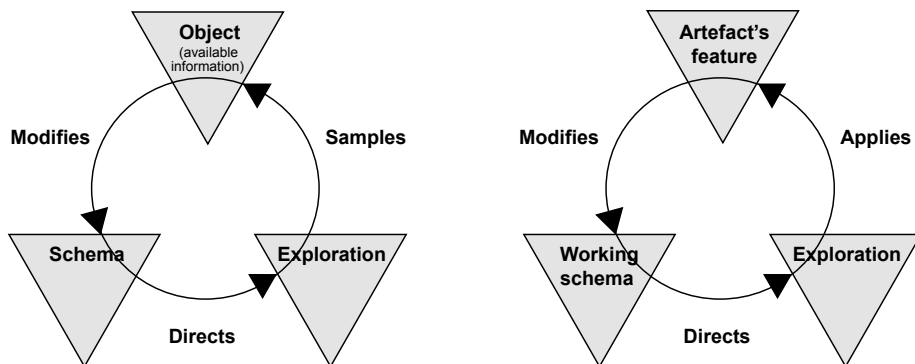


Figure 3.3: Neisser's (1976) perceptual cycle (left) and its adaptation (modified from work in Paper 4) for describing repurposive appropriation (right).

environment, including the technologies. The user applies (i.e., performs actions on) suitable features of the technology. If they prove beneficial and are novel, the user's understanding of the feature's possible uses will change (i.e., the user learns).

The focus in this chapter is on the cognitive processes represented by the arrow labelled 'Directs' that leads from working schema to exploration. This means that both the verification of one's perception through action and the changes that the verification causes in the existing schemas are not addressed in this thesis. Consequently, longer-term processes that involve multiple cycles are not addressed either. This limitation of scope is justified for two reasons. First, generating hypotheses for even one part of the cycle involves many hypotheses already, any or all of which may prove to be untrue. Addressing the full cycle, or multiples cycles, could introduce more serious errors. The choice to focus on perceptual processes within a cycle is justified by its similarity to discovery, which is the primary event in repurposive appropriation (see the definition in Subsection 1.2.1, p. 32).

With the foundation on symbolic representations now established, the following sections describe Figure 3.1's elements in more detail and present three suggestions for mapping processes to explain cognitive processes behind repurposive appropriation.

## 3.2 Situational features

Situational features constitute the bottom box in Figure 3.1. The definitions of the three types of features – working content, technologies, and environment – are those already provided in Subsection 2.5.1. The features include all constraints and opportunities for solving the problem, such as the functions of the present technologies, the physical properties of both the technologies and the environment, and social elements such as other people. This set of features is limitless, because it depends on the user and his or her specific situation. Some of these features are situation-dependent (e.g., lighting conditions for photography), while others are more permanent (e.g., the ability of a camera phone to take pictures).

In line with the physical symbol system hypothesis, those features that the user knows about, interacts with, or attends to during piecewise visual content creation are processed via their mental representations. These mental representations constitute the elements that the user finds relevant (or *apperceives*; cf. Saariluoma and Kalakoski, 1998) in his or her present interaction in the piecewise visual content creation process. The representations contain declarative knowledge of what the features are (e.g., what a camera’s various flash settings do) but also the user’s predictions of their effect on the present task. The representations are not static; they can change, depending on the user’s assessment of the ongoing progress of the task.

## 3.3 Mapping-based repurposive appropriation processes

Mapping is the middle element in Figure 3.1. This section presents the following three suggestions for mapping processes:

- Recognition of solutions from the environment on the basis of mapping of solution schemas to the situational features (Subsection 3.3.1).
- Analogical problem-solving-based repurposive appropriations. Introduction to these suggestions is provided in Subsection 3.3.2.
  - Analogical mapping through problem generalisation (Subsection 3.3.3).
  - Analogical mapping between tools (Subsection 3.3.4).

These suggestions imply that not all repurposive appropriations can be explained by a single cognitive process. The following sections first present the mappings based on recognition of solutions from the environment's structures and continue with an introduction to analogical problem-solving and a presentation of two, different analogy-based mapping processes.

### 3.3.1 Recognition of solutions from the environment

Most technology use takes place in human-built dedicated environments that provide a lot of structure and explicit information that guide and orient people in their activities (cf. Alterman et al., 1998; Hutchins, 1995a; Kirsh, 1995, 2001; Norman, 1988). With experience, people become attuned (Kirsh, 2009) to such structures. Repurposive appropriations may be discovered via perception of such structures. These structures represent *partial solution schemas*, which are mappings of situational features, their relations, and actions that can be carried out on them but lack problems for which these structures can serve as solutions. Repurposive appropriation may result if a person discovers such a problem and if the complete solution schema involves a novel use of one of the tools. This would explain the process behind abductive appropriations and discoveries of solutions to dormant needs (see Table 2.7) – repurposive appropriations in which the discovery appears to take place serendipitously, without an immediate consciously attended problem. Findings from studies of distributed cognition (DCog) and situated cognition (SCog) provide background for this hypothesis.

#### Distributed and situated cognition

The basic premise underlying both DCog and SCog is that cognitive activity is carried out not only in the brain but also in the user's environment. The two frameworks have a lot of overlap. However, research on DCog often focuses on the use of tools in cognitive activities such as calculation and planning while SCog is a more general framework encompassing many, quite different viewpoints and commitments with respect to the mind–body boundary (e.g., Robbins and Aydede, 2009, pp. 3–10). For the purpose of this thesis, it is useful to present DCog as studies of information processing in systems that distribute the computation effort across different actors (both humans and tools; e.g., Hollan et al., 2000; Hutchins, 1995a,b; Rogers, 1993) and SCog as studies of the use of physical environment as cues and reminders about actions (e.g., Alterman et al., 1998; Kirsh, 1995, 2009).

Studies of DCog have analysed, for instance, ship navigation (before GPS devices became widespread). The ship's captain and the crew use a number of specialist tools (e.g., alidade, hoey, record log, and chart) on the command deck to track the route of the ship (Hutchins, 1995a). The navigation includes tasks such as finding out where the ship is positioned on a map, what its speed is, and where it is heading. Completion of these tasks is distributed across a number of agents, consisting of both humans and tools. The analysis of the system's processes focuses on the propagation of a representational state across a series of representational media (ibid., p. 117). This framework is oriented to analysing distributed information processing, often in routinised tightly coupled activities between/among multiple agents. In itself, it would not be a sufficient basis for a theory of individual repurposive appropriation, which would have to focus also on actions that are not aimed at computation only.

SCog's studies of external representations and use of physical space as an organiser of activities complement DCog's main findings and are highly relevant for a theory of repurposive appropriation. The physical space provides entry points that invite initiation of actions (Kirsh, 2001) and simplify choices and perception. Also, as already mentioned, tools save on human actors' internal computation (Hutchins, 1995a; Kirsh, 1995). In contributing to activities in these ways, the physical space and the tools become external representations of the problem and its constraints, relations, rules, and other problem-solving-relevant properties (Zhang and Norman, 1994; Zhang, 1997; Wright et al., 2000; Scaife and Rogers, 1996). During problem-solving, the solver may also interact with the physical space in order to gather more information about the problem. These actions are called *epistemic actions* (Kirsh and Maglio, 1994). They do not move the solver closer to the goal but produce information that helps him or her in further problem-solving steps (see Kirsh, 2009 for a review).

### **Application to repurposive appropriation**

When a user appropriates by recognising structure in the environment, he or she notices an opportunity for using a technology in a novel manner by mapping a partial solution schema presented by the environment to the working schema of his or her ongoing problem. This can happen (i) in a situation that resembles problem-solving (where the goal also affects the user's attention to situational features) or (ii) abductively (where a technology produces an outcome that catches the user's attention and the user then maps this outcome to a hypothetical problem). Figure 3.4 depicts this mapping.

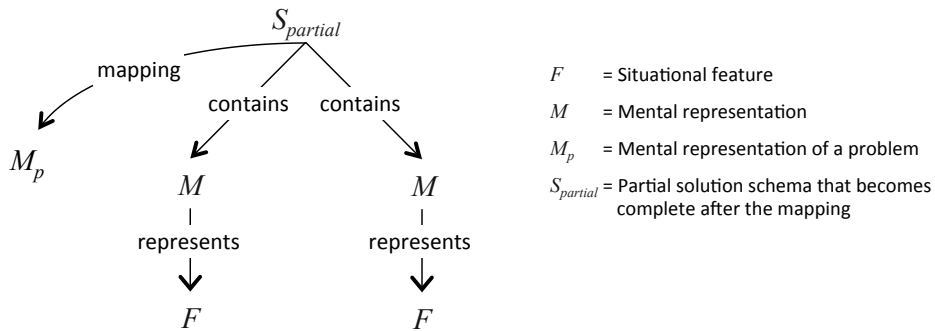


Figure 3.4: Repurposive appropriation through recognition of a partial solution schema ( $S_{partial}$ ) and subsequent mapping of it to a problem ( $M_p$ ) that it can solve.

The studies presented in this thesis (see the previous chapter) have not provided empirical examples of type i on a sufficient level, but the extended quotation of a message creation process from the Comeks study (Section 2.3, pp. 51–53) contains multiple examples of changes with type ii. There, the changes in the message’s purpose (e.g., to a decision to have an secret-agent film theme in the story) may have resulted from mappings in which the structures perceived in the environment were sources for new representations to do with the message’s possible compositions.

Recognition of solution schemas resembles symbolic pattern recognition in that the situational features that the person has noticed first combine into patterns, which, in turn, become meaningful through their connections to the user’s previous knowledge. Such a recognition of solution schemas is similar to the processes of retrieval and recognition studied in psychological memory research (e.g., the model of associative memory; see Raaijmakers and Siffrin, 1981). Situational features therefore serve as memory cues that lead to recognition of previous memories of similar situations. Section 4.2 discusses how the recognition of schemas could be implemented in a computational model.

Thus existing knowledge (discussed in more length in Section 3.4) plays an important role in repurposive appropriation. Both the repository of already known solution schemas and general technological understanding help the person perceive more entry points for action in his or her environment. The more familiar a user is with the technology, the more opportunities and cues that user sees for using it (Kirsh, 2009; Greeno and the Middle School Mathematics Through Applications Project Group, 1998). Percep-

tion is therefore affected by the user's representation of the problem with the current working content and his or her background knowledge.

### 3.3.2 Introduction to analogical problem-solving-based mapping

The remaining two repurposive appropriation processes suggested are based on analogical problem-solving. This section provides the necessary background for these suggestions.

In psychology, 'problem' refers to a situation in which 'an organism has a goal but lacks a clear or well-learned route to the goal' (Dominowski and Bourne, 1994, p. 23). In workaround-related repurposive appropriation, the problem that the user faces is that a means to move forward towards the goal is not available (cf. p. 15, footnote). Research on problem-solving has identified multiple methods via which people start solving problems.

#### Weak and strong problem-solving methods

Problem-solving methods belong to two categories, according to whether the user applies expert knowledge about the domain and the tools in the problem-solving process. *Weak methods* are knowledge-lean techniques that can be applied in many domains but that may not always lead to a solution. Problem-solving using weak methods is also typically slow. These methods include general heuristics (e.g., trial and error) as well as algorithms, most importantly hill-climbing and means-ends reasoning.

In problems that are relatively free of specialised content and in which there is a clear goal, means-ends analysis is usually the method that solvers adopt most often (Novick and Bassok, 2005). In means-ends analysis, the solver analyses the difference between the present state and the goal state, and he or she identifies a sub-goal that is easier to resolve than the full problem and that will bring him or her closer to the overall goal. Then the user sets out to reach this sub-goal. Once done, he or she identifies the next sub-goal minimising the gap that remains. This will be continued until the full problem is solved. Alternatively, if a sub-goal is too difficult to reach directly, the user will divide it recursively into sub-subgoals (Newell and Simon, 1972).

*Strong methods*, in contrast, make use of the solver's expert knowledge of the problem domain. These therefore guide the solver to the goal more quickly. The cost of this benefit, however, is that the knowledge of suitable solutions is often specialised and does not transfer well to other problem

Table 3.1: Stages in solving a problem (Weisberg, 2006a, p. 179)

---

**Stage 1: Solution through application of strong methods**

1. Problem presented  $\Rightarrow$  attempt to match with knowledge
  - (a) No solution available  $\Rightarrow$  Stage 2
  - (b) Successful match with knowledge  $\Rightarrow$  transfer solution based on expertise or analogy
  - (c) If solution transfers successfully  $\Rightarrow$  problem solved
  - (d) If solution fails  $\Rightarrow$  Stage 2

*Comment:* If no match is found with the memory, the person proceeds to Stage 2; if match is made, solution is attempted. Can result in solution of the problem.

---

**Stage 2: Solution through direct application of weak methods**

2. Failure at Stage 1a  $\Rightarrow$  analysis based on weak methods
  - (a) Analysis successful  $\Rightarrow$  solution
  - (b) No solution  $\Rightarrow$  impasse; problem not solvable

*Comment:* Person works through problem using weak heuristic methods, trying to develop solution; if successful, problem is solved.

---

domains (Feltovich et al., 2006). In Figure 3.1, known solution schemas (*Ss*) represent the strong methods of which the user is aware.

Typically, both weak and strong methods are used when one is solving novel problems. Table 3.1 presents Weisberg's model of stages in a problem-solving process. The solver first tries to apply existing knowledge to the problem and solve it by using strong methods. If that is not possible, weak methods will be applied to the task.

**Repurposive appropriation as creative problem-solving**

A user who appropriates and finds a novel purpose of use for a technology discovers, in so doing, something new about the technology and its relationship to a context of use. All problem-solving – including repurposive appropriation – is therefore *creative*, because it leads to knowledge that the solver had not previously possessed.

Psychological research on creative problem-solving presents two competing views for explaining creative cognitive processes. This thesis sub-

scribes to the so-called *ordinary thinking viewpoint* (Weisberg, 2006a), from which creative problem-solving can be explained with the same theories as ordinary thinking, in this case when one draws from theories of analogical mapping. The competing viewpoint – based on Gestalt psychology – is reviewed next.

### **Competing hypothesis: Gestalt problem-solving**

The Gestalt theory of creativity (cf. Duncker, 1945; Dominowski, 1995) suggests that creative thinking requires the person to discard previous knowledge before being able to reach novel insights. The theory makes a distinction between reproductive thinking (i.e., routine thinking with no insights) and productive thinking (i.e., creative problem-solving) and maintains that these two kinds of thinking are based on different cognitive processes (e.g., Wertheimer, 1959). When a person faces a problem that can only be solved creatively, he or she usually first experiences an impasse. The reason behind the impasse lies in *fixation* on applying existing knowledge to the problem. A person at this juncture will be able to solve the problem only by discarding or reframing the assumptions that block him or her from noticing other solutions and restructuring the problem representation (Ohlsson, 1992). When the restructuring takes place, it yields a sudden experience of insight.

The concept of fixation plays a central role in problem-solving research in Gestalt tradition. One source for fixations is the cues in the problem setting. Another source, importantly for repurposive appropriation, is the solver's previous knowledge. A Gestalt explanation for repurposive appropriation would suggest that the cues and the person's knowledge would lead the solver to fixate on a subset of characteristics of the problem, leading away from a solution by blocking the solver from seeing other alternatives (e.g., Smith, 1995).

Some non-Gestalt theories considering the creative process maintain a similar view and suggest that a creative solution can be found only if the solver breaks free from previously held views. The cognitive processes suggested as able to make this happen include lateral thinking (De Bono, 1970); generation of many alternatives, from which the bad candidates are then filtered out (Finke et al., 1992); and blind variation and selective retention (Campbell, 1960).

However, these theories and Gestalt psychology have two problems when applied for explaining repurposive appropriation. First, the existing empirical data on repurposive appropriation processes have not provided evidence



(e.g., in the stories collected in the Web-based survey study; see Section 2.4) that impassive and non-productive problem representations usually precede repurposive appropriation. Second, more importantly, existing knowledge, on a large scale, does not appear to have a negative effect on repurposive appropriation. The opposite – that existing knowledge supports repurposive appropriation – seems to be more likely. One of the findings from the Web-based survey study was that repurposive appropriation is more commonplace among those users who stated that they put effort into developing a good understanding of technology. This finding holds at least on a general level. However, functional fixedness may still manifest itself in more narrowly defined technology use domains, although this is yet to be shown.

Another important claim in Gestalt theory on problem-solving is that insight problems can only be solved through *restructuring* (e.g., Köhler, 1969; for a brief summary regarding claims, see also Weisberg and Alba, 1981) of the problem representation. The idea of a changing problem representation is not unique to Gestalt psychology, however. Other problem-solving research approaches too (e.g., analogical problem-solving; see below) maintain that problem-solving involves discovery of new solution strategies and problem representations. This part of Gestalt theory is unproblematic for theorising related to repurposive appropriation.

In conclusion, the unique parts of the Gestalt viewpoint are poorly suited to explaining repurposive appropriation. Therefore, this thesis proceeds from a premise of ordinary thinking in problem-solving.

### **Analogical problem-solving**

In some situations, when facing a problem during an activity, the user may become aware of another technology that would be suitable for the task but that is unavailable at present. With this awareness, the user may be able to overcome the problem by using a tool that resembles the already known tool in relevant ways. Analogical problem-solving is suggested as an explanation for such discoveries. The definition of an analogy is that ‘two situations are analogous if they share a common pattern of relationships among their constituent elements even though the elements themselves differ across two situations’ (Holyoak, 2005, p. 117). The types of situations for which this explanation may be best suited are the repurposive appropriations arising from immediate needs and dormant needs (i.e., the situations in which the user has faced or is facing a problem; see Table 2.7).

Analogies are often studied through application of focus to an interaction between two problems. The known solution (e.g., that the user knows

that a document can be stored digitally by means of a scanner) is called the *source problem*, and the present situation (e.g., where the scanner is unavailable) is the *target problem* for which a solution is needed. Research has shown that a successful solution requires that the solver (i) recognise the analogy between the source and the target problems and (ii) find a mapping that aligns the features of the source and the target. Typically the first stage is more difficult for solvers than the second stage (Gick and Holyoak, 1980; see also Holyoak, 2005, p. 123).

Two forms of analogical problem-solving are now suggested to explain repurposive appropriation. In being based on analogical representations, they make use of the solver's expert knowledge and, therefore, belong among the strong problem-solving methods.

### 3.3.3 Analogical mapping through problem generalisation

The first suggested form of repurposive appropriation by analogy involves two steps. First, the user *represents the problem on a more general level*. This is followed by mapping to problem characteristics of a different solution schema. For example, in the cookbook photograph example (see the quote in Subsection 3.1.2), the respondent's target problem was to store the list of ingredients and the cooking instructions from an interesting recipe. The successful solution was based on a repurposive appropriation of a camera phone as a note-taking tool. In this discovery, the respondent may have first represented the problem as a more general working schema, as a problem of storing visual data. This may have been followed by another mapping, from the general schema to another concrete solution schema. This is visualised in Figure 3.5. User knowledge may play a part in the mapping's second stage, when the general schema is mapped to the candidate technologies: the more alternative mappings the user can evaluate, the better the chances of finding one that matches the requirements imposed by the problem.

This form of repurposive appropriation is suggested on conceptual grounds. The existing data are not complete enough to support or refute the hypothesis that users would appropriate by generating general problem representations. Research into abstract problem schemas shows that this form of analogical reasoning is usually difficult (Gick and Holyoak, 1983). One reason for this is provided by the theories of situated cognition. Studies suggest that recognising isomorphisms between solution representations is difficult because humans represent problems in very concrete ways. Thus, for a solver, problems that have a similarity on an abstract level are essentially understood and perceived entirely differently (Kirsh, 2009). More

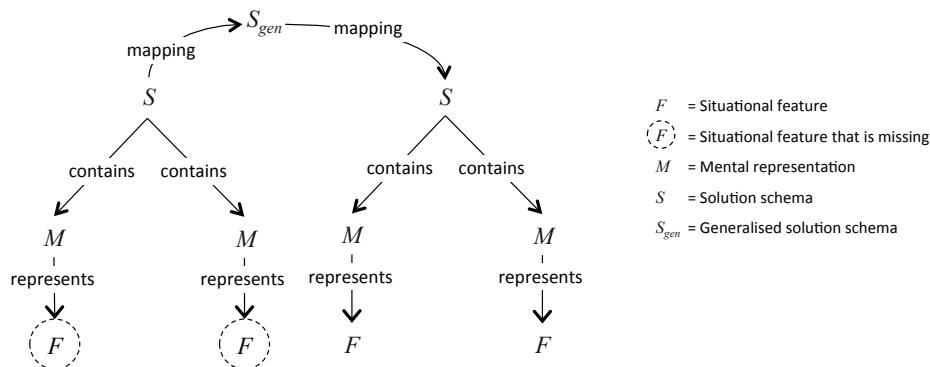


Figure 3.5: Repurposive appropriation via mapping to another solution schema through the problem's generalisation ( $S_{gen}$ ). The two missing situational features ( $F$ , in dashed circles) initiate the need to find another solution schema.

research is needed to evaluate the hypothesis of mapping through generalisation and to estimate how often repurposive appropriation may take place in that way.

### 3.3.4 Analogical mapping between tools

The other form of analogy-based repurposive appropriation is related to *analogies that are found between tools* instead of representations of the problem's nature itself. That is, drawing again from the cookbook photograph example (in Subsection 3.1.2), we find that, instead of establishing an analogy with a more general task (such as 'storing a recipe is like storing any visual data', as above), the analogy is related to tools in the problem-solving task ('the camera is like pen and paper').

As was stated in the section introducing analogical problem-solving, psychology has traditionally studied analogies at the level of problem representations. However, in this case, an analogy applies between two or more problem-solving *tools*. The analogical mapping is represented in Figure 3.6. It is established on the basis of the relationships among the tools' constituent elements. The greater the similarity is between the tools, the better the tools may replace each other in the problem-solving task. Knowledge plays an important role also in this form of repurposive appropriation. The greater the basis the user has for comparing different tools to each other, the better are his or her chances of discovering repurposive appropriations.

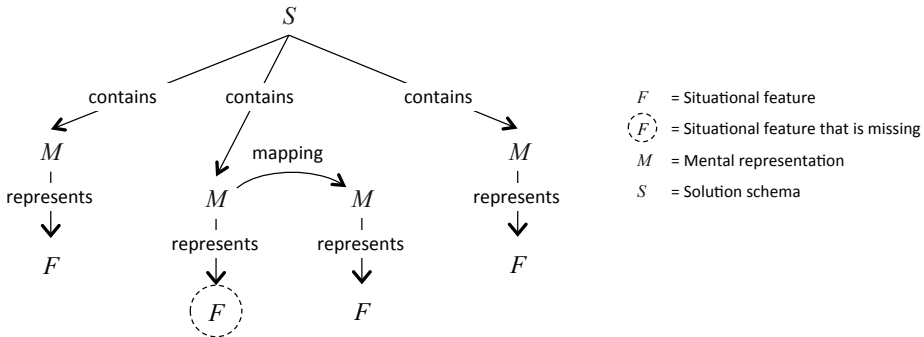


Figure 3.6: Repurposive appropriation via substitution (see the curved arrow labelled ‘mapping’) of a missing situational feature ( $F$ , in a dashed circle) with an analogical feature that is available in the situation.

In the presentation of eight analogies between a digital camera and other technologies, the repurposive appropriations studied in Paper 6 resemble this form of analogical mapping. However, although the study showed that such repurposive appropriations were common, it does not establish decisively whether the discoveries were based on this kind of analogical mapping. The previous two hypotheses for mapping (i.e., recognition of solutions from the environment and analogical mapping through problem generalisation), and perhaps also other forms of cognitive process, can be used to explain the same outcomes. This too must be studied in future research.

### 3.4 Existing knowledge

Figure 3.1 features existing knowledge as its topmost element. The importance of the user’s expertise, especially his or her understanding of technologies and tools, was mentioned multiple times in the previous sections.

This thesis applies a broad definition of expertise, denoting the quality (e.g., breadth, depth, and accuracy) of the user’s knowledge. In this, it differs from another common definition, ‘reproducibly superior performance on representative, authentic tasks’ (e.g., Ericsson, 2006, p. 688). Because of its reference to reproducible performance, we do not use this definition. Unlike task-specific expertise (e.g., violin playing; see Ericsson et al., 1993), knowledge about technologies is means-oriented and applicable in different domains. For example, the same knowledge of camera features (e.g., good

ways of using a flash) may be applicable both to photo manipulation tasks in advertising and to taking snapshots on social occasions. Task-specific reproducible superior performance (in the example case, tuning the brightness of the flash better than other users do in typical situations in which flash photography is used) would not be a suitable measurable proxy for a user's ability to appropriate. The main reason is that repurposive appropriation is closer to novel rather than reproducible behaviour.

In the previous sections, repurposive appropriation through recognition of structure from the environment (Subsection 3.3.1) was described as facilitated by the user's knowledge of solution schemas and technologies, because that provides a richer understanding of one's environment and more entry points for action. Also, both of the analogy-based repurposive appropriation processes (subsections 3.3.3 and 3.3.4) were hypothesised to benefit from knowledge, through increased possibilities for mappings either from technologies to a generalised problem schema or between tools.

Therefore, the hypothesis that existing knowledge benefits repurposive appropriation seems plausible also theoretically (as was discussed in the previous sections), not only empirically (cf. Paper 6). The hypothesis of a positive contribution was also one of the reasons for the judgement made above that Gestalt psychology cannot satisfactorily explain repurposive appropriation. In fact, psychological research has revealed that expertise usually increases creativity (see Weisberg, 2006b for a review). Experts differ from novices in the manner in which their knowledge is organised. They have a better memory of the problem's details, and they employ different strategies, have better and more elaborate problem representations, study and redefine the problem tasks more often and longer than novices do, and monitor their performance more carefully (cf. Chi, 2006; Eysenck and Keane, 2000, p. 420; Zimmerman and Campillo, 2003).

Also, through practice, experts learn a large number of *chunks* – encoded patterns of information that can be manipulated in short-term memory and that are organised into individual relational structures (Chase and Simon, 1973b, p. 56). Chunks help experts overcome the limitations of working memory and notice critical properties of the problem they face. Therefore, with the aid of chunks and better organisation of knowledge, experts possess more situation-relevant information. This helps them reason in a more flexible manner and determine the actions needed in the situation (Ericsson and Kintsch, 1995).

Instead of having a tendency to fixate users on existing solutions, the two types of knowledge discussed in this chapter – solution schemas and mental representations – improve users' *cognitive flexibility* (Spiro et al.,

1988). Cognitive flexibility increases the user's ability to act successfully in ill-defined domains (ibid.). Characterising the problem setting as ill-defined seems to match those problems well that are solved with repurposive appropriation. Accordingly, the more the user is aware of different solution schemas, the more problems he or she can solve with the technology. Likewise, the more the user knows about the features of the technology, the more ways he or she has of using the technology.

It is therefore possible that users whose expertise in technology use is heterogeneous (e.g., acquired from different problem settings) also have more cognitive flexibility and greater ability of repurposive appropriation than others do. And, vice versa, gaining experience from only a few domains may lead to knowledge structures that increase one's fixation and weaken ability to appropriate. These possibilities can be verified with further research. Because the empirical studies for this thesis were based on novel interactive applications (mGroup, CoMedia, and Comeks) and retrospective data (digital cameras), fixation on existing solution patterns remained an unaddressed topic.

Studies of technology-oriented expertise have suggested that expert users attempt to familiarise themselves with technology's features more systematically than do novices. They also follow Web sites and other media where the technologies are discussed, and through their extensive experience, they are aware of a large variety of *ad hoc* use situations (Oulasvirta et al., 2011). However, while this probably makes experts superior to ordinary users in terms of both the breadth and the depth of technology-related information, most of the performance difference can be attributed to better knowledge of the user interface (UI) features (ibid.). For example, in situations in which the same task can be accomplished in multiple ways in the UI, the experts are able to choose the methods that are most efficient (Bhavnani and John, 2000).

UI-related knowledge may be important also in all three mapping processes of repurposive appropriation. In the recognition of the ways in which the environment's structures can be mapped to a hypothetical problem (Subsection 3.3.1), broad knowledge of the UIs helps the user see more ways of manipulating the environment and making use of it in different tasks. In the mapping from a generalised problem representation to different technologies (3.3.3), UI knowledge helps the user consider more alternatives for concretising the generalised representation. Finally, in finding how one technology can be replaced with another (Subsection 3.3.4), the UI knowledge is of help in better considering the ways in which the inputs and outputs of the unavailable technology can be replaced with another

technology, one that offers different means of interacting with the environment. Despite these considerations, it appears less important to understand how the various systems have been implemented technologically. Since UI knowledge is closer to a surface-level than a deep understanding of the technology, this suggests that *the breadth of knowledge may be more important than the depth for repurposive appropriation*. The latter has, in fact, been suggested in one research paper (Mills and Chin, 2007), though one based on general self-report data instead of naturalistic empirical evidence.

Within HCI research, user knowledge of UI features has been studied through the hypothesis that knowledge is represented as mental models in users' memory. Technology-oriented mental models refer specifically to what users know and believe about the system they use (Norman, 1988; Payne, 2008). Studies of menu-based computer programs have suggested that novice users learn mental models through label-following: they search for a word in the UI that is identical to the name of the task they are trying to perform, or related to it. With experience, they appear to deepen their knowledge in an iterative manner (Engelbeck, 1986, cited in Rieman and Young, 1996). To understand how the features of a system map to effects in the external world, users may need to maintain not one but two representations of the problem – the states of the external world that can be manipulated and the states and operations in the technology – and a mapping between the two (Payne et al., 1990).

However, mental models have been studied in quite constrained contexts, often in word processing or spreadsheet-related tasks. They have not been considered for appropriation-like problems. For pursuit of research in this area, the mental model theories will need to be extended so as to describe how the situational features are used in interaction. One opportunity for this is found in Wright et al.'s DCog-based model of interaction resources (2000). The model includes a classification of resources in the environment that can guide the user during interaction. While this model provides an opportunity for further theoretical work for explaining the three mapping processes, this line of research was not pursued in this thesis. Instead, the research strategy desiderata emphasised field experiments and realism.

### 3.5 From a model toward a theory

This chapter began with a model (Figure 3.1) of a repurposive appropriation process in piecewise visual content creation. In itself, the model was descriptive, but the individual sections of the chapter substantiated it by

presenting three theoretical hypotheses for mapping-based repurposive appropriation processes.

One of the definitions posited for the difference between a model and a theory is that models are mostly descriptions of observed phenomena (see Reese and Overton, 1970, on analogue models, p. 119) while theories are explanatory and predictive constructs that can be used to generate hypotheses (p. 124). The hypotheses set forth in previous sections are consistent with these characteristics, providing a coherent picture of different cognitive structures that are important for repurposive appropriation and how they interact with each other. The hypotheses can be summarised as follows:

1. A user is able to appropriate a technology only to the extent that he or she has acquired mental representations related to the features of the technology (Subsection 3.1.1). Broad, surface-oriented knowledge about technologies may support repurposive appropriation especially (Section 3.4). A user who does not possess representations of the features will not be able to map the other situational features to these in any of the three types of mapping. This is because, without the necessary representations, he or she will neither recognise partial solution schemas in the environment's structures (Subsection 3.3.1) nor be able to find mappings between the technologies and the working schema that contains his or her problem representation (Subsections 3.3.3 and 3.3.4).
2. In a corollary to the point above, because of the importance of technology-related knowledge, weak problem-solving methods should rarely result in repurposive appropriations. Similarly, perception of affordances should rarely lead to repurposive appropriations in ICT use, because the opportunities for interaction with most ICTs are not directly perceivable (and therefore recognisable) without some knowledge and interpretation.
3. Opportunities for repurposive appropriations can be discovered both in the context of an immediate need for a solution and outside such a situation (subsections 3.1.1 and 3.3.1). Of the two, repurposive appropriation is more probable in the immediate situation, provided that a technology is present that can serve as a solution. This is because the presence of this technology helps the user perceive a partial solution schema for the problem (Subsection 3.3.1). However, the presence of the technology helps *only* if the user has knowledge about it, as was stated in the first item in this list.



These hypotheses on mapping bring the outcomes of this thesis closer to a theory of repurposive appropriation, particularly in the context of piecewise visual content creation but possibly also more generally. The following experimental designs can be used to evaluate the validity of the three types of mapping described here:

- *Recognition of structures in the environment:* While the claim that people appropriate by observing their environment is almost a truism and cannot be easily subjected to testing, it is possible to investigate the more precise claim that people pay attention to partial solution schemas in their environment and discover novel purposes of use with their help. If solution schemas support repurposive appropriation, users with a certain schema should be more likely to discover a particular repurposive appropriation than other people are.

In a two-stage experiment design, participants could be divided into an experimental group and a control group. All participants would first be taught a number of solutions to ICT-related problems. These solutions would not include repurposive appropriations of technology but would endow users with solution schemas that would be relevant in the second stage. Teaching for the experimental group would include some solutions that the other group would not hear. In the second stage, participants in both groups would be asked to solve a new problem with a set of tools that would be the same for all participants. The tools would support problem-solving in multiple ways, one of which would require a configuration that was taught only to the experimental group in the first stage and that would be atypical when compared to the other possible solutions. If that atypical solution were to be selected more often within the experimental group, this would increase the support for the hypothesis of partial-solution-schema-based repurposive appropriation.

- *Analogical mapping through problem abstraction:* While research (Cheng and Holyoak, 1985) suggests that people are able to, when instructed, benefit from generalised schemas at least when solving logic problems (e.g., Wason's selection task), it remains unclear whether people construct and use abstract schemas spontaneously, without instruction. Research on everyday mathematics suggests that abstract representations are rarely used (cf. Carraher et al., 1985; Lave, 1988; Scribner, 1986). Before an attempt to prove that abstract schemas are constructed and used spontaneously, it would be, as Cheng and Holyoak (1985) also did, useful to show that such a mechanism is

useful. Once a positive result has been seen, further studies could attempt to invoke generalised schema creation without explicit instruction.

An experiment evaluating the benefit of generalisation could follow Cheng and Holyoak's research design, comparing the performance of an experimental group with a control group in a repurposive appropriation task. The experimental group could be taught analogous solutions that require repurposive appropriations before being presented with a repurposive appropriation task. A positive difference in performance would suggest that generalised schemas can support repurposive appropriation. That result would motivate their further research.

- *Analogical mapping between tools*: The hypothesis that a user may notice a similarity between two tools by applying analogical mapping could be studied in a computer game environment. The participants might play a series of puzzle games in which the most obviously suitable solution element would be removed in the middle of the series. In all of the puzzles, other elements could be used as the removed element's replacement in a manner that could be discovered only through an analogy. The hypothesis would be supported if the participants started discovering this solution after the removal of the initially preferred element.

These experiments represent a number of technology usage domains, in diverse areas, and are not explicitly within the piecewise visual content creation scope. This may not be a problem, however. There is no reason why human cognition would function differently in piecewise visual content creation than in other domains that involve problem-solving and use of tools. A broader scope would put the hypotheses to a more critical test.

The hypotheses presented in this chapter have implications both for theories in both cognitive science and HCI. These will be presented in the following chapter.

# Chapter 4

## Discussion

The task for this thesis was to develop a theoretical hypothesis as to the cognitive processes in individuals' workaround-like repurposive appropriations (see Subsection 1.2.3). To address this, the previous chapter presented a model (Figure 3.1) and three suggestions as to how repurposive appropriations take place through mapping processes (Section 3.3). The task presented by the research question is considerable, however, so limitations remain in the work that has been presented. The next section reviews these limitations. The thesis concludes with implications of the findings for future research on technology acceptance, human–computer interaction, and studies in cognitive science.

### 4.1 Limitations

With no existing cognitively oriented theory on individual users' repurposive appropriation processes to proceed from, this work adopted an exploratory research approach. To simplify the theory-building task, the empirical studies addressed only piecewise visual content creation technologies, and only a limited part of the larger phenomenon was selected for study. The primary focus was on individual users' repurposive workaround-like appropriations of technologies that are not re-programmable (see Section 1.2). The influence of other users' suggestions, discoveries of novel activities with technology, gradually changing use processes, and technology modifications were, therefore, defined to be outside the focus of the research. In addition, the theoretical part of the work was focused on that part of the perception–action cycle that describes how schemas direct users' exploration of their environment (see Figure 3.3). Addressing the full cycle would

have covered also the processes with which users set out to verify their perceptions through tools' use and with which their technology-related mental representations undergo changes.

The thesis began with a presentation of open-ended field experiments and a synthesis of their findings, and the discussion concluded with a look at three cognitive mapping processes. This process required two substantial interpretive steps related to assumptions as to (i) the importance of technological understanding and (ii) mapping-like processes as a basis for repurposive appropriation. Both of these steps were derived mostly from the Web survey study of digital cameras (Section 2.4 and Paper 6). Drawing such inferences about mental contents or processes from Web survey data is methodologically problematic. In the survey, the questions addressed practices by which respondents learn about the technological aspects of digital photography (see Table 2.6, p. 57). In relation to step i, mental representations were cited as an important factor because high scores were associated with high levels of repurposive appropriation. As for step ii, respondents' open-ended qualitative descriptions of their repurposive appropriation situations appeared to be based on an underlying mapping-like process. The findings related to both steps should be confirmed in future research with experimental methods.

The two interpretive steps presented above are critical, because the theory-building in Chapter 3 is dependent on their validity. This uncertainty related to the theoretical inferences was, however, considered deliberately. Because a theory addressing the individual user's repurposive appropriation has been missing, the suggestions made in this thesis provide a novel starting point for further research, critical evaluation, and attention to design implications.

However, empirical evaluation of theoretical hypotheses is not the only method for evaluating a research contribution. A study may contribute to research also by clarifying poorly understood issues and exposing problematic assumptions that previously had remained ignored. In addition, the work can be of practical value. These contributions are presented in the following sections.

## 4.2 Computational simulations

The ontological commitments of the previous chapter's hypotheses can be analysed critically through their comparison to recent computational models of human cognition. Given that such models have been developed to simulate human cognitive processes to the best of current knowledge, the

previous chapter's hypotheses on the structure of solution schemas and the mapping processes should not diverge radically from the premises of those models.

The first of the three types of mapping – recognition of structure from environment – resembles pattern recognition wherein the patterns consist of perceptions of situational features. A pattern leads to a repurposive appropriation if it *reminds* the user of a previous problem-solving situation in which similar features were present. Reminding has been modelled in *case-based reasoning* theories (Kolodner, 1993; Kolodner and Simpson, 1989) and their predecessors (Schank, 1982). These theories and their simulations suggest that humans reason on the basis of memories of previous experiences. The experiences of similar situations are related to each other by their differences from a prototypical experience. When a human processes a new experience, the new experience serves as an index to the prototype in the memory. This provides quick access to the nearest previous experience that has a similar schema. Case-based reasoning can be applied to repurposive appropriation by considering the incomplete solution schema as a pattern that retrieves an experience of a situation from the user's memory. Repurposive appropriation results if the retrieved memory amends the pattern with a representation of a possible problem. This completes the pattern in the form of a solution schema.

Another possibility would be a simulation based on *template matching* (Gobet and Simon, 1996, 2000) in which the pattern recognition process is based on a recursive hierarchical comparison of memory chunks (Feigenbaum and Simon, 1984). The template theory suggests that competent problem-solvers' memories contain a large number of templates – schemas with empty slots that can be filled with information. Chunks and templates are stored within a 'discrimination network' that has the structure of a classification tree and simulates long-term memory. Template theory has been developed into a simulation, called CHREST (for 'Chunk Hierarchy and Retrieval Structures'; Gobet and Simon, 2000), that predicts how chess players reconstruct chess positions after brief presentations of the board. CHREST has also been developed to simulate spontaneous recognition of patterns (Gobet, 2005).

In terms of the structure of representations, both the template theory and its predecessor, chunk theory (Chase and Simon, 1973a), provide support for the structure of solution schemas presented in this thesis. The template theory presents two types of chunks – perceptual chunks and action chunks – which can be associated with each other through production links. Thus, when a person perceives a pattern of situational features, the

recognition process identifies the chunks and templates that best represent this pattern, and the result is used as an index to a solution representation (Lane et al., 2001, p. 893). However, the template theory simulations published until now have operated in the visual perception domain, with examples being chess board recall and electronic circuit diagram analysis. This is a simpler domain than what repurposive appropriation involves, and the model also assumes that perceptual and action chunks can be represented in a uniform manner. This assumption is unproblematic in, for example, circuit diagram analysis, where perceptual chunks related to target diagrams' images can be treated also as action chunks in problem-solving (Lane et al., 2000). However, in the case of repurposive appropriation, the representations of perceptual chunks and action chunks will differ. This leaves as an open question how to model the discovery of production links between chunks of situational features and chunks of possible action sequences. Representing action sequences may require a formalisation other than a discrimination network.

The second type of mapping – analogical mapping through problem abstraction – requires a different kind of architecture, because it involves comparison of two solution schemas with each other through an abstraction. Three simulations exist that do this. The Structure-Mapping Engine, or SME (Markman and Gentner, 1993), searches for analogies between hierarchically structured problem schemas by using local-to-global matching of structural similarities. Analogical Mapping by Constraint Satisfaction, or ACME (Holyoak and Thagard, 1989), is additionally able to find analogies in the presence of also other than purely structural constraints. Finally, LISA, standing for ‘Learning and Inference with Schemas and Analogies’ (Hummel and Holyoak, 2003), is a symbolic–connectionistic model that also takes into account the constraints of working memory and is based on a neural architecture.

The third type of mapping – analogical mapping between tools – resembles *relational mapping* and *constraint satisfaction* in that the user needs to find a new representation to replace another representation in an otherwise complete solution schema. This requires alignment of new representation with the existing relations (and, thereby, constraints) of the schema. The same simulations as above – SME, ACME, and LISA – appear to be suitable for this task. The assumptions made about mental representations in LISA are centred on the question of finding a way to implement symbolic representations on a neural basis. Beyond that, LISA is able to model any set of representations that can be expressed as propositions. Because solution schemas can be expressed as propositional networks (see Subsection 3.1.2),

LISA permits the representational assumptions adopted in this thesis but does not specify them further. In terms of simulations of repurposive appropriation, there appear to be no theoretical reasons for not using LISA if the size of the propositional network is increased to the level of the two types of mapping addressed in the previous chapter. Such attempts have not been published yet, however.

Analogical problem-solving has been modelled also by means of the Adaptive Control of Thought–Rational (ACT-R) production system (Salvucci and Anderson, 2001). However, that model cannot evaluate multiple simultaneous relations between the two schemas and can be led astray easily by superficial similarities (Lovett and Anderson, 2005, p. 410).

In summary, one can tentatively state that it seems possible to model repurposive appropriation computationally with the existing computational models for cognition. This means that repurposive appropriation – although it is a creative process involving a large amount of interaction with the situation – may be explained as an ordinary cognitive process.

### 4.3 Repurposive appropriation and acceptance

Studying repurposive appropriation helps one recognise that a system’s success cannot be measured with a single variable only. Instead, the same system may be useful in different ways in different situations and with different users. This claim is in interesting conflict with the studies in IS research that have focused on technology ‘acceptance’. Typically this variable has been operationalised as extent of usage, either as use frequency or as use duration (for reviews, see Lee et al., 2003; Schwarz and Chin, 2007). The main predicting variables have been the perceived ease of use and the perceived usefulness (e.g., Davis, 1989; Davis et al., 1989). In more recent studies, also antecedent predictors and moderating variables have been introduced (Venkatesh and Davis, 2000). The best technology acceptance model to date has been claimed to predict as much as 53% of the usage variance and 69% of use intentions (Venkatesh et al., 2003). With such high levels of explanation, TAMs have been lauded as empirically robust models and have therefore become one of the most widely applied theoretical frameworks within IS research (Lee et al., 2003).

However, this thesis has provided evidence that casts doubt on the validity of many TAM-based research findings. Reasons for this have been presented in Paper 5. Most importantly, TAM-based research has not acknowledged the variety of use purposes for which technologies actually are used. Paper 6 indicates that, on average, 48% of camera users have used

their camera(s) for atypical purposes at least once. Acceptance studies within IS have largely omitted such uses from their research models, even if they appear to be quite common.

Most users apply the same technology for different purposes at different times, and users also differ from each other (see Orlikowski, 1992b, 1996; Majchrzak et al., 2000; Tyre and Orlikowski, 1994; Lassila and Brancheau, 1999; Paper 5 and Subsection 1.1.6). These findings suggest that, instead of a single-measure approach as adopted in TAM studies, the starting point should be to acknowledge that users' judgements of perceived usefulness are based on very different orientations in different situations. The same argument applies to the perceived ease of use. The dominant line of thinking has until now been the opposite, with an assumption that all use can be measured in a uniform manner.

In some studies, discrepancies arising from simplistic definition of the dependent variable have already been observed. For example, some studies of Web acceptance have suggested that a new predictor – perceived enjoyment – is more important than perceived usefulness is (van der Heijden, 2004), while other studies have pointed toward the opposite result – that perceived usefulness is the strongest predictor of Web acceptance (e.g., Cheung et al., 2000). A likely reason for the discrepancy is that authors have treated the Web as a technology differently: as a means for enjoyment (van der Heijden) or as a utility tool (Cheung et al.). They have not validated their assumptions as to the Web's hedonistic vs. utilitarian nature with users, instead postulating these by themselves. Subsequently, they have recruited participants from different directions: from a film hobbyists' Web site (van der Heijden) and from a university notice board (Cheung et al.). As a result, the studies have probably investigated two different kinds of phenomena. Yet the authors in question have not made this explicit. In fact, they instead have generalised their findings to cover all uses of the Web, thereby producing conflicting results.

The high  $R^2$  values present a puzzle. If the dependent variable is defined in an insensitive manner, without acknowledgement of the varying purposes of use, it should introduce unexplained variance in the model and lead to low explanatory power. However, even though the variety among diverse purposes of use has not been included in TAMs, the findings have consistently shown high  $R^2$  values (as seen also in the study of Web acceptance). There are at least two tentative explanations for this.

First, it may be that the technologies studied have been so constrained in their use that successful predictions result, by necessity, from the contextual constraints. In other words, the policies and practices in the organisa-



tions and communities studied may have been so strict that the technologies were used only in the ways expected by the researchers, thereby removing the additional variance. In their review of 22 TAM studies, Legris et al. (2003) stated that most studies have examined office automation software (e.g., spreadsheets, mailers, and word processors) or systems development applications (e.g., programming tools). The review does not reveal how strictly the technologies' use had been prescribed in the 22 organisations. Accordingly, whether the high  $R^2$  values are a result of homogenous use practices in these contexts remains unproven.

Second, the relationship between the independent variables (perceived usefulness and perceived ease of use) and the dependent variables (intention to use and actual use) may be a truism. It appears typical in TAM studies to define both the dependent and independent variables very broadly. For example, perceived usefulness can be measured with statements such as 'my job would be difficult to perform without electronic mail' and 'using electronic mail improves my job performance' (Davis, 1989, p. 324). These statements do not specify the manners or purposes in which the technology is used. Paper 5 notes that, upon seeing such statements, the respondents can interpret them through their own intentions of use or actual ways of use. Active users and respondents with positive use intentions are likely to give higher ratings for such statements. This means that the correlations between the dependent and independent variables are likely to be strong in most cases. A negative correlation (e.g., low acceptance but high usage) is likely only when a technology use is enforced while its use is, in fact, complicating the work. The other possible reason for a negative correlation – high acceptance but low usage – would apply only in organisations that hinder people from using tools that they have provided to workers. Such a situation is very rare. Thus, the odds of high  $R^2$  values are likely to be high with any technology<sup>1</sup>. The problem with this possibility is that the independent and dependent variables mean different things for each respondent. This means that the model cannot be used as a guide for development of more accepted technologies. It will be unclear how to improve usefulness and ease of use if their meaning differs from one user to the next.

However, more critical evaluation of TAMs and empirical research on repurposive appropriation in an organisational context is needed if we are to explain the conflict between the TAM-based findings and the predictions related to heterogeneity that follow from studies of repurposive appropriation.

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<sup>1</sup>In inspiration for this reasoning, I am indebted to a remark of my supervisor Antti Oulasvirta on circular logic in TAM research.

## 4.4 Repurposive appropriation by an individual in a social context

The theoretical focus of this thesis has been on the individual user, leaving much of the user's social context unaddressed. In reality, however, people are always embedded in a social context, and this can be expected to have a strong effect on their knowledge, thinking, and ways of perceiving and interpreting events and situational features. More extensive consideration of the social context therefore will provide multiple ways of extending the theory-oriented hypotheses presented in the previous chapter. The following paragraphs suggest two starting points for such extensions.

First, this thesis suggests that the user's existing knowledge is important in repurposive appropriation and that this knowledge is represented with mental representations of situational features and solutions. What is not addressed in the previous chapter is the question of how the user has learnt the mental representations that constitute his or her existing knowledge. A significant amount of human knowledge is learned from others (e.g., Tomasello, 1999; D'Andrade, 1995; Wegner, 1986). In the situation in which the user appropriates, even when acting alone, he or she will therefore make use of knowledge that has social origins. One question of relevance for this thesis is whether the knowledge that has been arrived at via others is different from knowledge gained by the individual alone when used as a basis for repurposive appropriation. For better understanding of this question, research would be needed for investigating the processes of how knowledge, especially technology-related knowledge, is obtained.

Second, users not only learn from others but also can act as sources of knowledge. Solution schemas, by being mental representations of technology use, can be propagated to other users through teaching, demonstration, or passive observation on the part of the learner. In the framework of the proposed theoretical hypotheses, spreading of a repurposive appropriation can be understood as propagation of the corresponding solution schema among users. This parallels the conceptions within DCog, which sees co-operative activities as propagation and computation of representational states (Hutchins, 1995a). Propagation of solution schemas is a process in which the mediators have been found to play an important role (see Subsection 1.1.3). Each user, upon learning about another user's repurposive appropriation, makes interpretations related to that use. The solution schema may change as it propagates in the user community. This conceptualisation may provide a means of combining the hypotheses pro-

posed here with the theories and empirical evidence on social aspects of repurposive appropriation.

When the models and the theory development from Section 2.5 onward are compared to the socially oriented studies reviewed in Chapter 1, it is important to notice that the interpretations of the term ‘appropriation’ differ across different research domains. The conclusions and propositions – focusing on repurposive appropriations and individuals – made in this thesis can be used to complement the findings from the other domains. The unique starting points for theory development in this thesis – those of mental representations and situated problem-solving – are not in a theoretical conflict with the socially oriented approaches, save for one domain. In ethnomethodology and conversation analysis, many researchers are sceptical of applying any mentally-framed concepts to analysis of activity. This conviction stems from a devotion to base findings only for such matters as can be observed directly in naturally occurring interaction (e.g., Potter and te Molder, 2005). Among the authors whose works are mentioned in Subsection 1.1.2, Button et al. reject theories based on mental representations, Suchman has some reservations as to representations’ explanatory value, and Brown and Perry do not appear to take a stance on this issue. Also, Papers 3 and 4 in this thesis applied the concept of ‘resource for action’ from the ethnomethodological framework without a conflict arising with the ontological status of mental representations.

Integrating the outcomes of this thesis and those of socially oriented studies into a larger framework of repurposive appropriation requires bridging that has not been attempted in this study. One element in need of further work involves *co-discovery*. Repurposive appropriations can also be co-discovered by a group of people acting in the same situation. In this case, the co-present people do not simply provide suggestions (as classified in Table 2.2) but may contribute significantly to the discovery as equal partners. Such situations may require different theoretical models than the ones presented in this thesis. In particular, the theoretical hypotheses regarding mapping and partial solution schemas (which are easiest to understand as the individual user’s cognitive processes and knowledge) may need to be extended. Another element requiring further research is the *sharing* that takes place after a piece of content has been created (see the step labelled ‘sharing’ in the situated content creation model in Figure 2.8). When a piece of content is shared with others and repurposive appropriations have played a part in the creation of that content, different receivers of the content will pay attention to the novel parts of the content to differing extents and in different ways. The resulting changes in technology use practices

may vary a lot and lead to further conversions, which currently are poorly understood. Finally, future research should also attempt to investigate gradual processes in which novel purposes of use may be discovered without distinct events of mapping or other insights. Muller et al. (2005) have maintained that shared technological resources develop in a piecemeal fashion. Whether mappings play a role also in gradual appropriation processes requires further research.

## 4.5 Supporting repurposive appropriation in HCI

Part of the research agenda in HCI is to increase knowledge of how to design better technologies. Research into repurposive appropriation supports designing technologies that can be useful in more than one way. The most straightforward design implications presented in the literature so far (e.g., Dix, 2007; see Subsection 1.1.1) have been largely based on a common-sense understanding of good design without empirical or theoretical backing. This thesis substantiates such implications in the following ways, where the terms in brackets are from (Dix, 2007):

1. Technological features should be easily observable (i.e., ‘provide visibility’). Doing this will help the users better recognise technological features that are relevant to their present goals and map them to their working and solution schemas. Good observability also helps users recognise entirely new solution schemas. An example of good observability is the small mirror located next to the camera lens of an Ericsson mobile phone. This helped one of the respondents in the Web-based survey study to recognise the possibility of using the mobile phone camera as a mirror (see Table 2.7, on p. 60). Had the mirror not been there, the respondent may not have noticed this opportunity.
2. Connectivity with other technologies (i.e., ‘plugability and configuration’) makes a technology more easily appropriable. In the manner described above, also connectivity increases the number of ways in which users can map the features of the technology to other features of the environment and their schemas. For example, modern mobile phones have an extensive set of wired and wireless ways in which they can exchange digital content with other systems. Phones typically afford easy sharing of content from the phone to other systems but inform much less (except for music and videos, for which many

phones have dedicated software) about the option of serving as media storage for other systems' digital content. As another example, content-editing systems should provide multiple import and export options in order to support connectivity (see also Twidale and Jones, 2005, for examples of using copy-and-paste features in different work flows). Provision of such connectivity alternatives would increase the likelihood of mappings between tools and solutions.

3. Technology should be responsive and allow exploration (i.e., 'support not control'). Immediacy and interactiveness encourage the user to engage in move-testing experiments (cf. Subsection 3.1.2, p. 80). Being able to manipulate the technology and the content helps users notice more mappings with the environment and also find analogues from their memories. The mobile comic-strip creator *Comeks* was an example of this. Its UI allowed direct manipulation (cf. Hutchins et al., 1985) of visual content. While the absence of a point for comparison means that this cannot be proved, the exploratory storytelling messages may have been a result of the ability to explore with the content-editing features.

The theoretical hypotheses also point to the following novel design implications related to the important role of mental representations in repurposive appropriation.

1. Breadth of technological knowledge may be more important for repurposive appropriation than depth is. In stark contrast, the previous literature (e.g., Norman, 1988) has maintained that the system's design must help the user develop a correct mental model of the system's internal operation. This has emphasised the importance of depth-oriented technology understanding.

The emphasis on breadth turns the focus toward (i) the discoveries that the user can make from the UI and (ii) the solution schemas that the user can learn from interaction. To increase the breadth of the user's knowledge, the UI could proactively (Salovaara and Oulasvirta, 2004) remind of alternative actions that one can perform with the system. The alternatives suggested could be reminders based on the user's past actions or mention actions that he or she has not tried yet. However, because suggestions may become a distracting experience for the user if taken to an extreme, the feature probably should be used only at particular points in the interaction – e.g., when the user searches for help via a keyword-based search.

2. Technology should be made easy to interpret. This suggestion is in opposition with some previous papers on repurposive appropriation (e.g., Gaver et al., 2003; Höök, 2006; Sengers and Gaver, 2006), which recommend ambiguity as a means of supporting novel interpretations. The present work, in contrast, advocates design that helps users develop solution schemas based on interpretations of concrete effects of technology's features. One way to support this is to let users preview the effects of different actions without changing the actual content. A feature of this sort is already in use in image editors, where the effects of various filters can be tested on a preview image. This could be applied more generally in computer programs through provision of previews within the top-level drop-down menus. This would help users increase their awareness of a program's various features.
3. Design should support both old and new ways of use. The model in Figure 3.1 shows solution schemas as co-existing in human memory. In other words, when a user discovers a new solution schema through repurposive appropriation, the new schema will not have negative effects on the existing solution schemas. Even when the newly learned creative uses are more effective than the old ones, the user will not forget the old uses or abandon their application. Instead, the user may use the system in both the old and new ways as he or she deems appropriate. Existing research on repurposive appropriation has not addressed this phenomenon, although it has implications for system design. In particular, customisable and user-programmable technologies should not be designed in such a way that new adaptations disable old uses. Designers should be careful if they intend to allow or force removal of old features when new ones are added.

As a final note, Paper 6 indicated that a significant proportion of users are capable of appropriating technology. This capacity should be brought into better use by increasing users' awareness of opportunities to appropriate. Design should promote 'open-minded use': a mindset that would direct users to 'stay open to (new) interpretations' (Sengers and Gaver, 2006). Seemingly extraneous situational factors are easily filtered out from users' attention. Systems should help users to overcome this limitation. For example, sometimes content creation becomes easier if its tasks are carried out by means of two different systems. However, the user may not recognise this possibility. In this situation, the individual editing programs could better inform as to which methods they can provide for information exchange between each other. Another application of this idea is the no-

tifications that computers often display if they discover a trusted nearby mobile device that can act as a wireless modem, data storage, or a messaging gateway. These notifications help users become better aware of the possibilities of the surrounding technology ecology.

Repurposive appropriation is a positive phenomenon in practically all technology use. Appropriability increases systems' usefulness and helps users solve problems that they have not encountered before. By supporting this, it increases both user efficiency and enjoyment. A significant proportion of modern life is related to the use of various technologies. If these technologies support natural repurposing and allow frictionless adaptation for a wide range of purposes, our day-to-day life is improved. Repurposive appropriation is, therefore, at the core of good design and deserves more attention from design and research.

## 4.6 Implications for research and theories on cognition

Repurposive appropriation as a phenomenon involves many challenging features for research into cognition. It is self-directed, creative, dependent on expertise, and something that takes place in the user's technology-mediated interaction with the environment. These features lead to challenges in achieving sufficient experimental control and reducibility to independent phenomena that can be studied rigorously.

This thesis has suggested a way in which repurposive appropriation may be theorised about through cognitive constructs and hypotheses that can be subjected to more in-depth scrutiny. On the basis of the empirical work and the hypotheses that were developed in the previous chapter, the present work suggests three implications for cognitive science:

1. The role of technology-related knowledge should be better understood. The thesis suggests that this understanding plays an important role in repurposive appropriation. Furthermore, it suggests that this applies especially for breadth-oriented knowledge. These hypotheses would need empirical verification. Ideally, this should include investigation of the dimensions of technological knowledge (e.g., breadth, depth, and accuracy) in general.
2. Solution schemas should be better understood. This thesis assigns them an important role in repurposive appropriation, both in the execution of actions and in the recognition of problem-solving solutions

in the environment. However, it does not make suggestions as to their exact structure. It is only hypothesised that they contain two parts: a mapping of situational features that are relevant in a solution and a description of actions to be performed on these features.

3. Research should pay more attention to creative use of problem-solving operators, such as the cognitive and physical tools that are used in the course of a search for a solution. The operations that solvers choose to carry out are heavily dependent on the representations of the available tools. Despite the importance of tool-related knowledge, researchers for the most part have studied how the problem representations for the entire problem are changed before a successful solution can be found. In contrast, repurposive appropriation draws attention to *operator creativity* – creative use of operators (i.e., tools) that solvers decide to use in their path toward the solution. Operator creativity can change the solution schema of any problem, even a routine one, by restructuring the prototypical sequence of actions needed for reaching the goal. Therefore, studying problem-solving operators may have relevance far beyond the scope of repurposive appropriation.

As is stated in the first chapter, appropriability is a general quality factor that applies to practically any technology. This thesis has provided viable hypotheses for a theory of repurposive appropriation by grounding its hypotheses empirically in field experiments and surveys in HCI and theoretically in cognitive science and psychology. Further research on repurposive appropriation and application of the findings within the HCI field may have a significant effect on daily problem-solving and living.



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