More Than Writing Text: Multiplicity in Collaborative Academic Writing

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Ph.D. Thesis

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More Than Writing Text:  
Multiplicity in Collaborative Academic Writing

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by
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Abstract

This thesis explores collaborative academic writing with a focus on how it is mediated by multiple technologies. The thesis presents findings from two empirical studies with university students and researchers: The first combined semi-structured interviews with visualizations of document editing activity to explore transitions through co-writers’ artifact ecologies along with co-writers’ motivations for performing these transitions. The second study was a three-stage co-design workshop series that progressed from dialog through ideation to exploration of a prototype for a shared editor that was based on the participants’ proposed features and designs. The contribution from the second study to this thesis is the analysis of participants’ viewpoints and ideas.

The analyses of these findings contribute a characterization of co-writers’ practical and social motivations for using multiple tools in their collaborations, and the challenges this poses for sharing and addressing the work. Multiplicity is also addressed in terms of co-writers bringing multiple and diverse needs and preferences into the writing, and how these may be approached in efforts to design and improve support for collaborative writing. Additionally, the notion of text function is introduced to describe the text’s role as a mediator of the writing. This notion is applied in an extended analysis of the relationship between characteristics of the tools in use and the ways in which co-writers are able to organize themselves and their efforts around a common text.

In sum, this work constructs an understanding of collaborative writing as mediated by multiple artifacts and situated in a web of activities, practices, and human interaction.
Titlen på denne sammenfatning kan oversættes til: *Mere end at skrive tekst: pluralitet i akademisk samskrivning.*

Denne sammenfatning undersøger akademisk samskrivning med fokus på, hvordan den er medieret af mange teknologier. Sammenfatningen fremstiller resultater fra to empiriske studier med universitetsstudierende og -forskere: I den første blev semi-strukrerede interviews kombineret med visualiseringer af redigeringsaktivitet i et dokument, med det formål at udforske transitioner gennem medforfatteres artefaktøkologier og medforfatteres motivationer for at udføre disse transitioner (medforfattere bruges i betydningen: “folk der skriver sammen”). Det andet studie var en serie af co-design-workshops i tre trin, som gik fra dialog over idé-generering til udforskning af en prototype på et delt tekstredigeringsværktøj, som var baseret på deltagernes forslag til funktionalitet og design. Dette studies bidrag til sammenfatningen er analysen af deltagernes synspunkter og idéer.

Analysen af resultaterne bidrager med en karakterisering af medforfatteres praktiske og sociale motivationer for at anvende mange redskaber i deres samarbejder, samt de udfordringer det bringer med sig i forhold til at dele og adressere arbejdet. Pluralitet bliver også adresseret i form af de mange og forskelligartede behov og præferencer, som medforfattere bringer med sig ind i skrivningen, samt hvordan denne forskellighed kan adresseres i arbejde med at designe og forbedre understøttelse af samskrivning. Ydermere bliver begrebet tekst-funktion ("text function") introduceret for at beskrive tekstens rolle som medierende for skrivningen. Dette begreb anvendes i en større analyse af forholdet mellem karakteristikker ved de redskaber, der anvendes, og måderne hvorpå medforfattere er i stand til at organisere deres arbejde omkring en fælles tekst.

Alt i alt opstiller dette stykke arbejde en forståelse af samskrivning som medieret af mange artefakter og situeret i et netværk af aktiviteter, praksisser og menneskelig interaktion.
Corrections

This page describes corrections made to the thesis after its approval, by agreement with the assessment committee chair, Ira Assent. The corrections were made on November 1, 2020.

Chapter[1]—Minor Corrections
P. 4: relationships to each other → relationships to one another
P. 5: carried out, findings supported → carried out; findings supported
P. 5: Chapter chapter 4 → Chapter 4
P. 6: On the basis of this, it proposes → On the basis of this, the chapter proposes
P. 6: The chapter discusses → Chapter 6 discusses
P. 6: a question protocol to address → a protocol based on questions meant to address

Chapter[1]—Additions
PP. 3–4, under the heading 2. Mediated:
The concept of mediation [29] directs focus away from the typing and other interactions with the computer and over to the work that is accomplished through the typing and the various other interactions with devices and software.

(…)
Mediation refers to the way these activities happen through the use of tools [29]. By characterizing collaborative writing as mediated I want to emphasize the mutual relationship in which tools and activities shape each other, as opposed to focusing only on the tools themselves or on those of their features designed specifically for writing and/or collaboration.

Chapter[7]—Minor Corrections
P. 127: [131, introduction] → [131, Introduction]
P. 127: (see 6 on page 95) → (see quote 6 on page 95)
P. 134: Fluid [166] As this → Fluid [166]). As this
P. 134: locate each other, and → locate each other and
Acknowledgments

I am thankful to many people for the parts they have played on my journey here. I hope my sincerity is not obscured by the abundance of words on these pages.

I have many things to thank my advisor, Susanne Bødker, for. First of all, thank you for helping me get to this point. Thank you for suggesting that I study collaborative writing, a topic I am very glad to have ended up working with. Thank you for planting seeds in my head that grew into (mostly) interesting ideas. And thank you for seeing me for who I am as a person.

Although, somewhat ironically, most of the chapters in this piece of writing have been authored by a single person, all of it has grown out of a confidence and a trust in the people I have worked with, and the mutual confidence and trust they have shown me. A special thanks to Henrik, Susanne, and Marcel for being my co-authors.

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Thank you, Mich, for the countless number of times you and the IT support team have helped me with all sorts of problems, including your patient email communications with me. Also a big thanks to Marianne for all the work you do to make the machinery run smoothly, among other things by answering a lot of practical questions from me and proofreading journal-length papers. And thank you, Tina, for always being there for me and all of the other students and employees at CS, to help with anything from understanding vacation schemes to needing a band-aid. And for always making everyone know you’re happy to see them.

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I would like to thank Dat1 (known to friends as DatAss), for making university be about more than books, assignments, and exams. A special thanks to Astrid and Else (in increasing alphabetical and numerical order, as well as by decreasing length, as per our convention) for fighting your way through the bachelor’s degree with me. I also want to thank Anke and Nathalie, for a friendship with space for sharing ups and downs during the Ph.D. work. My other colleagues in Ada-1 and Hopper-1 also deserve a huge thanks, for believing in me both before and during my Ph.D. studies. In particular Peter Lyle has been, and continue to be, a great friend and support.

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Thank you, Mom and Dad, for always letting me know I was special to you — even if “I’m sure all the other parents think that about their children, too”. With this thesis, I may be standing on the shoulders of giants, but you lifted me up so I could climb here.

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Ida Larsen-Ledet,

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Included Papers

Publications


Unpublished Manuscripts


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Part I

Overview
Chapter 1

Introduction

“You don't just do collaborative writing.” This was said by a person who kindly spent some of their free-time participating in the last study I conducted as part of my Ph.D. project. As this person was telling me and his fellow workshop participants, there is a lot more to collaborative writing than just the writing itself. Co-writers need a confidence in each other, which is a human aspect “that is solved outside the software,” as he put it. My field of study, computer-supported cooperative work, is full of things that take place outside the technology in use, such as embodied articulation of software design [208] or the orchestration of multiple technologies to facilitate nomadic work [207]. This work outside the software, and how it relates to what goes on in the software, is part of what makes this field of study so challenging and fascinating. In addition to the human aspects that workshop participant was talking about, there are also plenty of other things going on outside the writing software: Co-writers organize turn-taking that must fit in with their other obligations; they discuss printed drafts annotated with feedback; and they deal with disagreements over where the writing is headed. Furthermore, “the” software is never just one application or one device.

To me, computer-memediated collaborative writing is characterized by being:

1. **Centered around a common object of work:**
   Collaborative work may not necessarily be focused on one or the same object of work for all those partaking in the work [15]. Collaborative writing, however, is focused on the production of a text that is the object of co-writers’ attention during most of the work [156]. There may be numerous other artifacts involved, such as drafts, notes, and annotated versions, but the text is the central, common focus of all involved.

2. **Mediated:**
   Writing collaboratively is, in several ways that will be elaborated in this thesis, more than just people typing on computers. The concept of mediation [29] directs focus away from the typing and other interactions with the computer and over to the work that is accomplished through the typing and the various other interactions
with devices and software. Computers, applications, and other artifacts mediate complex activities that rely just as much on developed and developing practices as on technology. In addition to writing text, collaborative writing involves co-writers negotiating the tools to be used; continuously working to align their expectations and contributions; dealing with aspects of human nature like conflict and concerns for presentation of self; etc. Mediation refers to the way these activities happen through the use of tools. By characterizing collaborative writing as mediated I want to emphasize the mutual relationship in which tools and activities shape each other, as opposed to focusing only on the tools themselves or on those of their features designed specifically for writing and/or collaboration.

3. Multiple:
All human activity is multi-mediated, with individuals and groups managing ecologies of artifacts and adapting them to changing abilities and needs. To facilitate the complex work of collaborative writing, co-writers rely on multiple tools for writing, coordinating, getting feedback, etc. As stated above, collaborative writing is also multiple in terms of the many other artifacts involved and the multiple aspects of collaborative activity that co-writers are dealing with.

While there is plenty of software made to support collaborative writing, considering just that software is too narrow of a scope. We must also address the multiplicity of artifacts mediating the writing and the practices and strategies used by co-writers to align their multiple efforts directed toward a common object of work. This includes addressing how those practices and strategies are influenced and motivated by both practical and social concerns.

Early CSCW (Computer-Supported Cooperative Work) research on computer support for collaborative writing, in the 1980s and early 1990s, was naturally dominated by technological development, without much room for concern for subtleties of human activity: New tools demonstrated ways to have access to a document across computers and communicate about the writing, and theoretical work improved the mechanisms underlying those functionalities. The field has since grown to include work on not only sharing of files and messages but also awareness of co-writers’ whereabouts and activities, to name a prominent example. Alongside technological developments and proposals for features, and evaluations of these, there has also been an empirical interest in how collaborative writing takes place, starting as early as 1987 but with a much smaller presence in the literature.

Newer empirical work has been used to characterize collaborative writing as a complex process influenced not only by issues of coordination and agreement on responsibility among many co-writers but also by social norms and the effects they have on co-writers’ relationships to one another. Birnholtz and Ibara describe how co-writers attribute social meaning to the way work is
1.1. OVERVIEW OF THE CONTENTS

carried out; findings supported by Wang et al.’s description of social norms among co-writers [252]. Both of these works describe how the socially situated nature of collaborative writing is connected to the tools that co-writers use for writing and the features they use to give feedback, as well as the ways in which they use them.

This more recent work describes some of the motivations at play in today’s collaborative writing. It also leaves a number of open questions, including the following which are addressed in this thesis:

- (How) do different tools used for collaborative writing complement each other, or (in terms of co-writers’ perspectives) what motivates co-writers to use and move between multiple tools?
- What challenges does multiplicity pose for co-writers during collaborative writing?
- What are the related challenges for designers who aim to improve support for collaborative writing?

This thesis addresses those questions through analyses of two empirical studies with people who have experience with collaborative writing in university settings (detailed further in chapter 3). The work was carried out as part of the Common Interactive Objects (CIO) project which has among its objectives to offer a new understanding of human-computer interaction with a focus on malleability, control, and shareability, and to empower people to better understand and develop the technologies they use. I have worked towards these goals by focusing on co-writers’ ability to make transitions between tools in their artifact ecologies and by questioning the ways in which this is facilitated or becomes problematic for co-writers. In the following section, I outline the resulting contributions as they will appear through the thesis.

1.1 Overview of the Contents

The two publications included in this thesis (chapters 4 and 5) describe findings from empirical work conducted in the spring and summer of 2018. These are followed by an unpublished manuscript (chapter 6) describing a series of workshops conducted from the fall of 2019 to late winter 2020.

Chapters 4 and 5 are based on an interview study with university students and researchers. Chapter 4 additionally analyzes visualizations of documents from interview participants’ own collaborative writing projects, written in Google Docs. Methodologically, this work adds to the literature by studying week- and month-long projects, compared to shorter, task-based projects which are more frequently studied [e.g. 27, 188, 261]. Chapter 4 further contributes to the literature by relating participants’ reflections to traces of the work they describe.

Chapter 4 centers on the management of boundaries between individual and shared work. It thereby describes and analyzes a subset of co-writers’ motivations
for performing transitions through the writing ecology (referred to in chapter 4 as separation and analyzed along with other strategies for boundary management).

Chapter 5 instead takes a birds-eye view by categorizing the transitions according to four types of motivation for performing them: Functional transitions, communication transitions, aesthetics and user experience transitions, and personal space transitions (the latter describes the kinds of transitions analyzed in chapter 4). It furthermore analyzes the text’s role in mediating collaborative writing.

Chapter 6 describes a series of co-design workshops with participants from the interview study as well as newly recruited participants. The co-design approach is novel in work on collaborative writing and a number of reflections on the use of the method are included in chapter 3. Chapter 6 discusses co-writers’ opinions of collaborative writing and the tools they use for it, identifying a number of contrasts in them. On the basis of this, the chapter proposes a protocol based on questions meant to address multiple and sometimes conflicting practices and preferences when designing for collaborative writing.

Drawing on insights from these three chapters, chapter 7 analyzes collaborative academic writing in terms of mediation, development over time, and multiplicity. This is followed, in chapter 8, by the outline for an approach to critically examine the conceptualizations at play in the design of computer applications using Fauconnier and Turner’s theory of conceptual integration.

Chapter 9 concludes the thesis with a discussion of computer support for collaborative writing in light of the presented research, along with minor commentary on aspects of the empirical work and theoretical concepts introduced in the thesis. The degree to which the research questions have been answered is also assessed.
Chapter 2

Related Work

Collaborative writing has largely come to be synonymous with computer-mediated collaborative writing. In this chapter, I therefore focus on the literature that, to a greater or lesser degree, addresses aspects of collaborative writing related to computer-mediation. The papers and manuscript included in the thesis (chapters 4, 5) include additional related work which is relevant for the individual chapters but has not been included here. There is some overlap in the related work presented in those chapters, in particular among chapters 4 and 5, but generally, the three papers cover different aspects of the literature.

Collaborative writing has been a topic of interest since early on in the study of CSCW. Research on the topic started becoming widespread in the 1980s, with the development of early tools to support multi-author documents [69, 80, 93] and investigations into the relationship between digital technology and collaboration [6, 138]. The technological contributions from the early 1990s placed their emphasis on how to implement and improve essential functionality, such as coupling windows in a multi-window workspace [71] or supporting synchronous as well as asynchronous cooperation [110]. Some have additionally presented considerations regarding the need to support a diverse set of contextual and social needs [103, 178].

This chapter has three parts: Section 2.1 outlines the kinds of collaborative writing that have been studied. Section 2.2 summarizes ways in which collaborative writing has been studied. Finally, section 2.3 describes six topics in collaborative writing research that have shaped my own research.

2.1 What Collaborative Writing is Studied?

To provide the reader with a way to situate my research I give an overview of what kinds of collaborative writing that have been studied and what fields are studying it. Collaborative writing is studied several subfields of HCI (Human-Computer Interaction), including CSCW and CSCL (Computer Supported Collaborative Learning), as well as the learning, teaching, and education sciences, from where I also include some examples here although I will emphasize research done within HCI.
CHAPTER 2. RELATED WORK

Academia  Collaborative writing in academic settings has been given a lot of attention in research. One reason for this is likely its easy availability for study compared to other forms of collaborative writing. Central work includes Kraut et al.’s study of the influence of physical proximity on scientific collaborations [138] and Beck’s survey of academic’s experiences with collaborative writing [19]. Kraut et al. conclude that computer-mediated communication must support exchange of text and visuals in both digital and analog media, as well as referencing and modification of those objects, while Beck underscores the significance of writing group dynamics and the challenge this poses for design of tools for collaborative writing.

Education  Collaborative writing in educational settings makes up the other large bulk of the collaborative writing literature. Contributions in particular come from the field of CSCL, with technology-oriented work about non-academic educational settings including development of tools [232] and studies of the effect of using particular technologies in teaching [259]. Contributions from HCI about these settings are mostly limited to tool evaluation studies [52, 86], with Mitchell et al.’s ethnographic study of collaborative writing by students in the sixth grade [169] as an important exception. Mitchell et al. describe among other things the role of gesturing and complex perceptions of the meaning of ownership over text, noting that many of their observations are similar to those made with adult writers.

Research in educational settings often involves university students, not least in the learning sciences where focus is largely on potential benefits or negative impacts of technology on learning [e.g. 27, 45, 56, 143], in contrast to findings from CSCW which naturally tend to focus more on how particular facets of the technologies in use impact, e.g., efficiency and experience. A notable example of this is Galegher and Kraut’s large field experiment [95, 96] which highlighted challenges resulting from using computer-mediated communication rather than interaction face-to-face, such as challenges in coordination [95] and development of positive social relationships [95, 96]. Cerratto Pargman and Rodriguez also report on a field study [53, 54], based on which they similarly argue that support for collaborative writing should aim to support and facilitate mutual understanding [54] and relationships between co-authors [53], and suggest ways of facilitating that (see also the section on socially situated writing further below).

Many of these studies do not focus on university students’ writing practices in particular but instead use university students as a proxy for studying collaborative writing in general. Wang et al., on the other hand, examine patterns of collaboration in undergraduate students’ writing [250], followed up by further studies by Olson et al.’ [188] and Yim et al. [261].

Mixed Academia  There are also examples of studies involving a mix of researchers and university students, notably Rimmershaw’s study of relationships between writing technologies and collaborative writing practices [202] which was not re-
2.2 WAYS OF STUDYING COLLABORATIVE WRITING

stricted to examining a particular kind of writing but interviewed participants about collaborative writing of texts ranging from professional writing, such as research reports and textbooks, to non-professional writing such as birthday invitations and tax returns. Kim and Eklundh include both Ph.D. holders and Ph.D. students, but no other students, in their study of reviewing in collaborative writing [129]. Kütt et al.’s Eye-Write tool was designed based on a survey answered by undergraduate and graduate students as well as professors, although it was subsequently evaluated only with undergraduate students.

Office Work The HCI literature also includes research on office work, such as insurance work [64] or legal work [6, 62, 252], and consultancy [62, 74, 252]. These studies usually involve participants from a number of areas rather than focusing solely on, e.g., lawyers’ collaborative writing practices. Examples of such mixed studies also include the interview study that Posner and Baecker [197] based their well-known taxonomy of collaborative writing on, as well as Newman and Newman’s analysis of two case studies on writing for decision making [182]. Tammaro et al.’s study of collaborative writing in a department of The MITRE Corporation[1] is one of few studies involving participants from industry that does not have participants from multiple domains.

Other Areas Aside from these major areas, of which academic and educational writing are by far the most represented, other settings for collaborative writing, such as TV scriptwriting [197], are scarcely represented. They appear only in studies with participation from a mix of areas, usually studied together with office academic work [e.g. 197, 252], and with only a small number of participants representing each perspective.

2.2 Ways of Studying Collaborative Writing

With this section, I paint a rough picture of the way that research on collaborative writing is and has been carried out. My agenda is to provide the reader with a background for understanding the methodological choices I describe in chapter 3. I mainly reference work from research in HCI but have not made a strict division and will not go into differences in methodological preferences and tendencies among the different fields. I devote the most space to document analysis using visualizations, as this method was used in the empirical work analyzed in chapter 4. I expect the rationale I provide in chapter 3 for doing interviews and conducting a co-design study can be understood without the need to elaborate on those here, but document visualizations are a newer and less frequently used approach that I would not expect most readers to be familiar with.

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1According to [www.mitre.org/news/media-resources](http://www.mitre.org/news/media-resources), the MITRE Corporation is a not-for-profit organization in the United States.
Interview studies are a common approach \cite{6,23,65,129,139,197}. In addition to pure interview studies, interviews have also been used in connection with, e.g., lab studies \cite{11} and field experiments \cite{54,164}. Observations, for example as part of field studies, are also fairly common. They are typically not carried out for the entire duration of a project but rather for shorter periods \cite{61}, presumably due to the often longitudinal nature of collaborative writing projects. Participant observation studies, such as Cross’ \cite{64}, are a rare exception to this.

More common is the post hoc analysis of, e.g., changelogs and saved electronic communication, either stemming from real-world projects \cite{111,188}, field experiments \cite{53}, or lab studies \cite{24}. Some studies include additional methods such as interviews or observation \cite{54}. Within the last ten years, researchers have implemented tools to enable the study of log data through visualizations \cite{224,228,251}. These allow visual inspection of developments that are otherwise practically unavailable for observation, such as the document production patterns identified by Wang et al. \cite{250}. Document visualizations have also been suggested and studied as a utility for writers themselves \cite{97,140,164,244,261}, or for educators to make assessments about students’ work \cite{240,250}. Studies have also compared the quality of the produced documents to some of these measures \cite{54,140}, particularly in educational settings.

2.3 Topics of Study in Collaborative Writing

The six topics I describe here can roughly be split into two categories: The first three are communication and coordination, awareness, and the involvement of multiple tools, which are mostly focused on technological needs and features. The last three topics are the socially situated nature of collaborative writing and the two closely related topics ownership and privacy.

I am restricting this section to the topics most relevant to my own research. My research has been focused on practice rather than technological contributions, which is reflected in the topics I address and the way I address them. However, the development of tools has been a driving force for research on collaborative writing, particularly in its early years, and so this section does describe ways that the topics have been addressed in those technological contributions.

2.3.1 Communication and Coordination

The necessity of facilitating communication and coordination was acknowledged from the outset of the work to support collaborative writing, with the AUGMENT \cite{80}, the tool that Delisle and Schwartz named the pioneer of multi-person editing \cite{69}, which incorporated communication support in the form of (essentially) a built-in e-mail client \cite{80} and screen sharing \cite{81}, essentially enabling Posner and Baecker’s \cite{197} joint writing strategy in a remote setting. Quilt similarly enabled directed messages \cite{99}, as well as document annotation \cite{152}.
2.3. TOPICS OF STUDY IN COLLABORATIVE WRITING

Some of the earliest empirical work involved studies of collaboration systems like these, such as Galegher and Kraut’s [95] field study comparing face-to-face collaboration with technology-mediated collaboration using the computer-conferencing system ICoSY. Galegher and Kraut concluded that failure to support rich communication can impede coordination and damage collaboration [95, 96]. Sharples et al. [218] predicted a number of challenges in supporting communication for collaborative writing, including ambiguity and lack of contextual information. Based on studies, others have also remarked on [85], and tested [179] the effect of different communication modalities on what is communicated [179] and how it is perceived [85, 179].

Another challenge of computer-mediated communication about a text is the coupling of communication with the content being discussed [168]. This challenge has not been widely discussed, but there have been proposed implementations that address it [58, 238].

2.3.2 Awareness

Awareness has received a great deal of attention throughout the CSCW field’s lifetime [75, 102, 206, 212, 229, 235], not least in work to support collaborative writing. Not much empirical or theoretical work on awareness in collaborative writing specifically is available, even though Dourish and Bellotti call it “fundamental to coordination of activities” [75, p. 7], so I shall mainly describe examples of awareness features in this section. The concept of awareness has many facets, but the ones most often addressed in tools for collaborative writing are change awareness [e.g. 82, 152, 177, 215, 229] and awareness of co-writers’ activities and whereabouts in the digital collaborative environment [e.g. 78, 141, 162, 169, 254].

Awareness of what has changed in a text was supported in a rudimentary way by AUGMENT’s changelog [82], showing changes along with author information and a timestamp. The tools Quilt [152] and Prep [177] additionally both provide facilities for co-writers to explain the rationale behind changes. One of the few empirical studies on change awareness in collaborative writing, by Kim and Eklundh [116], showed that enabling co-writers to understand why particular changes were made is essential to the usefulness of change representation. Tam and Greenberg [229] speculate that understanding co-writers’ changes might make it easier to accept the changes.

As opposed to the retrospective nature of change awareness, providing awareness of co-writers’ activities addresses the challenge of face-to-face interaction being partly or fully replaced by the system’s representations of activity [206]. A prominent example of tool support for awareness in collaborative writing is ShrEdit [162]: It enabled co-writers to locate each other in the workspace and “track” each other by seeing another person’s cursor positions and text selections [75]. It furthermore enabled co-writers to see whether other users were currently tracking someone [75]. With ShrEdit, other writers’ cursors were only visible in the tracking
mode which locked the view to the co-writer being tracked, whereas the editor Aspects [169] included telepointers.

A recent innovation on this front is EyeWrite [141], an extension to the open-source editor Firepad [1] that uses gaze tracking to enable co-writers to see where in a document collaborators are looking.

2.3.3 Writing With Multiple Tools

While many of the tools that have been developed over the years include comprehensive sets of features to support multiple aspects of collaboration, some empirical work indicates that multi-tool scenarios may be more realistic: For example, Noël and Robert [184] found, in a questionnaire survey published in 2004, that respondents were more inclined to combine multiple familiar tools to facilitate collaboration than to use a group writing tool that was unfamiliar to them or their co-writers. Blin and Appel’s [28] analysis of a forum-mediated collaborative writing includes examples of co-writers negotiating the inclusion of additional tools to support the collaboration, and Das et al. [65] describe how writers with vision impairments maintain a large set of tools to be able to have a working configuration of writing tools and assistive technologies. Work in CSCW on multiplicity [31] and artifact ecologies [33, 127] is highly relevant to this and is described and applied in chapter 5.

Technical contributions related to this branch of work includes efforts to enable collaborative integration of heterogenous tools [57, 256, 257] or to create extensible and malleable text editors [135].

2.3.4 Socially Situated Writing

Although sparse, there is literature that places emphasis on writers’ experience of the social situation and the social impact of the technologies in use in collaborative writing. Although focusing on other topics, a number of authors have noted the presence of social norms and sensitivities when it comes to collaborative editing [129, 186, 252]. In 2019, Das et al. described the role of social concerns faced by writers with vision impairments when negotiating with sighted co-writers what tools to use [65]. The place that humor can have in collaborative writing [186, 188] likewise speaks to a social nature. Some attention has been given to conceptions of ownership and privacy, both of which are addressed separately below, but the lack of research on social aspects in collaborative writing persists despite several authors [152, 156, 182, 218, 230] noting, in connection with other work, the importance of addressing them. Olenewa et al., for instance, remark on a gap in the literature with respect to “the social process that harnesses the technological advancement of simultaneous writing” [186, p. 42].

The earliest work specifically addressing the social situation is Neuwirth et al.’s 1994 paper on the social meaning that writers attribute to annotations in different modalities [179], but studies focusing on the socially situated nature of
collaborative writing are far in between with the only other work being two studies presented in 2012 and 2013 by Birnholtz et al. [23, 24].

In the first study, an interview study, Birnholtz and Ibara investigated users’ perceptions of edits [23]. They find that edits and comments often have a social significance that users are conscious of during collaborative writing when they are editing work contributed by others as well as when their own contributions are being edited. Birnholtz and Ibara apply the notion of group maintenance, a concept describing behavior aimed at maintaining social relationships, to explain their findings. In doing this, they indirectly draw on work by Jehn who distinguishes task conflict and relationship conflict in her analysis of workgroup structures [125]. Jehn defines relationship conflict as arising due to interpersonal incompatibilities among group members, while task conflict is defined as disagreements about the content of the task. Birnholtz and Ibara describe how participants in their study express a need to balance group maintenance and task maintenance (although Birnholtz and Ibara never use the term task maintenance). Findings from Birnholtz et al.’s follow-up study [24] showcase more examples of group maintenance behavior in collaborative writing.

2.3.5 Ownership and Territoriality

One way in which the social nature of collaborative writing manifests is in sentiments of ownership. Kim and Eklundh [129] describe how co-writers in their study described avoiding major changes to parts written by other people, and according to Wang et al. [252], editing text written by co-writers may be considered impolite. Mitchell et al. [169] describe a similar reluctance, however also remarking that this reluctance would reduce as the text was edited more. Blau and Caspi [27] also find that editing each other’s text reduces writers’ sense of ownership. Lai et al. [143] reveal a more nuanced picture, relating the level of experienced ownership to one of three “collaboration styles”. Fish et al. [93] assert that feelings of ownership are more likely in hierarchically structured collaborations, something that is reflected in Wang et al.’s findings [252].

Except for Blau and Caspi’s observation [27], these findings are all reported as discoveries in studies with a broad focus and no particular focus on ownership. In addition to these studies, there have been studies on collaborative editing in Wikipedia that focus explicitly on ownership and territoriality. Although the connection between ownership and territoriality is not completely trivial [233], I address them both here without delving into the differences. Thom-Santelli et al. [237] describe Wikipedia maintainers’ feelings of attachment to their articles and their opinions regarding their own and others’ way of editing, such as discontent with new editors making substantive changes to maintained articles. And in a study of edit rejection patterns on Wikipedia, Halfaker et al. [111] show editors’ tendencies to reject changes to text they have written themselves.

A couple of systems facilitate enactment of ownership through “locking” of parts (e.g. SharedBooks [153] and Aspects [169]) or entire files (e.g. DCWA [55]), or
read and write permissions (e.g. GROVE [78] and Quilt [152]). The editing environment DUPLEX [191] takes a less stringent approach by partitioning the document according to co-writers’ assigned responsibilities. It must be noted that such features are — particularly in early work — likely aimed mostly at avoiding problems introduced by concurrent editing, more so than at supporting social protocols to do with ownership. ShrEdit [75], for instance, simply prevents concurrent editing of pieces of text, and the partitioning feature in DUPLEX [191] (in which editing takes place asynchronously) seems mainly to be targeted at avoiding merge conflicts.

Having described these tools, it is worth mentioning that Kim and Eklundh point out that ownership of segments was understood “by social consensus rather than by technical means” [129, p. 255], implying that co-writers may not need designated “ownership features”. Mitchell et al. [169] make a similar observation.

2.3.6 Privacy

The social nature of collaborative writing also brings with it a need to withdraw from social interaction and availability, as noted, e.g., by Wang et al. [252] who suggest that systems for collaborative writing should provide facilities for private writing. Such facilities were available in, e.g., ShrEdit [75] and GROVE [78], both of which allowed work in a private window in addition to the shared environment. Introducing a feature that allows writers to share changes at a varying degree of detail, Ignat et al. [124] characterize the ability to work in private as essential for collaboration. Along with Neuwirth et al. [181] they use drafting to exemplify the need for privacy; an assertion supported by Wang et al.’s [252] finding that co-writers often do their writing in a document separate from the jointly accessible one.

Birnholtz and Ibara [23] attribute the need for privacy in collaboration to people’s need to manage presentation of self [100]. In fact, Wang et al. [252] describe another self-presentation concern that is complementary to privacy; namely that if a writer is editing in a private window this should be clear to co-writers, so that they do not misinterpret it as absence or laziness.

Privacy, as discussed in this section and later in the thesis, is understood as a process of boundary negotiation [192], contrary to the more individualistic perceptions prevalent in the privacy and security literature.
Chapter 3

Methodology

In this chapter I describe the motivations for my choice of methodology. I have strived to limit the amount of repetition from the included publications and manuscript and to instead detail aspects not accounted for in those, including how the methods developed along the way. This chapter contains explanations of what I initially envisioned as well as what I ended up doing, along with reflections on why changes came about and what I learned from them.

The work that has gone into my Ph.D. project has had as its primary purpose to account for those parts of collaborative writing having to do with where the individual meets the collaboration. I have approached this as a learning process, in the sense of acting as a researcher who needs to be humble about what she does not know and what practitioners of collaborative academic writing can and want to teach her about the topic and their experiences with it, but also as someone who was and is still in the process of learning to write collaboratively and academically herself. My empirical and analytical work has therefore been carried out with a regard for other writers as skilled experts [29]. I have been conscious of maintaining this attitude throughout the work, as the potential benefits of studying a community of practice [147] that I was part of myself was countered by the risk of (consciously or most likely subconsciously) deeming myself an expert of other practitioners' experience(s).

In this sort of work it can be difficult not to reduce the people one is dealing with to representatives of the topic being studied: “users” or, slightly more accurate, “writers” or “co-writers”. When writing about my research I mostly use the term “co-writer”, as a reminder about the role through which people have described their experiences to me. The viewpoints, anecdotes, and motivations they have presented to me are passed on in my writing mainly through an understanding of them as co-writers. It is a question of framing an analysis and its description, in which language sometimes makes it hard to simultaneously achieve clarity and nuance. I, of course, view and respect the people who have lent their time and voices to this research as full and complex human beings and this underlies my empirical work and my analyses thereof, even if I must resort to somewhat
reductionist language.

I have aimed to understand what co-writers do to make collaborative writing work and why they do it the way they do. As mentioned, my focus has been on the balancing accomplished by multiple individuals making an effort to function together in a collaboration. By describing and, importantly, explaining people’s practices I hope to lay the grounds for treating the cause rather than the symptoms. By this somewhat dramatic metaphor I do not mean to imply that current collaborative writing practices are sick or in need of curing. My point is that I do not think there is much value in speaking of the “what” without understanding the “why”. Chapters 4 and 5 therefore both devote a great amount of attention to co-writers’ motivations and sentiments.

To make the findings from this work more easily applicable in design-oriented work, part of the analytical effort has been to break collaborative academic writing into smaller pieces that can be addressed more directly (see chapter 5 on transition types and text functions, and the trade-off protocol presented in chapter 6). The intention is not to prescribe action but to describe and provide interpretations and abstractions that can act as foundations for action [63, 174, 199], such as design or further research.

A qualitative approach lends itself well to these aims [26, 161], supporting my priority for accuracy [22] in my descriptions and explanations. My empirical work has therefore consisted of the following three methods: Semi-structured interviews (section 3.1 and chapters 4 and 5), visualizations of document revision logs (section 3.2 and chapter 4), and a series of co-design workshops (section 3.3 and chapter 6). The visualizations have served as support for qualitative interpretation, although they could also support a quantitative research agenda.

Chapters 4 and 5 contain separate analyses of the same set of interviews. They respectively build an account of academic co-writers’ motivations for withdrawing from the common writing space and their motivations for switching between tools. The co-design study presented in chapter 6 makes up the next step in my empirical work, operationalizing what I learned in the interview study. The visualizations were part of the interview study, providing a form of indirect observation to shed additional light on findings from the interviews. In chapter 4 my co-author and I include visualizations of collaboratively written documents as a way to illustrate territorial patterns described by interviewees. Chapter 5 on the other hand, relies solely on the interviews, as it addresses co-writers’ transitions between different tools and these transitions are not captured in the visualizations.

As I have gained new insights from these inquiries, I have adapted my conception of co-writers’ experiences and made subtle adjustments to my expectations and my approach [160, 174]. Deciding to use visualizations, for instance, was a response to realizing the role of territorial functioning in co-writers’ accounts of writing together. I will describe and reflect on such changes throughout this chapter.
3.1. INTERVIEWS

Timeline and Formal Procedures  The interview study took place between March and August 2018, during which time the tool for generating the visualizations was developed by my co-author Henrik Korsgaard. The co-design workshops took place between September 2019 and February 2020. They were carried out with my co-author Marcel Borowski.

All the empirical work in this thesis has been approved by The Research Ethics Committee Aarhus University. All participants have given informed consent, as per the European Research Council’s regulations. This consent included permission to collect the demographic information reported in this chapter and in the papers and manuscript contained in the next chapters.

3.1 Interviews

I originally set out to investigate the place and experience of privacy in collaborative writing, and how co-writers create or seek to create privacy for themselves as well as what motivates them to do so. As mentioned in section 4.2 privacy in the context of collaborative writing refers to boundary negotiation, or boundary management. In this regard it seemed relevant to examine co-writers’ perception of what text is theirs; hence the notion of ownership also became a focus early on. In collaborative writing, privacy and ownership intersect, among other things, when it comes to drafts: Drafting is often done by one person alone and that person usually has some opinion on, and sometimes control over, when the draft should be shared with others. Drafting in collaborative writing takes place in an interesting borderland between privately conducted work and work aimed towards sharing and holding in common.

The inspiration to study collaborative writing in the first place came from colleagues’ observations as well as my own experiences. In particular, the focus on privacy was spurred by observations made by colleagues regarding their students’ approaches to writing collaboratively. Given this origin, it made sense to begin by studying writing done by university students. However, I was curious to gain some perspective on the extent to which my colleagues’ observations were particular to students, and what place privacy and ownership might have in other forms of academic writing with more hierarchically diverse roles in play. I thus expanded the focus to include researchers. Including both groups of co-writers turned out to provide some valuable perspectives: I, for instance, noticed different views on the extent to which a text needs to be jointly “owned”, which hints at potentially useful distinctions between ownership and accountability (chapter 4 contains a brief discussion on this).

Going through the literature on collaborative writing and groupware, it became evident to me that while privacy takes a backseat in the literature, a great deal of attention has been given to the closely related topic, awareness, as also outlined in subsection 2.3.2. The need to balance mechanisms for awareness with the possibility for privacy has been acknowledged in the literature on collaborative
CHAPTER 3. METHODOLOGY

writing [83, 123, 137, 252] and more broadly [43, 59, 104, 122], but has not received near the amount of attention that work towards supporting awareness has (see, e.g., [235] for a thorough review). I was therefore inspired to look closer at the role of awareness mechanisms in co-writers’ privacy-related experiences.

On these grounds I approached the investigation by focusing on 1) drafts: co-writers’ habits of drafting in collaborative and individual work and their sentiments around co-writers reading drafts, and 2) collaborative editors as the place of collaboration: how co-writers experience working in a shared document, in particular real-time collaborative tools, and whether they are conscious of other co-writers’ presence in the document and how this affects their work.

Privacy and ownership turned out to be subparts of a larger web that I have framed using Taylor’s [233] notion of territoriality (see Chapter 4). However, in the presentation of how this interview study unfolded I will present it from the perspective of the initial focus that shaped it.

Starting with interviews Interviews [142] became my entry into examining co-writers’ experiences of privacy and ownership in collaborative academic writing. The flexibility possible with interviews [217] allowed me to keep my inquiry open-ended and discover which directions to explore further, potentially using other methods. Indeed, what I uncovered in the interviews was what motivated the use of visualizations (see Section 3.2 below).

As described in Chapter 2 interviews are a common approach to the study of collaborative writing practices. While there would be merit to re-examining the research questions and findings from previous interview studies in a locally and/or temporally different setting, the work presented in this thesis examines a new set of research questions with only very few reminiscent precedents. The only other empirical collaborative writing study focusing specifically on privacy attitudes is Wang et al.’s [252] recent interview study, while no studies have focused specifically on ownership outside the context of Wikipedia [111, 236, 237] although some have presented findings related to ownership [23, 24, 27, 143, 169] (as also outlined in Chapter 2).

3.1.1 Participants

Participants were recruited by reaching out to contacts in five departments at Aarhus University, as well as through posts on personal and professional social media accounts, including a post made by the Department of Computer Science on their official Facebook page.

The initial interview study involved a total of 31 participants. I was fortunate to end up with quite a balanced group of participants as regards the forms of writing they had experience with, as well as the extent of their experiences. Table 3.1

\footnote{Note that we report 32 participants in the paper included as Chapter 4. One additional participant joined for a follow-up interview with her group. See Section 3.2}
3.1. INTERVIEWS

Table 3.1: The number of participants in each occupation category represented in the interview study. The parenthesized count includes an additional participant from the follow-up interviews (see section 3.2).

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master’s students</td>
<td>13</td>
</tr>
<tr>
<td>Ph.D. students</td>
<td>8</td>
</tr>
<tr>
<td>Postdocs</td>
<td>2</td>
</tr>
<tr>
<td>Assistant professors</td>
<td>2</td>
</tr>
<tr>
<td>Associate professors</td>
<td>5 (6)</td>
</tr>
<tr>
<td>Professors</td>
<td>1</td>
</tr>
</tbody>
</table>

shows the distribution between participants’ occupations. Table 4.1 on page 49 in chapter 4 describes the projects that the interviews centered around (group size, duration, and primary writing tool).

In a demographic questionnaire, participants reported how long they had been in their current occupation. Based on this, participants’ level of experience with academic collaborative writing ranged from, at most, the duration of their master’s studies (approximately five years) to more than 20 years. The master’s students that participated were all studying at one of two Danish universities, while the researchers represented four different universities from around Europe.

3.1.2 Procedure

I decided to interview the master’s students as groups, to support joint recollection[94, 133] as well as to create a more everyday-like, comfortable atmosphere by letting the students be interviewed alongside familiar faces. However, I opted against this approach for the participants who were researchers: Seeing as many of them work in hierarchically skewed constellations of people I feared that a group interview would inhibit participants too much[134].

Thus, the five groups of master’s students were interviewed jointly while all other participants were interviewed individually, for a total of 23 initial interviews. 18 interviews were conducted in person, with the remaining 5 taking place via Skype. The consent form was emailed to all participants in advance of the interview, to give them time to read through it and voice questions or concerns. Participants interviewed via Skype were instructed to send a signed version of the consent form via email before the interview. The interviews were conducted in Danish when all participants were native Danish speakers, and otherwise in English. All interviews were audio-recorded and transcribed. I personally translated all quotes used in the publications that came from Danish interviews. All quotes appear only in English and with no indication of the original language.

The interviews were divided into four sub-topics:

1. Collaborators and projects
2. Tools and writing process
3. Drafts

4. The collaborative situation

With the questions in the first two topics, I aimed to obtain an understanding of participants’ projects and relationships; as well as how they carry out collaborative writing projects on a practical level, such as which tools and features they used, how they coordinated the writing, and whether or not they worked co-located and/or synchronously. The latter two sets of questions aimed particularly at uncovering sentiments related to privacy and ownership. They addressed habits of drafting in collaborative and individual work, and attitudes regarding co-writers reading each other’s unfinished work; as well as participants’ experiences of working in a shared document (in particular in real-time collaborative tools) and the extent to which they felt conscious of co-writers’ presence and how this affected their work.

As for the questions about collaborators and projects, the interview template was customized to differ between interviews with researchers and interviews with master’s students. In the case of researchers, it made sense to refer to their collaborators as “colleagues” and to ask about their work relationship (such as differences in employment status), whereas with the master’s students it made more sense to frame the question in terms of their project and the extent to which they had previously done groupwork together. The two interview protocols are available in appendices A and B.

Aiming to spur the discussion, I incorporated two scenarios with accompanying questions into the interview protocol. The scenarios consisted of storyboards and a verbal description (see Appendix C) and focused on sentiments of ownership and privacy, respectively. They were used in all of the student interviews, but all of the interviews with researchers went on for so long that there was not time to introduce and address the scenarios. Given that the main purpose of the scenarios was to stimulate discussion, I would argue that they were as such not necessary in those interviews.

The interviews were semi-structured and conducted in an open-ended manner: I loosely followed the interview protocol, but generally participants’ responses would often direct the conversation to topics later in the protocol, as well as open up unexpected avenues for discussion, resulting in the protocol being followed in a non-linear manner.

The first four interviews took place in March 2018 while the remainder took place in July and August the same year. I began transcribing and coding the interviews in-between and continued this process alongside conducting the remaining 19 interviews. More details about the coding are included in the method sections of chapters 4 and 5. The qualitative coding naturally evolved as the interviews progressed. I did not revisit previous codings to update them to match the understanding applied on later interview data, as I valued the coding as a way to structure and understand each individual interview rather than letting separate

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Note that a majority of the later interviews were transcribed by student employees.
3.2. VISUALIZATIONS OF REVISION HISTORY

Interviews dictate how other interviews were to be interpreted. Transferring perceptions gained from analyzing one interview onto others is, of course, natural and I make no claim of my case being different. But by not attempting to impose an all-encompassing coding scheme I let this transfer happen organically, allowing each interview analysis stand for the unique experiences it represents. The interview protocol stayed the same, except for a restructuring to place the topic of the collaborative situation after Scenario 1. Both the student protocol and the researcher protocol were updated. Appendix A contains the updated student protocol while Appendix B contains the original researchers protocol. In the March interviews, several participants had needed clarification regarding those questions and Scenario 1 had served as a good way to exemplify the intended meaning.

3.2 Visualizations of Revision History

In addition to the more traditional approach to inquiry described above, chapter 4 includes visualizations of writing activity in academic writers’ documents. As described in the previous chapter, this approach has seen the light of day within the past decade and has only seen more frequent application within the past five years, most notably in Wang’s Ph.D. work.

As stated above, the interviews brought my attention to territoriality as a more comprehensive framing for what I was uncovering, compared to privacy and ownership. The decision to study collaboratively written documents came from the notion of territoriality as something spatial: The patterns relevant to study would likely manifest in the “place” where the text and thus the work is “located”.

Examining what occurs in collaboratively authored documents provides a different view from conducting interviews: It has allowed me to (indirectly) observe editing patterns in relation to the sentiments and motivations described by participants. While interviews provide a condensed and momentary narrative of a long-spanning and evolving process, the revision history contains all occurrences during the longterm development. It can show, e.g., the temporal scale at which co-writers disperse and merge in the text, and thus how they share the writing space over time.

The purpose of the visualizations was never to validate or debunk statements made by participants; it was for the different kinds of knowledge to jointly scaffold an understanding. The visualizations could have complemented the interviews by enabling a quantitative analysis with a vastly larger number of participants, but for our purpose the visualized editing activity was merely complementary to the interviews in that it could provide examples of patterns described by interviewees.

Observing Collaborative Writing I imagine that any researcher of computer-supported cooperative work would scoff at the notion that everything of relevance
happens on the computer screen. Collaborative writing is not a special case in that sense; it involves the spaces that co-writers are in, the notes they write on post-its, the multitude of devices they use, the walk from an office to a meeting room, and so on. However, the territorial phenomena I have analyzed do largely manifest in the virtual documents where co-writers create their text. Conducting observations of such screen-confined phenomena is not trivial. The literature on collaborative writing has very few examples of studies involving direct observation as a method \[54, 62, 64, 202\] and they all focus on things external to the document itself, such as different phases of writing \[54\] or the passing around of a document \[64\]. The example most related to my focus of study is Cohen et al. \[62\] observing the timing of when lawyers or consultants work on a shared document, and if they do so co-located.

Traditional forms of observation would hardly provide what was necessary for this study: Watching over co-writers’ shoulders would not only be intrusive (and paradoxical given the study’s focus on privacy) but also impractical, particularly for observing longterm developments throughout the course of a writing project. The latter can also be said for observing from a distance, which further would not provide access to the kind of minuscule in-document behaviors relevant to territorial functioning in collaborative writing.

Rather than observing in person, recording activity on co-writers’ screens would better capture what takes place in the documents. One could still question the paradoxical nature of such imposition on privacy, particularly if recording for hours, weeks, or months on end. And data storage would hardly even be feasible; analyzing the material even less so.

Another challenge, to all of these approaches, is that collaborative academic writing does not take place over just a few continuous stretches of time. Many of the projects described by participants had taken place as highly intermittent work over several months; none were shorter than a few weeks. Co-writers go to and from writing projects, with other work being cared for simultaneously.

Analyzing the revision history provides the benefit of getting an overview of the entire development of a document, including both the timing of activity and who did what, while being unintrusive \[161\]. The researcher is not restricted to the perspective of one individual or a subset of a group being observed, or particular temporal instances of the work. Visualizing the writing history (as opposed to, e.g., only performing statistical analyses) further makes it possible to directly spot patterns such as territories.

My colleague and co-author, Henrik Korsgaard, and I therefore set out to develop a visualization tool for collaboratively written documents. The choice of platform to support fell on Google Docs \[101\] because it happened to be the primary tool used by all the groups that were interviewed in March. This is when the development of the tool started, as the potential of visualizing document activity had already become evident by then. Ideally, we would have extended the tool to accommodate other writing platforms and applications as well, in particular Overleaf \[190\], Microsoft Word \[167\], and workflows incorporating Git \[2\] or Subversion.
3.2. VISUALIZATIONS OF REVISION HISTORY

[repositories, as they were used by co-writers participating in later interviews. However, the lack of standardization across these tools, sometimes combined with the lack of an API, introduced a large overhead in developing a broadly applicable visualization tool. We therefore prioritized a working tool for Google Docs.

The creation of the visualization tool was a joint effort in which Henrik implemented the tool based on conversations about my observations and the research questions I had derived from those.

As the implementation of the tool is Henrik’s accomplishment, I will only describe the essentials of the implementation and shall instead focus on describing what the tool visualizes and in what way it does so.

The research questions we intended to answer using the tool were as follows:

a) Are there blocks of texts which are primarily written and edited by one individual?

b) Does editing develop towards being more joint and overlapping in time and location as the deadline gets closer, compared to earlier in the writing?

c) Is the person contributing the majority of edits to a piece of text (the “owner”) also the first person to write proper text there (i.e. do they contribute more than just outlines or similar)?

d) Are edits made by different people on the same piece of text temporally separated?

e) Do other co-writers than the “owner” only make smaller changes to the owner’s text?

Note: I have gripes with the word “owner”, as I also discuss in [chapter 4]. However, it is the simplest term to use here to denote the person whose territory a given piece of text is.

In order to answer these questions, we needed a number of things to be made salient:

• We needed to be able to identify who made which edits (or at least distinguish individuals).

• We needed to be able to identify when and where each edit was made.

• We needed to be able to visualize both the temporal and the spatial information, as well as visually distinguish individual co-writers. Preferably all in one place.

• Granularity became a question: How do we define “one edit”? At what granularity can/will we visualize locality (section, paragraph, line)? When are edits considered to have taken place at different times?
There are, and were, already a couple of visualization tools for research involving collaboratively written documents, but they did not meet this particular combination of needs: Uatu [164] provides an overview of the timing of individual co-writers’ revisions and the size of these revisions but contains no indication of where in the document these revisions were made. Itero [244] likewise only visualizes the relative amount contributed by each user, or the time at which each edit was made. The collaboration visualizations made by Sun et al. [228] show which writers were undertaking particular activities at certain times but contain no information about the location of edits. Southavilay et al.’s [224] revision maps do include location, by providing an overview at the granularity of paragraphs and indicating the extent to which different co-writers have edited each paragraph at what time. However, the visualization only distinguishes individual authors by tags and thus does not provide a visual indication of territorial patterns. AuthorViz [249] somewhat achieves this by color-coding the final document text based on authorship. However, this excludes any temporal overview that may indicate territorial patterns in behavior: A paragraph that has been extensively written by one individual and only late in the writing had a large number of linguistic corrections made by a co-writer could look the same as a paragraph that has been jointly written by two co-writers. Finally, DocuViz [249, 251] does visualize the distribution of individual co-writers’ contributions throughout the document. However, it does not provide the granularity that we need for examining the combined locational and temporal closeness of edits. See Wang’s [249] review of information visualization and visual analytics of collaborative writing and software development for a more extensive overview.

3.2.1 The Tool

Instead of taking one of the approaches described above, we designed visualizations that combine fine-grained spatial information with temporal information and authorship data. This is presented in one view that is closely coupled with a view of the document itself, to enable contextual interpretation of the visualization. Two central notions must be clarified before further description of the visualizations:

- An edit is a locally and temporally delimited set of character entries, deletions, or formatting.
- A paragraph is defined, in the implementation, as being delimited by line breaks (or the beginning/end of the document). In a few cases this results in some discrepancies between the visualization and the appearance of the document. This is, however, amended by tightly coupling the visualization to a view of the document.

The visualizations localize what we may call “territories” to paragraphs, with a sub-division into individual edits. Each edit is visualized as a solid block, colored to signify which co-writer made it, as shown in Figure 3.1.
3.2. VISUALIZATIONS OF REVISION HISTORY

Figure 3.1: An edit is represented by a block, colored to signify writer identity.

A paragraph is visualized as a line of such blocks, one for each edit made in the paragraph:

Figure 3.2: A paragraph in which A has made six edits and B has made three.

Since a block is added for each edit, paragraphs with more edits will contain more blocks. All paragraph visualizations are displayed at the same width, meaning that the more edits that have been made in a paragraph, the smaller the blocks will be (in order to fit the width):

Figure 3.3: A paragraph with few edits.

Figure 3.4: A paragraph with many edits.

All edits in the same paragraph are visualized using the same size of block. The width of a block thus does not represent any characteristics about the corresponding edit.

Rather than being ordered by the time at which the corresponding edits were made in the paragraph, the blocks are laid out according to the relative positions at which the corresponding edits were made:

"The use practice is the origin for design."

```
+-------------------+
| BLUE DELETES AND WRITES |
+-------------------+
```

"The use practice must be the origin for design."

```
+-------------------+
| BLUE WRITES |
+-------------------+
```

"But the use practice must be the origin for design."

```
+-------------------+
| RED DELETES |
+-------------------+
```

"The use practice must be the origin for design."

```
+-------------------+
| RED DELETES |
+-------------------+
```

Figure 3.5: Placement of edit blocks in relation to existing blocks in a visualization. The example text is a small tribute to my advisor — see [29, p. 154].
The full visualization shows all paragraph visualizations stacked according to the order in which they appear in the document:

![Figure 3.6: Visualization of a document with nine paragraphs, each represented by a line of blocks.](image)

The visualization is shown next to a rendition of the document. It is possible to click a line in the visualization and have the corresponding paragraph in the text highlighted:

![Figure 3.7: Visualization next to document rendition. A line in the visualization has been clicked and the corresponding paragraph is now highlighted. The example text is another small tribute to my advisor — see [29, p. 32].](image)

Finally, each paragraph visualization can be unfolded to display on a timeline when each edit was made. The timeline is separated into sessions, with a session being defined as an active period of writing, with a timespan greater than 15 minutes separating it from the preceding and the following session (inspired by Sun et al. [228]):

![Figure 3.8: Timeline of the edits shown in Figure 3.5](image)

Thus, the timing of edits can be visualized relative to the timing of other edits within the same paragraph. Looking at the whole paragraph can provide an idea of who has been the dominant writer, and whether this has changed over time.

The relative positioning of the blocks representing edits means that the first, e.g., 20 blocks of a paragraph visualization may all represent (what was) the very
first word in the paragraph at different times. Some of the spatial unfolding is thus lost. It, however, accomplishes the essential task of seeing whether edits by the same individual are made in close proximity to each other.

In summary, the visualizations provide the following: Looking at their temporal unfolding can give us an idea about how (territorial) editing patterns evolve over time. Looking at the positions of individual edits can give us an idea about how multiple individuals edit within a territory, be it shared or not. We thus retain temporal information while allowing it to be abstracted away.

There is, of course, a trade-off in any method choice. Using visualizations of editing history, the observations we can make become detached from the writing situation. As McNely et al. [164] phrase it, many parts of a collaboration, such as verbal interaction, are invisible to the type of visualization tool we have designed. They “only depict the contribution made through keyboard use” [140, p. 2] and we are left to speculate about rationales and the communication that may have taken place. Wang et al. [251] explicitly caution against overinterpreting outputs from DocuViz. Other tools, ours included, should be approached similarly.

As discussed in the beginning of this section, other approaches would have given us something different. In-situ observations would be able to provide a more holistic picture, but instead we would lose out on other kinds of details and longer stretches of time. We could instead get rich insights into a few particular moments in the writing process.

### 3.2.2 Participants

We asked all interviewees who had used Google Docs as their primary tool if they were interested in sharing their documents with us so that we could study them. A total of seven groups shared a Google Document with us. We conducted one joint follow-up interview with each group, with 17 participants in total. One writer participated in two follow-up interviews as this person had been part of two of the collaborations being discussed. Another participant had not participated in the initial round of interviews and only participated in the follow-up interview.

Table 3.2 shows an overview of the groups and the types of documents they shared with us. More details can be found in Table 4.2 on page 51.

### 3.2.3 Follow-up Interviews

Rather than merely collecting data from the participants as passive contributors, we wanted to involve them in the interpretation of the visualizations of their documents. We envisioned a procedure akin to retrospective think aloud [245, 246], retrospective user-reported critical incidents technique [50], and self-confrontation interviews [48].

---

III: This number was mistakenly reported as 4 in [145].
IV: This number was mistakenly reported as 4 in [145].
Table 3.2: Overview of the groups that participated in follow-up interviews and their documents which were analyzed using the described visualization tool.

<table>
<thead>
<tr>
<th>Type of text</th>
<th>Page count</th>
<th>Number of writers</th>
<th>Follow-up participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student project</td>
<td>29</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Master’s thesis</td>
<td>68</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Master’s thesis</td>
<td>96</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Master’s thesis</td>
<td>81</td>
<td>3(^{III})</td>
<td>3</td>
</tr>
<tr>
<td>Master’s thesis</td>
<td>68</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Scientific paper</td>
<td>14</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Scientific paper</td>
<td>43</td>
<td>5(^{IV})</td>
<td>3</td>
</tr>
</tbody>
</table>

However, as the reader may have sensed when reading the preceding pages, the tool is not straightforward to understand upon first encounter. We decided to defer such joint interpretation to a later study where participants could be given the necessary time to become comfortable with reading the visualizations. We have planned such a study and obtained approval from the Aarhus University Research Ethics Committee but have yet to carry it out.

We instead approached the follow-up interviews by centering on participants’ experiences of territorial functioning in their documents and reiterate reflections from the first interviews. Because this entailed a focus on the joint practice of constructing and being in a document together (and not so much the sentiments of individual writers), we opted for group interviews to allow participants to negotiate the description of their common practice. The follow-up interviews took place in August 2018, after the conclusion of all initial interviews.

The protocol for the follow-up interviews was divided into five parts:

1. Document re-familiarization and reflection.
2. Questions about content production and decision making.
3. Questions about division of the work and norms around shared text production.
4. Questions about communication and structuring of work.
5. Questions about coherence and the text as a common product.

In part\(^{I}\) we gave each participant a printed copy of their document and asked them to go through it individually, marking who had been the main contributors to which parts (themselves, someone else, or a mix). We intended for this to help participants keep the writing process more fresh in mind, as some projects had ended several months earlier by the time the follow-up interviews took place. We aimed to use the print-outs actively in the interview.

Part\(^{II}\) focused on which roles\(^{197}\), activities\(^{197}\), and patterns of document creation\(^{250}\) the group recognized from their experiences with writing together
3.3 Co-Design

The aim of the co-design workshop series was to formulate concepts to be used in design for collaborative academic writing. My personal aim was to move from description and analysis to a constructive approach, both in terms of the final outcome and how the knowledge was generated. Involving co-writers in a design process was thus intended to serve a dual purpose of reaching insights together and producing a tangible outcome in the form of a prototype collaborative editor. There is a dialectical relationship among the two, in that while insights from the workshops fed into the production of the prototype, the prototype was the center of discussions that led to further insights. In the end, the prototype came to be a vehicle for knowledge generation more so than being a product of its own.
Co-design [35, 210, 262] is an atypical method in the area of collaborative writing. I am unaware of any previous work that uses co-design to understand or design for collaborative writing. I believe the method has potential to help researchers address the challenges posed by the meeting between multiplicity and needs for advanced writing capabilities that characterizes the academic writing practices I have studied (see in particular chapters 5 and 9).

The workshop series was divided into three stages, described further below. It consisted of a total of five two-hour workshops conducted between September 2019 and February 2020. Stages 1 and 3 were split into two workshops each to reach a number of participants more ideal for plenary discussions and closely managed facilitation of the exercises. A more thorough overview can be found in chapter 6. The three-stage division was intended to facilitate a move from conversation, over ideation, to a running prototype:

1. Defining Problem Spaces (2 workshops): Discussions and identification of themes to work with, along with initial ideas.

2. Integrating and Elaborating Ideas (1 workshop): Idea elaboration and refinement.

3. Use and Reflect (2 workshops): Exploring the ideas in a running prototype.

The stages fed into each other, with the work participants had done in one stage being picked up on in the next. This continuity was motivated by wanting participants to experience their thoughts and ideas being taken seriously and worked on, in addition to enabling continued development from initial problem descriptions to solutions. Letting participants know that their contributions and dedication were valued was a priority throughout the workshop series. The significance of this became even higher by us not being in a position to promise participants a usable or maintainable product after the workshop.

Participants were not involved in the development of the prototype. This choice was made in order to be able to implement a somewhat advanced prototype that participants would be able to recognize their ideas in, regardless of their individual levels of programming expertise and what amount of time they were able to commit.

As mentioned, the work was conducted with my colleague Marcel Borowski. Marcel took the lead on the prototype implementation and execution of the third stage of workshops, which dealt primarily with the prototype, while I led the planning and execution of the first two stages. We both acted as the facilitators during the workshops. We split the more practical planning and preparation tasks among us, with me being in charge of recruitment and scheduling while Marcel was in charge of the technical setup and data collection.

Below follows a brief description of the workshops participants. The three workshop stages are then presented in more detail, followed by a description of the data collection.
3.3. CO-DESIGN

Table 3.3: Occupations of the 18 participants in the co-design workshop series.

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master’s students</td>
<td>2</td>
</tr>
<tr>
<td>Ph.D. students</td>
<td>5</td>
</tr>
<tr>
<td>Postdocs</td>
<td>3</td>
</tr>
<tr>
<td>Assistant professors</td>
<td>2</td>
</tr>
<tr>
<td>Associate professors</td>
<td>2</td>
</tr>
<tr>
<td>Recent master’s graduates</td>
<td>3</td>
</tr>
<tr>
<td>Recent Ph.D. graduates</td>
<td>1</td>
</tr>
</tbody>
</table>

3.3.1 Participants

We invited those of the participants from the interview study who would be able to attend multiple workshops in person to take part in the co-design workshops. We also advertised the study widely around campus, to both students and researchers. We restricted the advertisement to Aarhus University, the only local university, because of the need for participants to attend in person.

18 participants joined, 11 of whom had also participated in the interview study. They all participated in at most one workshop per stage, with eight participating in all three stages while some only participated in one or two stages (see also Figure 6.5 on page 109). Table 3.3 shows the participants’ occupations at the time of the first workshop they each participated in. More details about the participants are included in Chapter 6.

3.3.2 Progression of the Three Stages

Stage 1 (Defining Problem Spaces)  The pragmatic goal of this stage was to identify themes to work with in Stage 2. On a more reflexive level, the aim was for participants to examine and elaborate their own conceptualization of the writing situation, in order to identify which constituent elements could potentially be addressed differently in a new design.

We took our starting point in guided dialog, first among the participants in pairs and then in plenary discussions facilitated by us. The pair dialog was used to help participants recollect experiences with collaborative writing, while the plenary discussions had them reflect on these experiences, their own as well as each other’s. The outcome of the discussions was a list of the topics that had been discussed, compiled on a board by a facilitator during the discussions. Each participant picked a topic from the board to work with. They were asked to individually reflect on salient aspects of that topic by sketching a conceptual blend [89, 90]: This was essentially a diagram that depicted relationships between different aspects they found to be relevant to the topic and collaborative writing. The conceptual blends were used as the basis for a brain writing exercise [247], a silent form of brainstorming.

The choice of methods for this stage emphasized two things: a) balancing joint
and individual reflection and ideation, and b) nudging participants to think outside
the box. I wanted to avoid the co-design workshops becoming a discussion on how
to improve Microsoft Word or Git integration with Emacs. The expectation was that
forcing the ideation away from identification of needs and the most obvious solu-
tions would result in more novel and enlightening ideas. The aim with balancing
joint and individual activities was to get the best of both worlds: The benefit of
creative sparring combined with uninhibited ideation.

The move from joint to individual reflection (i.e. from discussions to sketching
contceptual blends) was intended to give all participants, regardless of personality,
room to unfold their reflections more deeply, hopefully stimulated by input from
the preceding discussions. The brain writing method was likewise chosen for its
ability to let participants build on each other’s ideas without the risk of some people
dominating or receding from the activity.

In the conceptual blending exercise, participants were asked to describe a
desired scenario along with the opposite of that. In the brain writing exercise they
were then to come up with ideas that would make the undesirable scenario come
ture. As an additional means to steer clear of conventional collaborative writing
ideas, we asked participants to build their ideas on a set of inspiration images with no particular relation to writing, collaboration, or technology.

Stage 2 (Integrating and Elaborating Ideas) The purpose of Stage 2 was to for-
mulate more elaborate design ideas to be turned into a high-fidelity prototype.
After an initial plenary discussion, we settled on a number of design challenges and
participants formed groups based on the challenge they wanted to work on.

We had pooled the ideas generated in both workshops in Stage 1 together
and the groups now incorporated ideas one-by-one into a concept for a design.
The reason for pooling all of the ideas together was to benefit from the input of
multiple people, similar to what motivated the techniques used in Stage 1. Since
the ideas had been targeted at undesirable scenarios (see the description of Stage
1), this involved “flipping” the ideas so they would be solutions rather than “anti-
solutions”. While incorporating the Stage 1 ideas, participants were also asked to
consider different collaborative writing scenarios (see Appendix D). This was to
help participants look for numerous opportunities rather than trying to morph
ideas to fit a preconceived system or design.

The next step had participants reflect on and elaborate their overall idea with
respect to a set of concepts related to collaborative academic writing, using a lotus
diagram exercise. The concepts were taken from the article presented in
chapter 4. The purpose of integrating theoretical concepts was to (once again)
push beyond “default” solutions, by asking participants to change focus from their
immediate impressions of the chosen topic.

In the end of the workshop, the groups presented their ideas to each other. This
was meant as a way for the groups to get feedback and discuss each other’s ideas
as well as showing them, through the attention on each individual design concept,
that their ideas were valued and taken seriously.

Our goal with Stage 2 was to end up with storyboards and paper mock-ups that could be implemented in the high-fidelity prototype. We, however, did not get as far as that, instead ending out with elaborate concept descriptions that branched off in a number of directions. I attribute this to the loose organization of the ideation and in particular of the documentation we asked of participants: Rather than merely encouraging participants to sketch and make storyboards, describing the ideas visually should have been an explicit part of the exercises. We accounted for this experience in Stage 3, where we prepared empty storyboards and asked participants to fill them in during their discussions.

**Stage 3 (Use and Reflect)** Stage 3 centered around a running prototype that was implemented between Stages 2 and 3. The prototype was implemented using Codestrates \[72, 198\], a software framework for creating malleable [201] software. The prototype was constructed in a modular fashion: When first opened, it only provided basic text editing and formatting. Participants were able to add and remove features as desired, as well as modify the code to alter features or add new ones. The prototype was able to run in browsers on participants’ own computers regardless of operating system.

Aside from the basic text editing and formatting, the features of the prototype were all implementations of ideas developed by participants in Stage 2. Time constraints along with the complexity of some of the ideas prevented us from including all of participants’ ideas, but we made sure that all groups were represented in the prototype.

Unlike Stage 2, in which participants grouped up based on topics of interest, we had grouped participants in advance for Stage 3. This was to strive towards groups that were somewhat balanced with respect to participants’ experience with programming. We based the grouping on our existing knowledge of participants as well as some clarifying questions in connection with the scheduling of Stage 3.

To leave time for participants to familiarize themselves with the prototype and potentially do some (re-) programming of their own, we only scheduled few activities, with very brief interruptions. After being introduced to the prototype in plenary, participants were asked to group up and explore the prototype. They were instructed that exploration could be anything from trying out different features to modifying them. We provided them with a pamphlet describing each of the features and how to use the prototype. The pamphlet was made to look nice so that participants could see their ideas presented in an appreciative manner.

After the exploration step, each group was asked to choose among three scenarios to work with (the same that were used in Stage 2; see Appendix D) as a way to give a direction to their work. They were asked to put together a version of the prototype suited for their chosen scenario and were supplied with a fitting sample text to use in case they wanted to test features using realistic text (e.g. an actual book chapter if choosing the scenario involving the writing of a book chapter). After a
time working with the scenario, participants were provided with a sheet describing a pre-defined disruption to their scenario, intended to spark reflection about how different events impact the collaborative writing experience (see Appendix E).

We instructed participants to take notes and sketch on pre-made storyboard templates, the use of which were introduced along with an example, as not all participants were familiar with storyboards as a design technique. In addition to helping us understand later on what participants’ ideas and intentions had been, the storyboards served the purpose of enabling participants to express their ideas without needing to program. We knew that participants would be pressed for time and that some were not comfortable or familiar with programming, and we wanted to limit the impact of this on their experience and on what was achieved in the workshops.

The intention with letting participants try out a running prototype was to let them experience features that they had up until then just imagined, so they could evaluate and tweak their own ideas. However, it was not evident that they experienced the features of the prototype as their ideas. This could be attributed to a number of things and is likely due to a combination of factors:

1. Almost four months had passed between Stage 2 and Stage 3, and the ideas participants had worked on may no longer have been salient to them.

2. It may not have been noticeable to all participants that their ideas were included in the prototype, as the Codestrates framework made the prototype gravitate towards real-time shared editing environments, whereby it represented some participants’ practices and experiences to a lesser degree than others. Hence, the implementation may have been very far off from what they imagined for their design. In general, there is the risk that we misinterpreted participants’ ideas or that their appearance in the prototype was too influenced by the Codestrates framework.

3. By excluding participants from participating in or being present during (at least part of) the implementation step we may have taken the ownership of their ideas away from them. Although a reasonable pragmatic choice, it may have been a mistake from a more idealist perspective.

Another issue, which likely also had to do with participants not being involved in the implementation, was that discussions often diverged to the behavior of Codestrates rather than the prototype. Participants seemed to conflate features of the prototype with features of Codestrates, an issue we had not foreseen but which, in hindsight, is not surprising.

3.3.3 Data Collection and Analysis

After each workshop, we collected and later cataloged all artifacts made by participants. The workshops were video-recorded and we additionally took photos during
3.3. **CO-DESIGN**

the workshops. The artifacts and video recordings were collected for data analysis while the main purpose of the photos was documentation, although photos were occasionally used to aid the analysis, such as by helping to identify which timestamps of the videos would correspond to what activities.

Following the conclusion of the study, the audio from the video recordings of plenary discussions and presentations was transcribed. The material was coded inductively: My co-author and I coded the artifacts and transcripts from Stage 1 individually before consolidating our codes into a joint set that was applied on artifacts and transcripts from Stages 2 and 3.

### In Between Stages

In order to facilitate the workshops building on each other, we included artifacts from completed stages in the preparations for the next. Between Stage 1 and Stage 2 we grouped and labeled the ideas that participants had written down. We did this to make it easier for participants to select, among the approximately 40 ideas, the ones to incorporate into their design concept. Multiple copies of these sorted ideas and of all other artifacts created by the participants were made available to all participants during the workshop in Stage 2.

The preparation for Stage 3 included, as mentioned, the development of a prototype based on participants’ descriptions of design concepts. Copies of participants’ descriptions of these were furthermore made available to all participants during the Stage 3 workshops. The pamphlet mentioned in the description of Stage 3 also contained snippets of these descriptions, next to screenshots of the prototype. The purpose of this was to highlight to participants that the prototype features were implementations of their ideas.

### 3.3.4 Reflections

Unlike the interviews, the co-design workshops became more of a conversation, in which participants would challenge each other’s preferences and opinions. It allowed us to guide participants to question assumptions by occasionally nudging the discussion, resulting in moments of insight for participants as well as ourselves.

Furthermore, discussions were closely tied to technologies and features of tools, both as regarded their impact on writing and, most particular to the co-design workshops as opposed to interviews, as regarded participants’ ideas for improvements. The involvement of multiple people in the conversation also led to participants pointing out potential problems with ideas and discuss suggestions for improvements.

Finally, the focus on features and the iterative development of ideas through discussions provided a more direct basis for implementing an explorative solution than could have been expected if relying on interviews.

Focusing on one sub-topic or concept throughout each workshop worked well to structure participants’ discussion and ideation. Also when presenting their work and providing feedback to each other, being able to connect each group’s work to a particular focus seemed to help participants voice concerns or suggestions
regarding the chosen approach. The whole workshop series may have benefitted even more from this if participants had remained in the same groups throughout. This would have complicated the logistics but may have been worthwhile.

In the end, we did not formulate concrete concepts for design based on this study. Instead, we were able to make a more general point, namely that collaborative writing must be approached as a space of contrasting needs and preferences. I have no doubt that this insight was strengthened by the qualities of the co-design approach that I have just described.

3.4 Overview

This chapter has described the two empirical studies accounted for in this thesis. The first study, consisting of interviews and document visualizations, is presented and analyzed in two published papers included as chapters 4 and 5. The second study, consisting of a series of five co-design workshops, is presented and analyzed in an unpublished manuscript included as chapter 6.

The three chapters progress from characterization of behaviors and their motivations in chapters 4 and 5 to a still descriptive but more constructively oriented analysis in chapter 6. This is followed by two new chapters in which I apply concepts from chapter 5 to frame an analysis of findings from all three chapters.
Part II

Publications & Manuscripts
Errata

Chapter 4, Territorial Functioning in Collaborative Writing: Fragmented Exchanges and Common Outcomes

Table 4.2 on page 51 contains two errors:

- The line for G-S04 (fourth line) should have the number of authors listed as 3.
- The line for G-R16 (seventh line) should have the number of authors listed as 5.

The publisher has been notified, but a correction will not be made in the publication as it appears in their database.
Chapter 4

Territorial Functioning in Collaborative Writing: Fragmented Exchanges and Common Outcomes

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Henrik Korsgaard, Aarhus University, Denmark


Abstract

This paper examines territorial functioning in collaborative writing through a mixed methods study involving interviews and analysis of collaboratively authored documents. Our findings have implications for the way we think about collaborative writing as a design problem, in that current conceptualizations of collaborative writing emphasize the work context rather than the work itself, at the cost of understanding interpersonal dynamics that are central to the common process. The findings come from 23 interviews with 32 university researchers and students regarding their experiences with collaborative writing of academic texts. The analysis of these interviews is supplemented with visualizations of the revision histories of documents written by a subset of the study participants. We discuss our findings in terms of fragmented exchanges in common information spaces and consider the shared document as a mediator for the simultaneous accomplishment and negotiation of work.
CHAPTER 4. TERRITORIAL FUNCTIONING IN COLLABORATIVE WRITING: 
FRAGMENTED EXCHANGES AND COMMON OUTCOMES

4.1 Introduction

Collaborative writing is a broad topic, covering multiple modes of working; from synchronous, co-located writing [93] to asynchronous, distributed writing among strangers [237]. Addressed early on in CSCW, focus was on the technical feasibility of project management [69], synchronous editing [78], change awareness [178], and a decade later workspace awareness [108]. With the improvement of tool support collaborative writing has become common in several areas, including education [140, 261], industry [228], and research [23], and more effort has been devoted to practices for collaborative writing [188, 252].

This paper presents findings from an interview study on collaborative writing, primarily (but not exclusively) focusing on synchronous collaborative editors, supplemented with analyses of editing patterns in collaborative documents authored using these editors. Participants were university students and researchers and the documents analyzed comprise student projects, master’s theses and scientific papers. The research is part of a larger effort towards understanding how collaboration and sharing is mediated by technology, as well as a push for re-thinking this technological support.

In the meeting of multiple people who contribute to the production of content it is not unlikely for some of these people to develop an attachment to what they have produced, as has been shown with respect to Wikipedia [111, 237]. This attachment has in some of these cases resulted in territorial protection and curation of content, thus influencing and sometimes even hindering further production and development. So far, this sort of territoriality has only been examined in the context of Wikipedia, meaning that the content over which territoriality is exhibited is produced over long-term periods of multiple years with infrequent major edits as the content matures. Other work in CSCW has addressed very short-term (almost micro-term) territoriality in the context of tabletop interaction [216]. In this context, research has addressed people’s maintenance of and respect for personal territories in the immediate interpersonal interaction around regular and interactive tabletops.

In between these two scales of territoriality we have identified a gap in current research. In our studies of collaborative academic writing we have taken note of a territorial behaviour that has not previously been addressed in CSCW. Segmentation of text in collaborative writing has previously been addressed as a general strategy applied by writers [252]. This and other studies have examined editing patterns in collaborative documents, typically of collaborations lasting between a one hour and a few days [188, 261]. Our findings extend these by looking at collaborations spanning weeks and months. It is in these collaborations that we have identified a territoriality in connection with segmentation of the text being worked on.

Our motivation for this research is to understand 1) how the work of multiple writers becomes aligned in the production of text as common material and product, and 2) how these processes are influenced by current technological support. This leads us to the following research questions:
4.2. THEORETICAL BACKGROUND

- What are writers’ motivations for territorial behavior?
- What means and strategies do writers apply to support territorial functioning?
- How are territorial practices negotiated during the writing?
- What challenges can we identify regarding the mediation of territorial functioning?

Our main contribution is empirical and theoretical: We present empirical findings from interviews and document revision logs that demonstrate territorial behavior in writing, and we discuss the implications of these findings on how we conceptualize this territoriality. Additionally we suggest implications of territorial writing behavior for CSCW research and design.

4.2 Theoretical Background

In this section we first introduce territoriality as a theoretical concept, before we discuss theoretical notions from CSCW that are central to our discussion of territoriality in collaborative academic writing. We begin by outlining Schmidt and Bannon’s notion of common information spaces as well as Boujut and Blanco’s [41] analytical concept of intermediate objects. Then we describe the role of double-level languages, developed by Robinson [203], with respect to articulation work. This is extended to include a perspective on disarticulation, discussed in terms of Clement and Wagner’s [59] notion of fragmented exchanges.

4.2.1 Territoriality and Territorial Functioning

Definitions of territoriality differ. Understandings of what counts as a territory vary, as do characterizations of territorial behavior. Taylor [233] outlines a number of understandings, including that of an active defense, a defense achieved without aggression, laying claim, creating and maintaining boundaries, or the signalling of claims through markers and warnings.

Taylor [233] describes territorial functioning as place-specific and shaped by shared subjective definitions or perceptions of the given locale. His precise definition reads:

‘Territorial functioning refers to an interlocked system of sentiments, cognitions, and behaviors that are highly place specific, socially and culturally determined and maintaining, and that represent a class of person-place transactions concerned with issues of setting management, maintenance, legibility, and expressiveness.’ [233] p. 6]

Taylor describes territorial functioning as a group-based process that is, among other things, relevant to solidarity. We interpret his use of the word process to mean
CHAPTER 4. TERRITORIAL FUNCTIONING IN COLLABORATIVE WRITING: 
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that territorial functioning is territorial experiencing and acting while territoriality 
is the inclination for territorial functioning.

The purpose of territorial functioning is not simply to keep others out. The 
signalling of claims also serves to communicate expectations as to who is allowed 
in and how those entering the territory should behave [233]. Territorial functioning 
is thus about expectation setting and fulfillment regarding behavior within a given 
location. By extension it also relates to control over activities in specific sites.

Taylor [233] further describes territorial functioning as comprising *sentiments, 
cognitions, and behaviors*. Territorial functioning thus extends beyond behavior; it 
involves people’s sentiments and perceptions of situations as well. It spans both 
purposive behaviors, such as explicit management of territories and the use of 
signs for this, and non-purposive behaviors such as responses of annoyance toward 
people who impose on the territory with their presence. Territorial behavior is 
as such not necessarily contemplated or intentional; nor are territories always 
permanent.

In contrast to Taylor, Bakker and Bakker-Rabdau state that people’s ‘sense of 
territory is not limited to physical space alone’ [12, p. 11] and include in their 
examples of territoriality personal thoughts and attachment to tasks or roles. They 
define an individual’s territory to be ‘those areas in which he has special expertise, 
shows initiative, and takes responsibility — in other words, where he has control’ 
[12, p. 11]. We would add to this the areas that people develop an attachment to, in 
line with Taylor’s [233] idea of attachment through familiarity.

In their descriptions of territorial behavior, Bakker and Bakker-Rabdau focus on 
conflicts over territories, such as when a person’s position in a job is threatened by 
someone else performing that job, and various emotional and behavioral responses 
to such conflicts [12]. This conflict-centric understanding is not appropriate for 
characterizing the practices described by our participants, as they for the most part 
consist of non-conflictual management of the collaborative work and social situa-
tion (we discuss this near absence of conflict in Section 4.7). However, Bakker and 
Bakker-Rabdau’s more general conception of what constitutes a territory includes 
relevant perspectives that go beyond Taylor’s spatial understanding. While their 
classification of territorial behavior may not be applicable, their descriptions of 
emotional responses are useful for discussing some of the sentiments expressed by 
our participants.

Taylor [233] classifies definitions of territoriality along four organizing dimen-
sions (see Figure 4.1). The *makeup* dimension addresses whether territorial func-
tioning is primarily determined by behavioral or non-behavioral components. A 
behavioral understanding means that territoriality stems from behaviors associated 
with the specific physical, social, and cultural characteristics of a situation; while 
a non-behavioral understanding means that territorial functioning is rooted in 
perceptions and feelings about particular locations. The *interpersonal function* 
dimension has to do with whether the primary function of territorial behavior is 
perceived to be the establishment of dominance, or whether territorial behavior 
is perceived as facilitating social organization and social life. The *linkage with*
place dimension regards the extent to which territorial functioning is understood as being influenced by physical features of the space and/or by social and cultural dynamics (akin to Hall’s [112] concept of proxemics). The endpoints of this dimension are not mutually exclusive. The final dimension, spatial extensiveness, describes whether territories are understood as limited (and small) in spatial scope or as widely varying in size.

![Figure 4.1: Our graphical depiction of Taylor’s four organizing dimensions for definitions of territoriality.](image)

Although Taylor’s definition regards territorial functioning as relating to space, we find that this does not need to exclude virtual space (see also Dourish and Harrison [113] on the relationship between place, space and media space). In the case of collaborative writing the ‘place’ is in some sense a metaphorical or abstract one; the text and the document(s) containing it are perceived as locations. This is evident from some of the language used with respect to it [144]: ‘in the document’, ‘what page are you on?’.

In the following analysis of collaborative writing, we use the word territory to mean an amount of text with which a particular person is the main affiliate and over which that person perceives and/or is perceived to have a right to control. In the end of Section 4.5 we present our conceptualization of territoriality in collaborative academic writing using Taylor’s classification. Below, we describe concepts from CSCW that will support us in applying the psychological perspectives on territoriality presented above to our findings.

### 4.2.2 Collaborative Work

Collaborative work presents a particular challenge compared to individual work due to the added effort of placing material in common in a way that it is understandable and useful to multiple actors [13]. Continuous communication, negotiation, and time-keeping play a crucial part in collaborative writing. According to Bannon and Bødker [13], such articulation work [214], requires the construction and maintenance of a common information space, a term that Schmidt and Bannon [213] use to refer to a collection of information with differing origins and context, which holds a shared meaning to a group of collaborating actors and which is maintained
CHAPTER 4. TERRITORIAL FUNCTIONING IN COLLABORATIVE WRITING: FRAGMENTED EXCHANGES AND COMMON OUTCOMES

by them employing ‘different conceptualizations and multiple decision making strategies, supported by technology’ [213, p. 22]. This definition is very suitable for the instances of collaborative writing that we have studied. Writers bring different skills and thus goals and perspectives to the table and participants in our study have described intricate variations in the strategies employed, depending on the type of decision to be made, on who is involved in it, as well as on the timing of it. The technological mediation of this is central since the collaboration, as it looks today, could not take place without it — factoring out cloud storage, version control, e-mail, instant messaging, and so on would remove most of the current collaboration, even for co-located groups.

Schmidt and Bannon emphasize that cooperative work is not facilitated by technology simply allowing the sharing of information — rather it requires actors to actively construct an information space in which the meanings of shared objects are negotiated [213]. Communication and information sharing is required in order for actors to distinguish what is central to the joint work in a particular situation [13]. These negotiations and communication can be understood as what Lee [149] calls boundary negotiating. As a model that aims to widen the perspective on coordination provided by boundary objects [225] it does not presuppose high levels of coordination or standardization, and it embraces both coordinative and disruptive aspects of collaboration. As such it aims to help describe collaborative work characterized by partial alignment and incomplete shared understanding.

Lee emphasizes the coordinative role of artifacts, one example being intermediary objects [41]. Intermediary objects are shared representations that foster cooperation by mediating understanding and are ‘oriented towards interaction and knowledge dynamics’ [41, p. 212]. Intermediary objects are both the traces and the output of the creation process and as such represent either the product or the process. They thereby crystallize conventions and rules, providing collaborators with a ‘shared frame for co-operating’ [41, p. 216] and supporting the creation of local conventions. We have picked up the notion of intermediary objects as an analytical perspective for this work because of the character of collaborative writing as a process of creation of a text/document that is simultaneously the object of work and a mediator for the process. The document/text in its intermediate states serves as an intermediary object mediating the collaboration, feeding into its own further development.

Along with coordinative artifacts the technology in use also acts as a mediator for articulation work. Robinson’s [203] notion of double-level language emphasizes the difference between two levels of communication: The formal level of communication is rule-governed and predictable and provides a common external point of reference for actors. In the cultural level, which is steered by norms and subjective interpretations, a co-constructive process takes place through interaction. According to Robinson, CSCW applications need to support both the formal and the cultural as interacting levels of communication. In this way, both the factual and the social context are mediated, allowing people to discover each other’s subjective viewpoints through conversation in both formal and informal
4.3 RELATED WORK

encounters. Supporting only a formal level of communication removes meaning from interactions taking place through the system, disabling mutual influence and adaptation among actors [203]. The notion of double-level language provides a perspective on CSCW applications, such as those for collaborative writing, in which the capabilities for articulation work can be scrutinized.

Just as central as articulation work is the enactment of informational regionalization, in what Clement and Wagner [59] refer to as fragmented exchange. Clement and Wagner discuss articulation work and the counterpositional need for disarticulation in collective communication spaces. Based on the argument that communications in the physical world have a regionalized character that captures and supports operationalization of competences and roles, they argue that technologically mediated shared contexts require consideration of ‘the politics of sharing and withholding’ [59, p. 33]. Disarticulation can, for example, be motivated by the desire to protect a practice or for control over blame and credit, as well as by information overload or protection of personal boundaries. Heath et al. [115] provide a similar argument, describing collaborative work as an ‘ongoing and seamless transition between individual and collaborative tasks’ [115, p. 89] which relies on the continuous adjustment of people’s access to each other’s activities.

4.3 Related Work

4.3.1 Territoriality in CSCW

Work on interactive tabletops and shared displays has shown that users perceive and act according to a territorial division of the workspace [44,151,154,173,196,216,243,248]. Multiple studies in this area have also made distinctions between personal and public artifacts [10,88,105,154,171,172,220,222]. The word territory is typically used simply to refer to an area of the table or display that is associated with specific people (potentially the entire group). A spatial reasoning is often applied as part of the explanation for territorial behavior, such as personal territories enabling users to perform actions without ergonomic strain [216].

Thom-Santelli et al. [237] conducted interviews with Wikipedia users who maintain articles. They examine notions related to territoriality such as ownership, boundaries, and control, and they describe users’ feelings of attachment to their articles as well as opinions regarding their own and others’ way of editing, such as discontent with new editors making substantive changes to maintained articles. Thom-Santelli et al. argue that territoriality can be both beneficial and negative to the collaborative process and product.

Similar to the territorial attachment of Wikipedia article maintainers, Mockus et al. [170] have observed that software developers working on the Apache server obtain a form of ownership over code that they have created or are maintaining. This manifests in other developers showing greater respect for their opinions on changes.
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4.3.2 Private and Social Writing

The idea of enabling a distinction between personal and shared during collaborative writing has been explored by several authors. When describing (and critiquing) their NEPTUNE system, Delisle and Schwartz [69] argue that users should have the option of trying things out in private before showing their work. Dourish and Bellotti [75] present the collaborative text editor ShrEdit which has capabilities for private windows. Newirth et al. encourage similar capabilities on the grounds that writers ‘may not wish to make their developing drafts public’ [180, p. 145]. Posner and Baecker [197] describe the separation of individual writing using a different perspective, with an emphasis on division of work.

Wang et al. [252] discuss writers’ reluctance toward ‘writing together’, including the observation that writers often write in a separate document and copy-and-paste their work into the shared document. They also suggest that collaborative systems should provide writers with a ‘private writing place’.

Ignat et al. [124] outline the implications of technologically facilitating different levels of seclusion for users during collaborative work, in particular the issue of maintaining privacy while also avoiding concurrent modifications.

Birnholtz and Ibara [23] find that writers attribute social significance to edits and comments during collaborative writing, which can affect relationships between co-writers. This social aspect of collaborative writing is also emphasized by Lowry et al. [156] who characterize collaborative writing as a group act that requires activities extraneous to single-author writing, such as consensus building.

Cerratto-Pargman [54] likewise highlights the social aspects of collaborative writing. According to her, collaborative writing is ‘mediated twice’, through both technology and the experience of interacting with others. Cerratto-Pargman argues for shifting focus from task support for individuals or groups to support for relationships between individuals. This involves recognizing the tension between shared and personal space, and enabling seamless transitions between individual work and collective efforts [54].

4.4 Study and Methodology

To study collaborative writing in modern tools that facilitate collaboration, we recruited groups of students, predominantly working on their master’s thesis, and researchers writing conference papers and/or book publications. We selected both students and researchers to include groups of equal peers (students) and groups in which authority and role might differ between authors (researchers). Note that master’s theses in Danish universities are frequently carried out as group work by two or three students who submit a thesis authored together. The students either jointly carry the full responsibility for all content or may be required to specify which parts of the work and report each student has been responsible for. All of the student groups interviewed for this study worked by the model of joint full
### Study and Methodology

Table 4.1: Study overview: Group ID, group size and interviews, outcome type, project duration, and primary writing tool. The group ID is used as reference in quotes. Dash (-) letter indicate Student/Research group.

<table>
<thead>
<tr>
<th>Group ID</th>
<th>Size (number interviewed)</th>
<th>Type</th>
<th>Duration</th>
<th>Primary writing tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-S01 *</td>
<td>4 (3)</td>
<td>Student project</td>
<td>34 weeks</td>
<td>Google Docs</td>
</tr>
<tr>
<td>G-S02 *</td>
<td>2 (2)</td>
<td>Master’s thesis</td>
<td>17 weeks</td>
<td>Google Docs</td>
</tr>
<tr>
<td>G-S03 *</td>
<td>3 (3)</td>
<td>Master’s thesis</td>
<td>19 weeks</td>
<td>Google Docs</td>
</tr>
<tr>
<td>G-S04 *</td>
<td>3 (3)</td>
<td>Master’s thesis</td>
<td>19 weeks</td>
<td>Google Docs</td>
</tr>
<tr>
<td>G-S05 *</td>
<td>2 (2)</td>
<td>Master’s thesis</td>
<td>24 weeks</td>
<td>Google Docs</td>
</tr>
<tr>
<td>G-R06</td>
<td>4 (2)</td>
<td>Paper</td>
<td>5 weeks</td>
<td>MS Word (Dropbox)</td>
</tr>
<tr>
<td>G-R07 *</td>
<td>4 (2)</td>
<td>Paper</td>
<td>5 weeks</td>
<td>Google Docs</td>
</tr>
<tr>
<td>G-R08</td>
<td>6 (2)</td>
<td>Paper</td>
<td>13 weeks</td>
<td>Google Docs</td>
</tr>
<tr>
<td>G-R09</td>
<td>5 (2)</td>
<td>Paper</td>
<td>4 weeks</td>
<td>ShareLaTeX</td>
</tr>
<tr>
<td>G-R10</td>
<td>2 (2)</td>
<td>Paper</td>
<td>18 weeks</td>
<td>ShareLaTeX</td>
</tr>
<tr>
<td>G-R11</td>
<td>3 (2)</td>
<td>Paper</td>
<td>19 weeks</td>
<td>ShareLaTeX</td>
</tr>
<tr>
<td>G-R12</td>
<td>2 (2)</td>
<td>Paper</td>
<td>2 weeks</td>
<td>Overleaf (Git)</td>
</tr>
<tr>
<td>G-R13</td>
<td>4 (2)</td>
<td>Paper</td>
<td>3 weeks</td>
<td>Overleaf</td>
</tr>
<tr>
<td>G-R14</td>
<td>3 (1)</td>
<td>Paper</td>
<td>1 week</td>
<td>LaTeX (Git)</td>
</tr>
<tr>
<td>G-R15</td>
<td>3 (1)</td>
<td>Paper</td>
<td>56 weeks</td>
<td>LaTeX (Git)</td>
</tr>
<tr>
<td>G-R16 *</td>
<td>5 (3)</td>
<td>Paper</td>
<td>28 weeks</td>
<td>Google Docs</td>
</tr>
<tr>
<td>G-R17</td>
<td>40 (1)</td>
<td>Book</td>
<td>32 weeks</td>
<td>LaTeX (Git)</td>
</tr>
<tr>
<td>G-R18</td>
<td>2 (2)</td>
<td>Book</td>
<td>3.5 years</td>
<td>MS Word (e-mail)</td>
</tr>
</tbody>
</table>

The collaboration history within the groups ranged from working together for the first time up to three decades of collaboration. However, in all groups there were at least two members who had four months experience or more working with each other.

The study evolved from the initial interviews in March 2018 over a second round of interviews with an additional set of participants in July and early August 2018. During that time we started exploring ways of examining the insights from the interview study through various document data made available through the platform used for writing by participants. Following a small survey of techniques for analyzing document revisions, primarily in Google Docs (e.g. Sun et al. [228] and Wang et al. [250]), we decided to explore the emerging themes (see section 4.5) by examining revision data from some of the documents produced by the participants. Later in August 2018 we conducted a series of follow-up interviews with the groups whose document revisions had been examined.

#### 4.4.1 Qualitative study

During the first two rounds of interviews we conducted 23 semi-structured interviews with 13 students and 19 researchers spanning 18 collaborative writing projects (see Table 4.1). The student groups were interviewed in groups and, be-
cause of the expected differences in authority and role, researchers were inter-
viewed individually. Each interview lasted between 50 and 86 minutes, on average
64 minutes. The follow-up interviews, described in further detail below, lasted
between 39 and 75 minutes, on average 58 minutes.

The interviews focused on both practical and social aspects of the collabora-
tions: Writing strategies; division of labor and document sections among writers;
ways of editing text written by others and ways of coping with others editing one’s
own text; personal strategies for draft writing; approaches to decision-making dur-
ing the writing process; and the on-going negotiation of tasks and approaches.
Particularly the latter two types of questions were aimed at eliciting insights about
articulation work and the role of intermediary objects. The interview questions
were divided into four topics, each covering a number of questions:

1. *Project*, focusing on details about the project and the group of collaborators
   involved.

2. *Tools and writing process*, focusing on tools and features used as well as
   process-related aspects such as coordination and timing.

3. *Drafts*, focusing on whether, how, and when the participants use drafts when
   writing collaboratively as well as when writing alone.

4. *Presence in the document*, focusing on the experience of working in a shared
   document where people’s activities may be traced.

The questions remained the same throughout two rounds of initial interviews.
The participants were not made aware of the four topics and the division into topics
was not followed rigidly.

When we originally set out to do this interview study, the plan did not include a
focus on territoriality in particular. We had a general interest in writers’ perception
of and behavior relating to segmentation of the work, but the topic of territoriality
arose during the interviews and ensuing analyses, as a salient underlying theme
deserving of a full analysis. This work should thus be seen as part of a greater
research agenda on collaborative writing which acknowledges that there are many
other themes to be covered, even though the scrutiny of these have been reserved
for later writings.

The interviews were transcribed and analyzed through thematic analysis and
meaning condensation [142]. The thematic coding took place as bottom-up identi-
fication of codes that were manually clustered into themes following the coding
of all transcripts. We coded for both semantic themes, such as the means of com-
munication mentioned by participants, and latent themes such as ownership [42].
The clustered themes are topics that were prevalent across interviews. As multiple
codes contribute to a theme, some interviews mostly contributed to one subset of
codes while others mainly contributed to a different subset of codes. For example,
in the theme *ownership* some participants often spoke explicitly about ownership
4.4. STUDY AND METHODOLOGY

Table 4.2: Analyzed documents: Group ID, number of documents analyzed, number of authors, total page count and total revisions count.

<table>
<thead>
<tr>
<th>Group ID</th>
<th>Number of documents</th>
<th>Number of authors</th>
<th>Pages</th>
<th>Revision count</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-S01</td>
<td>1</td>
<td>4</td>
<td>29</td>
<td>12772</td>
</tr>
<tr>
<td>G-S02</td>
<td>1</td>
<td>2</td>
<td>68</td>
<td>119326</td>
</tr>
<tr>
<td>G-S03</td>
<td>8</td>
<td>3</td>
<td>96</td>
<td>364638</td>
</tr>
<tr>
<td>G-S04</td>
<td>1</td>
<td>4</td>
<td>81</td>
<td>170440</td>
</tr>
<tr>
<td>G-S05</td>
<td>1</td>
<td>2</td>
<td>68</td>
<td>68871</td>
</tr>
<tr>
<td>G-R07</td>
<td>1</td>
<td>4</td>
<td>14</td>
<td>19819</td>
</tr>
<tr>
<td>G-R16</td>
<td>1</td>
<td>4</td>
<td>43</td>
<td>34685</td>
</tr>
</tbody>
</table>

while other participants used other terms and/or hardly mentioned it, but on the other hand focused on accountability for produced content or achieving a feeling of shared ownership. We include salient and representative excerpts from the interviews in the presentation of our findings and analysis.

These analyses were supplemented with data from seven follow-up group interviews (marked with + in Table 4.1) in which we asked detailed and clarifying questions regarding discussions from the initial interviews. The follow-up interviews were structured and grouped into four topics: Content production and coordination; division and territories; collaboration, co-location, and timing; and coherence and ownership. The questions on content production and coordination were based on Posner and Baecker's [197] taxonomy and the strategies for text production identified by Wang et al. [250], and focused on the strategies that the participants had applied in documents on Google Drive which the groups had granted us access to (see Table 4.2 and below). The follow-up interviews served to corroborate or correct our conceptions of their writing processes.

4.4.2 Analyzing Document Revisions

To aid our analysis of how territorial functioning and other aspects of group collaboration manifest in the writing, we have developed a visual analytics tool that allows visual exploration of the edit history of a Google document. A few tools and plug-ins for visualizing Google document revisions already exist (e.g. Sun et al. [228] and Wang et al. [251]), but these tools enforce a different focus than what we find to be required for a fine-grained analysis of territorial behaviors. These other tools highlight e.g. relative individual contributions or the chronology of revisions. Furthermore, they separate the visualizations from the text in the document, making it difficult to explore the connection between revision data and document content or information obtained from the interviews. A secondary concern is the methodological implications in appropriating an analysis tool designed for a different purpose without knowing its inner workings.

The visualization tool developed to aid our analysis provides spatially structured visualizations that are coupled with the original text. The tool a) extracts
the revisions using a technique similar to [228][251], b) identifies spatial groupings of revisions, i.e. which paragraphs the revisions belong to based on their positions in the document (as opposed to chronology), and c) generates various visualizations alongside a reconstruction of the document in a side-by-side view. The visualizations show which authors have made revisions where and when; and the side-by-side view allows identification of which revisions belong to which paragraphs. The corpus of data is revisions extracted from the documents shared with us by participants (see 4.2).

Our focus when studying the visualizations has been to identify patterns in the revisions relating to which authors have written what, where, and when. The visualizations have served to provide clarity for us in the writing of this paper, by letting us study indirect examples of the behaviors described by participants and include them here for illustrative purposes. Future work will involve presenting interviewees with visualizations of their own writing process to facilitate an in-depth discussion about the connection between practices and the patterns that manifest in the revision log. Such a study would require more space to discuss the concrete writing patterns and potentially make some more nuanced distinctions between the different group writing practices represented.

Reading the visualizations

We include examples of the visualizations in our analysis. Therefore, it is necessary to briefly introduce the three visualization levels. We visualize and distinguish between the ordering of the revisions in two ways. The chronology of the document refers to the history of the revisions. When extracted from Google documents, the revision data is organized chronologically, so that the first revision is the first activity in the document and the last revision is the last activity. It is important to note that there is no correlation between the chronology of revisions and their spatial position in the document. The latter, the spatial position in the document, we refer to as the spatial revision index. This is useful when trying to understand and explore where in the document specific revisions ‘belong’ in relation to other revisions.

The first level (Figure 4.2, right) visualizes the revisions of the entire document as blocks, segmented by paragraph so that each line of blocks represents one paragraph (defined as one or more lines between two line breaks). The blocks are color-coded, each color representing an author. The number of blocks in a line corresponds to the number of revisions in the paragraph; the variation in block size is thus due to all lines in the visualization having the same length despite the paragraphs having a different number of revisions, and the block size thus does not reflect any characteristics of the individual revisions.

This level of visualization emphasizes the spatial index of the revisions. This stacked view of the revisions allows exploration of larger patterns of territoriality in the document by illustrating author contribution and territories across multiple paragraphs and larger sections of the document. Figure 4.2 shows the document
next to the stacked revision, with arrows added to indicate which line in the visualization corresponds to which paragraph.

Figure 4.2: **Left:** Paragraphs in the document that is visualized on the right. The superimposed heat map indicates how the revisions highlighted in the visualization correspond to the spatial structure of the paragraph. **Right:** Stacked view with each line representing a paragraph in the document on the left.

The second level (Figure 4.2, right, highlighted) of the visualizations shows the revisions in a single paragraph. This is what each line in the stacked view shows, but we describe it in more detail here. The visualization shows revisions structured by their spatial index in the paragraph, so that revisions adding/deleting characters in the beginning of the paragraph are visualized in the left end of the line representing the paragraph, with spatially subsequent visualizations added further right in the visualization. Note that this order does not indicate the chronology of the revisions. This level of visualization allows exploration of which users have contributed to specific paragraphs and when.

The third level (Figure 4.3) shows the revision chronology in connection with the spatial index visualization on a paragraph level. The visualization retains the spatial index on the x-axis and visualizes the chronology downwards on the y-axis in sessions, i.e. revisions that have been added sequentially with breaks of less than 15 minutes (using the same temporal collaboration metric as [228]). The sessions are separated by a horizontal line detailing the time span between the sessions (days, hours and minutes). This visualization allows exploration of the temporal aspect of a single paragraph in relation to the spatial index of its revisions, thus supporting identification of collaboration patterns.

Figure 4.3 shows the combined spatial/temporal view along with an excerpt of the stacked view. An indication of which paragraph is being visualized has been added for clarity. In this example, the additional temporal dimension reveals that the green and the blue author have first contributed synchronously to what is now the beginning of the paragraph. After an inactive time span of five days, the blue writer has made revisions near the middle of the paragraph (at the time of the revisions: the end of the paragraph). Finally, after another inactive time span of 3
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Figure 4.3: Combining the spatial revision index with the revision chronology. The x-axis is the spatial index and along the y-axis groupings of sessions separated by light grey bars with information about the time span are shown.

days, the yellow and the blue writer have worked synchronously on the paragraph.

4.5 Findings

4.5.1 Territories in Writing

It is clear from participants’ way of describing their experiences of writing with others that they are attentive to territorial affiliation:

‘[…] as a student you write something and then, I mean, it’s your thing. I mean, sometimes it’s group work, but you respect each others sections so you don’t go and edit them.’ (G-R15)

Figure 4.4: Two adjacent territories with a clean boundary [G-S04].

Figure 4.5: Another example of adjacent territories, with a bit more overlap around the boundaries [G-S01].

In the visualizations we observe territories spanning several pages as well as clear shifts. Figure[4.4] shows the cleanest example from the data set. The first four
4.5. FINDINGS

Paragraphs were left almost entirely to the writer represented by blue while the bottom three were left mostly to the writer represented by yellow (the large blue line was caused by a line break created by the blue writer). The second example, in figure 4.5 shows a more common example, with a few overlaps around the border. A way of recognizing these shifts is to compare with cases where clear demarcation and territories are absent: In figure 4.6 we can observe a case where four authors are all involved in editing.

![Figure 4.6: An example of a set of paragraphs with no clear territories](G-R16)

A territory is not necessarily a connected or consecutive block of text. One participant described what he called 'logical blocks':

'We had these logical blocks and then you wouldn't touch the logical block [...] So you might be working in a logical block and that has a reference, there's some dependency in another block [...] It's about, there's something here that belongs as one argument.' (G-R12)

As the following participant states there is often an awareness of who different sections of the text ‘belong’ to, and so where and when writers edit when writing with others is not a trivial decision:

‘[…] for me to then go in and change his words feels like a violation in a way, right, I don't have the right to do that.’ (G-R10)

‘I have sometimes experienced with others, who have a really really hard time letting go of their text, right? That others make edits in it.’ (G-R18)

Territories lie on a spectrum of permanence: There are regions of text that continue to be associated with one particular writer throughout the process, even after other people have been allowed to edit. They are thus controlled permanently by specific individuals. Figure 4.7 shows the visualization of a paragraph in which one writer (blue) has done a large majority of the editing, with a co-writer doing sparse editing throughout but never taking charge of the paragraph. There are also regions of text which are not associated with particular individuals or which may have a primary person in charge but are still freely editable. They may not be freely editable at any time, however: Participants frequently described a temporally local form of territoriality in which a writer's presence in a region means that other writers steer clear of it, in effect a kind of personal space. There is thus a temporal aspect to territories.
‘You don’t enter a section that’s being written by someone else and start editing anything significant. Neither do you just sit and wait for something to be written, looking at it. Then you move on to see if there’s something else you can work on. There are some sort of unwritten rules.’

(G-S04)

Figure 4.7: Permanent territory with co-writer performing only small edits. A) The spatial index visualization, B) The revision chronology. [G-R07]

Some of the participants also described a form of turn-taking in which a piece of text is ‘handed over’ from one writer to another. In these cases, there is always someone in charge of the text but who this is changes over time. We show an example of this in Figure 4.8 in which we see the control being transferred between three writers.

Because the non-permanent territories vary in their degree of ephemerality we feel that it is more useful to view all territories as being on a spectrum, rather than discussing totally permanent territories and other kinds as two separate types of territories.

Control

When we asked participants how text comes to be associated with certain writers, their responses typically had to do with an explicit division of work (by assignment of writers to different sections) or with who originally authored a given section. As assignment of a section leads to authorship of that section, control of sections thus comes down to authorship.

One reason for this is that the original writer acquires a form of local expertise. The difference between being the primary author of a region of text and being a visitor is comparable to borrowing someone else’s messy desk; for the visitor the act of moving a piece of paper with scribbles on it may seem insignificant, but to the usual occupant this could be immensely disruptive to their work flow. In the same way the original author has a certain expertise in navigating the particular region of text:
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Figure 4.8: Turn-taking, with writers handing over control of a paragraph. A) The spatial index visualization, B) The revision chronology. [G-S03]

‘I really mean the words that I’m using and why I’m using those words. So sometimes she changed that and I was like: Nope, that just doesn’t work. Like, that breaks all kinds of other stuff because it is this symphony, right, all of these things somehow hang together.’ (G-R10)

‘But what if you change it and you remove the thing that made my brain click […] Then I’m just reading an empty paragraph.’ (G-S05)

Our notion of local expertise can be related to Bakker and Bakker-Rabdau’s definition of a territory as an area in which the individual has special expertise (see Section 4.2). According to Bakker and Bakker-Rabdau, criticizing someone can be construed as enroaching on their territory. This view can explain why the indirect criticism contained in a modification of someone’s writing without an invitation may be perceived as an intrusion. Bakker and Bakker-Rabdau [12] also note how delegation of responsibilities, and hence of competence, can result in a loss of territory; conversely, in maintaining the role as the local expert, a writer keeps their territory. This corroborates our observation that local expertise is sustaining for a territory. Bakker and Bakker-Rabdau’s emphasis on showing initiative and taking responsibility may in fact be a very accurate description of the kind of control that participants describe with respect to writing territories.

Given the significance of authorship to territorial functioning in the collaborative writing process, identity becomes important. This parallels Bannon and
Bødker’s [13] observation that the identity behind information is significant to work in common information spaces. While Bannon and Bødker describe assessment of credibility as a reason for this, our findings highlight the connection between identity and judgments of a person’s rights with respect to a given piece of text. Text written by the person in charge of a textual territory has higher status than if written by someone else; it is less easily modifiable. That is, the history of a piece of text has an impact on territorial cognition and thereby behaviors. As the locus for this history the text thus acts as an intermediary object, modulating future work on the text.

As the following participant pointed out, knowing the identity behind a comment helps the writer prioritize:

‘[.] that’s one indication, also for other people, to know: Okay, if she wrote that comment in that section that is actually her expertise then it’s more valuable, or more interesting or more relevant, than coming from somebody else.’ (G-R06)

This quote exemplifies both the significance of local expertise and Bannon and Bødker’s point about credibility.

The perception of control is also influenced by role division. In many cases, the main author has the final say. By main author we mean the person contributing the majority of the content and/or actual writing. In some academic settings, this will be indicated by placing the person’s name first on the publication, as was the case for some of our participants. Examples of the main author having (or taking) the final say include these cases of Ph.D. students describing their relationships to their supervisors’ feedback on papers of which they are the main and first author:

‘I've really just gone in and changed stuff, also because I realized that even though he says: I think it should be this way. I can say: “No I don't think so.”’ (G-R15)

‘I might have times where I just ignore her feedback because I know that I'm trying to push this specific point through the entire paper […]’ (G-R12)

In all cases of writing where there was a role division with one author doing the majority of the writing, participants acknowledged the decision-making power as lying with this main author. This fits the image that being the main contributor to a piece of text puts a person in charge of that piece — it simply varies whether pieces of text are considered on the level of paragraphs, sections, documents, or entire projects. In the case where someone is seen as the primary contributor to the document as one unit of writing, this person has the right to overrule the writing of others. In cases where authorship is more equally divided, the case is sometimes a different one, as exemplified in an earlier quote.

This emphasis on the main author is not to say that other kinds of roles do not have an influence. Seniority can, for example, also affect sentiments about editing:
‘[…] with other senior people I think it would also feel strange if I were to just go in and change their text, I think they would feel that’s inappropriate.’ (G-R12)

In this case the right to edit still depends on who is perceived to control that piece of text, but it has to do with their status in general rather than their role with respect to the particular text. It is thus not necessarily based on local expertise but could instead be based on a general expertise.

4.5.2 Separation and Demarcation

While writing territoriality was frequently constituted in behavior and/or sentiment, supported by participants’ awareness of who is working where, we also encountered materialized territoriality in the form of separation and demarcation of text. By separation we are not referring to the generation of artifacts separate from the working text, such as the backups, notes, and to-do lists which participants also described to us, but rather to the act of temporarily separating the text that one is working on from the rest of the writing.

Separation

Separation can be of multiple forms: White space surrounding a paragraph or a section (made by use of line breaks or page breaks), a separate shared document, or a separate document inaccessible to co-writers. A group of students described that they would be working on each their part of the report and how they would often make a separate document for each section, not gathering them into the final document until later on:

‘We would sometimes take a section out and then be writing in each our document and then pull it back into the combined document afterwards.’ (G-S01)

Figure 4.9 shows an excerpt from this group’s document in which a paragraph has been created by copying and pasting, which can be inferred from the fact that the paragraph’s collection of revisions consists of only two edits (likely a paste followed by a small edit or vice-versa).

The motivation for such separation can be the desire for privacy or a more pragmatic need for a space in which to work uninterrupted; the latter may be to be
rid of visual distractions or free from co-writers intervening and disturbing one’s flow of thoughts. In the case of the above statement from students their motivation was the visual disorientation caused by multiple people editing simultaneously:

‘Then someone copy-pastes an image in and then the stuff you were looking at, it’s suddenly down on the next page, without you noticing. It can be a bit up and down all the time.’ (G-S01)

Another example of pragmatic motivation would be the impracticality of two writers simultaneously editing the same paragraph. Some of the participants also mentioned how interference from co-writers at inopportune times could disrupt their thought process:

‘Sometimes a sentence is tough to get out [. . . ] So it has a lot of intermediate states where it’s not that good but might be pointing towards something. [. . . ] It can break that process if someone goes in and changes it. [. . . ] It’s these kinds of individual processes that can sometimes get messed up if others go in and meddle with what you’re working on.’ (G-R10)

Several participants also described a preference for working in private:

‘I need my own process [. . . ] I think maybe it’s just that it’s a process inside the head that’s on paper and I need to, just, have that to myself until I get started.’ (G-S02)

According to Bakker and Bakker-Rabdau, ‘privacy is obtained by establishing a territory to which one can retreat from the influence and scrutiny of others’ [12, p. 16]. Fitting for the quote above, they state that the most private realm is a person’s thoughts. Taylor [233] presents a more nuanced discussion of the distinction between privacy and territorial functioning, but for our purpose here the important thing to note is that writers’ desire for privacy motivates territorial behavior. As demonstrated by the quote above there is not always a pragmatic reason behind, but protecting personal boundaries can be another reason for disarticulation [59]. Being disrupted by the presence of others is furthermore similar to Clement and Wagner’s [59] example of information overload. Potential disruptions in fact induce territorial behavior in two ways; in addition to being a way to create a space free from disruptions, territorial behavior is also a way to isolate those of one’s own activities that may be disruptive to others. Some of the participants described the forming of a personal workspace where they could work in the way that best suited them:

‘So there are some parts where you take kind of ownership of the document and it’s like: I’m polluting it with all kinds of stuff that’s for me and I don’t care about whether or not it’s bothering you!’ (G-R10)
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In many cases writers must rely on co-writers to respect boundaries. Several participants described announcing to co-writers when they were allowed ‘into’ a territory:

‘[...] it takes me a while to get something that somebody else can look at, that I feel comfortable with. So that’s why I generally, for those people, I’ll do it in a separate section and I try to write it completely and then: Okay, now you can look at it.’ (G-R10)

This form of enforcement of territories relies on social protocols to a much larger extent than separation of text. Of course the type of enforcement is often somewhere on a continuum: When separation is merely a page break the writer is more reliant on cooperation from co-writers than if working in a separate document, even if access to that document is shared, as co-writers will be separated from the territory to a lesser extent. Social protocols and compliance with these must be achieved through negotiation, whether direct or indirect. By indirect negotiations we are, for example, thinking of conflicts caused by differing opinions regarding rights to edit: As these conflicts surface and are discussed (and potentially resolved), or even just as a result of them even if no one brings up their dissatisfaction, changes in behavior will usually result.

Demarcation

Another way of segregating work is by demarcation rather than separation; that is, by use of signals to mark territories. Such signaling of claims is included in both Taylor’s [233] and Bakker and Bakker-Rabdau’s [12] descriptions of territories. A page break already borders on being a signal as it does not make a strong material boundary for co-writers and thus relies on compliance. Participants also described using color codes to signify who was in charge of a piece of text:

‘So in the top of the document we had a color code for each of us. And then we marked each point in that color so that we could see who was assigned what.’ (G-S01)

These color codes are not necessarily applied on the text itself but are used e.g. in a bullet point list which maps to the different sections or topics to be written (about).

Color codes are also used for identification of the writer, enabling co-writers to know who wrote a particular comment or piece of text:

‘We have comments in different colors, so we know that the yellow comment is from this author; the red color is from the other author.’ (G-R13)

Conventions, such as color coding, which are negotiated and mediated through the document provide co-writers with a foundation for cooperation [41]. Through
the forming of conventions that manifest in the document, the document becomes an intermediary object that simultaneously mediates the object of work and many of the conventions and interactions supporting the work, i.e. articulation work.

Separation, color coding, and use of macros for identification in general are all examples of writers appropriating the tools to cover needs for articulation work. By adapting their use of and combining features of the tools at hand writers achieve a form of double-level language that allows them to navigate the content, and thus the task, as well as the social context. The color of a bullet point comes to signify both that a task will be taken care of and who will do so, and additionally may signify that this person has certain prerogatives with respect to this task and conversely that others do not have such prerogatives.

4.5.3 Navigating Territories

From participants’ accounts we get an impression of a great amount of social expertise and awareness used to navigate the text as a social space. Participants generally take care not to overstep boundaries. A way to accomplish this is to make use of comments for editing to avoid directly ‘touching’ other people’s work, or to enable the original writer to reverse the decision:

‘[…] whenever they had something written […] I would always rewrite it as a comment and leave the original thing that they had, cause I wanted them to then approve, right?’ (G-R10)

Other participants were less reluctant towards making changes directly and were correspondingly more accepting of others changing their own writing. They, however, still had strong opinions regarding the way such changes were made, akin to Birnholtz and Ibara’s [23] findings:

‘I definitely don’t think it’s okay if anyone ever deletes someone else’s writing without explaining why.’ (G-R06)

These participants described a form of editing etiquette in which respect is shown for the original writer by providing explanations for edits (and conversely no explanation is disrespectful). This behavior is an expression of territoriality because it is rooted in an awareness of affiliation, ownership and rights with respect to specific regions of text. This is another example of double-level language: The comments in and of themselves contain edits or serve to explain rationale. But what they additionally (and at least as importantly) provide writers is a way to demonstrate respect and maintain social order. While demarcations, such as the color codes described earlier, mainly serve as a kind of expressive double-level language that signals expectations, writers use comments to communicate in a way that expresses compliance with such expectations, as such a more operative double-level language.
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As an extension of the guideline that you do not touch other people’s work, many participants who were using real-time editors also reported that they would generally not be editing in the same spots, out of courtesy as well as for practical reasons:

‘It rarely happened that a person would be messing with something that someone else was still editing.’ (G-S01)

We have already mentioned similar examples in the preceding sections. What we want to emphasize here is the role of courtesy in writers’ decisions. The choice of words (‘messing with’) indicates the negative connotations of interfering while someone is working.

What is furthermore exemplified in the quote above is the role that timing plays in territorial etiquette. Another participant’s statement additionally shows us that timing is a more delicate matter than simply being aware of the co-writer’s presence:

‘[…] if it’s something that’s just been written then there’s also a bit more ownership of a section, and then you really need to be careful when you change something.’ (G-S03)

As we see here, it is not always enough that the co-writer is not currently writing — some writers also take into account how recently the co-writer has been working on the text. This significance of timing can in part be explained with Bakker and Bakker-Rabdau’s discussion of action territories as areas in which a person exercises their expertise. Such a territory depends, according to Bakker and Bakker-Rabdau, on continuous performance of the work making up the territory. In our case, this means that as long as the co-writer is working on a piece of text, that piece of text is considered their territory. Thus, the less likely it is that they are still working on the text, the more likely it is that modifying the text will be acceptable.

Explicit Coordination

In addition to etiquette participants also used more explicit means to coordinate editing so as to avoid intruding on each other. One participant, a Ph.D. student, described a procedure that had developed between him and his supervisor, where his supervisor would ‘always wait for a “go”’ (G-R12) from him before editing anything that he had written. In this case it was mainly important for the student that they would not be interfering with each other’s work and that he would be getting feedback when it was most useful for him. In other cases participants put more emphasis on the writer’s ability to control their presentation of self. In the following statement, a participant describes why he and his co-writers would write a message in a group chat when they were done working on a section:
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“It was out of respect. […] Let the person finish the thing that he’s working on and when he has something presentable he can move on.”
(G-S01)

As is evident from the preceding quotes, territorial behavior is not always enforced by the person in charge of a territory. Furthermore, there is not always agreement between co-writers as to the enactment of territorial respect. One participant reported annoyance that co-writers would exhibit misguided respect for her territories by suggesting changes in comments instead of just making them directly:

“That’s usually why I ask people to go over my paper and just say “please, just add it, don’t make comments,” because it’s just a crazy overhead for me. And then they look over it again and they actually make comments, and I say: “No, change it!””
(G-R06)

In the end, her co-writers’ attempts at courtesy would result in a greater workload for her.

Territorial etiquette materializes in the document, as traces of the different writers. For example, as a participant put it, ‘the parts that you have drafted […] they will never lose this flavor of your words’ (G-R12). And during work, writers’ awareness of territories is mediated by the document as an implicit reminder of the division of work through section headings, paragraph spacing, etc. The current state of the document ties in with participants’ awareness of the division of work, reinforcing social structure and guiding further work. In this way the document acts as an intermediary object by crystallizing the territorial protocol and, in being the setting of the work, frames the onward writing process.

4.5.4 Reconciling the Outcome of Fragmented Work

The, for many participants relatively strict, separation of work requires an effort in order for the writing to become coherent and align the viewpoints of its multiple authors:

“You have to feel that the text is yours. So that’s the thing that I am most afraid, when I write the paper with someone else. It is to find that particular balance of feeling that the text is from both.”
(G-R13)

Disambiguation plays a core part in collaboration, not only to enable cooperation but also to enable eventual alignment among collaborators regarding their perspective on the contribution.

Statements like the ones presented in the preceding sections show us that territorial functioning is adaptable; closely intertwined with the dynamic writing process. They also demonstrate the negotiable nature of territorial functioning, highlighting the articulation work that is constantly taking place.
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And so, despite sentiments of territorial character, writers need to allow others into their territory:

‘Maybe I came up with a draft, but I should also allow people to make changes and come with different suggestions if they disagree with the content. I don’t want them to have their name on the document if they disagree with what’s written.’ (G-R07)

The consequence of this is that writers will, in the end, have had some influence on text written by co-writers, even when there has been acute awareness of territories and consequently enactment of territoriality. Many participants expressed how the text became a shared product through the influence of multiple people editing it. Towards the deadline, territories are no longer strictly adhered to and the editing etiquette falls back in favor of finishing the text:

‘Maybe if there was a rush at the end and they deleted part of what I wrote, then fair enough.’ (G-R06)

That writers will impose more on each other’s territories in the later phases of writing is something that we also observed in the visual analysis. Figure 4.10 exemplifies the pattern in which editing is conducted by one writer (the first three lines in B), until the final editing run when other writers join in (the last two lines).

Figure 4.10: A territory that ended up being edited by multiple co-writers towards the deadline. A) The spatial index visualization, B) The revision chronology. [G-S04]

It is still acknowledged that some sections are associated with specific people but there is no time to let work be influenced by this. For example, as the deadline approaches it becomes more important to cut the number of pages to fit the submission requirements than to heed the original writer’s right to have a say:

‘At that point in time then it’s just free to go and throw sentences away, and then she does it and then I do it and we don’t need approval from the other person.’ (G-R12)
4.5.5 Territoriality and Ownership

It is easy to get an impression that territoriality is simply a question of ownership. Document territories and their affiliations emerge through the writing and ownership carries a large significance in the creation of text, as demonstrated by the language used by participants:

“It's also the way we talk about it. That we say: That was your chapter and that was my chapter.” (G-R18)

This is different from just having an awareness of the division of work. As can also be told from participants' statements in the previous sections they clearly feel an attachment to the text they have contributed, and feelings of ownership are closely tied to the act of contributing, in one way or another:

‘I did very strongly remember feeling this thing of: It’s not my thing. I can't claim this as my paper 'cause [...] I didn't build any of the technology, I didn't do the video [...] all I was doing was just editing somebody else's paper — they already wrote most of it.’ (G-R10)

This participant is describing a project that he joined later than the other collaborators. Joining late made him feel like he did not have the right to claim ownership of the project.

While territoriality can also be related to attachment, territoriality and ownership are not inextricably entwined. For this participant, authorship did not carry the same significance for feelings of ownership as it seems to do for territories:

‘I feel it’s important that one also has ownership of all the technical parts and what’s in there [...] and then of course the wording might not be mine, but I think that’s not the important part.’ (G-R12)

She felt an ownership of the writing due to her contribution to the content, despite not having written much of the text herself and thus having no territorial claims to most parts of the document. Similarly, another pair of participants agreed that they each ‘feel more responsibility for what I’ve written but I don’t feel like I own it’ (G-S05). They felt a joint ownership of the full text despite being responsible for separate parts. It seems like ownership more holistically comprises the entirety of the project, having to do not only with the text but also with the content, the message, and other factors, whereas territoriality is about which specific parts of the text the writer has been working on.

4.6 Territorial Functioning in Collaborative Writing

The findings presented above paint a complex picture of human interpersonal coordination of digitally mediated document production and editing. This section interprets the findings and their implications for how we may understand
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collaborative writing. After outlining our understanding of territorial functioning in collaborative writing we discuss some dimensions along which this functioning unfolds by drawing on our analysis and comparing with Taylor’s understanding of territorial functioning.

Our findings do not align perfectly with Taylor or Bakker and Bakker-Rabdau’s definitions and discussions of territoriality. They, nonetheless, show that we are dealing with a form of territorial functioning when examining collaborative writing. Rather than presenting a new definition, we take territorial functioning in collaborative writing to be an exemplar of territorial functioning, and we here use Taylor’s organizing dimensions to characterize this exemplar (see Table 4.3). We discuss each of the dimensions below.

4.6.1 Makeup

As described, territories in writing may consist of multiple semantically, or logically, connected pieces of text that do not occur consecutively in the document. Their status as someone’s territory is highly dependent on writers attributing this meaning to them, along with certain expectations regarding behavior. The same is true for territories consisting of only one block of text, despite the dependence on meaning attribution and interpretation sometimes being less obvious. In order to construct and maintain a common information space, writers must thus agree on the territorial meanings of the various parts of the text, reflecting Schmidt and Bannon’s point that cooperative work requires the negotiation of meanings of shared objects in the common information space. Hence, writers’ behaviors are determined by their perceptions and interpretations. This places territorial functioning in collaborative writing closest to the cognitive/affective end of the spectrum; although not completely in one end as negotiated behaviors are significant for sustaining the territorial division of the work.

4.6.2 Interpersonal Function

The cases of collaborative writing studied in our analysis rely on writers’ expertise in navigating the text as a social space. The writer holding the initiative has the liberty to make alterations as they see fit while other writers will employ various means in order to leave the initiative with the original writer. Maintenance of territorial division in collaborative writing is a joint accomplishment that relies on this form of respect for territories. We thus view territorial functioning in collaborative writing as a mutual maintenance of task-related and social functioning. An interesting example of this reciprocity is how maintaining a territory of one’s own was described by some participants as a way to avoid bothering co-writers with one’s messy work. In sum, we classify territorial functioning in collaborative writing as oriented towards cooperation as opposed to power. While power relations do play into territorial functioning, this seems to serve the purpose of maintaining social order in order to cooperate.
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MAKEUP
behavioral ↔ cognitive/affective

Cognitive-affective: Closer to the cognitive-affective end of the spectrum, as the behaviors we have uncovered are grounded in writers’ sentiments about particular regions of text, as opposed to being determined by the material and social context.

INTERPERSONAL FUNCTION
cooperation ↔ power

Cooperation: In the cooperation end of the spectrum as the things at stake for writers are relationships to co-writers (getting along and avoiding conflict) rather than establishing dominance. The power dynamics at play in collaborative writing, although influential, are not a central source of territoriality.

LINKAGE WITH PLACE
place-dependent ↔ social/cultural

Social: Near the social end of the spectrum, due to the large influence of roles and relationships on territorial behavior. Behavior around a certain part of the text is not due to particular characteristics of that piece of text but to writers’ roles with respect to it.

EXTENSIVENESS
limited ↔ unlimited

Unlimited: Extension ranges from local and/or temporary to the full document and/or permanent.

Table 4.3: Writing territoriality along Taylor’s organizing dimensions.

4.6.3 Linkage With Place

We find territorial functioning in collaborative writing to be socially determined as opposed to place-dependent, since expectations based on writers’ roles with respect to a given piece of text are the central factor. We have also described how writers achieve a form of local expertise in their territories which factors into the continued attribution of the status as a territory. The importance of roles and the related expectations supports our understanding of territoriality in collaborative writing as socially determined as opposed to dependent on particular characteris-
tics of the various pieces of text as metaphorical places.

4.6.4 Extensiveness

We have chosen to refer to Taylor’s fourth dimension simply as extensiveness as opposed to spatial extensiveness since the behavioral aspect of territorial functioning in collaborative academic writing introduces a temporal dimension in addition to the spatial one. Since Taylor’s conception of extensiveness hinges on his focus on territorial functioning in physical space, we have to abandon Taylor’s physical terms in order to discuss extensiveness in collaborative writing.

As previously stated, territories lie on a spectrum of permanence. In one end of the spectrum, we have territories that continue to be associated with a particular writer throughout the project and may continue to be so after the project has been completed. In the opposite end, the significance of timing becomes clear, as exemplified by the temporally local form of territoriality in which a writer’s presence in a section of text causes other writers to leave that section alone. Similarly, on the spatial spectrum, one writer may be in charge of the entire document, effectively having all of the text as their territory, or a person may (possibly temporarily) be in charge of just a paragraph. In conclusion, both the spatial extensiveness and the temporal extensiveness of writing territories are unlimited in the sense that they can range from brief and/or very small to permanent and/or the full document.

4.6.5 Dimensions of Collaborative Writing

To contextualize our understanding of territorial functioning in collaborative writing, we here discuss some dimensions that have frequently been addressed in work on computer-supported cooperative work, namely time, place, and roles. Time has been discussed with respect to duration [70] or synchronicity [107, 150], while place is typically viewed as (physical) proximity or distribution [70, 107, 150]. Role has mostly been addressed with respect to collaborative writing [11, 180, 188, 197]. In addition to these, we discuss state as a dimension.

Time

Synchronicity as the way of speaking about time in collaborative work is of limited value in our case. It says nothing about the object of work despite the close integration of work on the common object with timing and place. For instance, what participants construe as acceptable behavior is highly dependant on the stage of the writing as well as on who is currently editing and on planned future work. To simply speak of synchronicity would be to ignore the significance of stages and planned work, which critically affect territorial behaviour: Territories evolve through the phases of a project and the working norms for territorial functioning adapt, e.g. to the approaching deadline. Late in the process, as time becomes pressing, previously unacceptable behaviour becomes necessary and happens without disputes. Although the lifetime of territories can extend throughout the duration of
the project, the degree to which work is structured around them thus varies with different phases of work. This shifting behavior influences the meaning that writers attribute to the text, meaning that acceptable behavior can be a question of timing.

Timing according to the phases of the writing is somewhat long-term while the timing of interpersonal exchanges happens on a more short-term basis. And timing clearly has an impact on the kinds of interactions that may take place between co-writers — for example, quick deliberation about changes versus leaving an explanation so as to avert negative interpretations by a co-writer in one’s absence [23].

Short-term timing, such as when previous changes to a section were made, also influences the acceptability of edits. This timing can also be related to place; whether or how a writer makes an edit can depend upon where co-writers are currently working and when they might see the change. The importance of timing derives, in part, from writers’ desire to demonstrate accordance with territorial expectations.

To speak of *timing* seems to better capture the nature of the writing process; the timing of different actions with respect to each other; the timing of presence; the timing of work to the state of the object and the stage of the project. Aiding writers in timing their work to each other and to the object of work would provide wholly different support than merely facilitating multiple modes of synchronicity.

Time is lacking in Taylor’s definition, something he in fact remarks himself [233, ch. 14]. He briefly discusses how the adaptive nature of territorial functioning relates to time, but this does not come close to the temporally dependent changes to territorial functioning that we have described in our discussion of progression towards the deadline. Furthermore, Taylor does not mention timing at all.

**Place**

Place in computer-mediated collaborative writing has multiple levels. We may talk about writers’ physical location with respect to each other, as well as location within the text at multiple granularities: document, file, paragraph, section, topic, the latter of which is solely manifest in writers’ minds, due to their unspoken awareness of which parts of the text are logically connected. It is the in-text place that is relevant to our discussion.

Taylor [233] is solely focused on place in a physical sense, such as physical layout and its connection with territorial cognitions and behaviors. He explicitly argues against a ‘despatialization’ of the concept [233, p. 321]. The term *territorial* applied with respect to ideas or projects is, according to Taylor, used metaphorically. However, permitting the metaphorical application of the concept without opening up to different forms of territorial functioning seems simplistic. As we have argued, a metaphorical view of collaborative writing as taking place in a virtual *space* makes good sense.

Territorial functioning in collaborative writing is not mainly determined by ‘physical’ characteristics of the text and the editing environment. Rather, what has significance are affiliations between writers and parts of the text, and how writers place themselves in the virtual space. There is a great deal of contextual
dependence at play in this: Whether the writer of a piece of text is currently present, whether the text is still a draft, and whether the project is at an earlier or a later stage all influence how writers and co-writers interpret the situation and each other’s actions. Place and timing are thus closely related.

The physical metaphor does not apply to writers’ attachment to the text. While Taylor’s concept of attachment is linked to familiarity with a place over time, attachment in collaborative writing is between the writer and their creation. Both kinds of attachments carry with them a desire to remain in control, but it is the writer’s attachment to the text that is significant for territorial functioning in collaborative writing.

**Role**

Part of territorial functioning is the association of certain people with certain places. In collaborative academic writing, the association between people and text stems from roles with respect to the project and the assignment of tasks, as well as the ensuing work which is what actually ties writers to certain parts of the text.

As in Taylor’s description of territorial functioning, cues about role ‘help set the ‘tone’ of the interaction, and shape expectations about its outcome’ [232, p. 216], but in our case the expectations regard modification (or not) of the text in question, as opposed to expectations regarding general interpersonal interaction. The territorial functioning of collaborative writing in a way comes down to activities that are associated with roles and assigned tasks. It should be stressed that these roles are not static: Users continually shift between writing, proofreading, planning, deliberation, and so on, as they relate to each other and each other’s work during the writing.

Different constellations of roles entail different forms of acceptable behavior [12]. For instance, if a writer has announced that their text is ready for feedback, a new role has been offered their co-writers in which they are allowed to ‘intrude’.

**State**

As mentioned, the state of the text is another dimension to be considered. The document as an intermediary object supports social functioning and cooperation by continually mediating the division and accomplishment of work [41]. Writers occasionally produce concrete separate instances of the text in the form of drafts, backups, bullet point plans, etc. But even more so, the actual document’s current state acts as a mediator for its own continued production. The various instances of this same document, along with separate versions and notes, make up intermediary objects that influence the way it is worked upon beyond simply being the foundation for the next addition. Writers’ awareness of territories is mediated through the document and they interpret the state of the text in order to act usefully and

\[\text{This interpretation is more dynamic than the one by Bakker and Bakker-Rabdau which focuses only on situationally dependent roles such as teacher/student.}\]
appropriately, such as by inferring whether feedback on a piece of text would serve as a helping hand or a disturbance. Such inferences of course also rely on awareness of the given co-writer’s preferences and ways of working, but the interpretation of the immediate situation relies on information to be read from the current state of the text.

The counterpart to interpretation of state is the articulation of conventions and of the work, which partly happens through territorial demarcation. Taylor, likely due to his physical perspective, focuses on ways of signaling that something is a territory and whose it is. In the presentation of our findings we have additionally discussed writers’ efforts to signal compliance with territorial expectations. This particular aspect of territorial communication plays a significant social role which Taylor’s definition does not cover. Addressing writers’ needs and means for articulating themselves and the work is central.

The granularity of state is difficult to specify. In the case of territoriality it is whatever carries meaning to the actors involved and influences whether and when they work on different parts of the text. This obscurity makes it no less of a significant factor in the interpersonal dynamics of collaborative academic writing. The challenge lies in identifying an actionable takeaway: How do we design for states as intermediary objects?

4.6.6 The Activity of Collaborative Writing

Some classifications of cooperative work take a perspective in which the collaboration is categorized based on characteristics of the group and the work context. We propose instead to view collaboration in terms of the transitions that take place; between people; between stages of writing; between different places; between shared and withheld; as well as the timing of transitions and interactions and what these mean for social dynamics. Focusing on classifying the collaboration according to characteristics of the group and the mode of collaboration enforces a static view that may result in a poor match between the classification and reality [107]. Emphasizing activity over classification serves to place focus on how the collaboration is and can be mediated.

Of course, a characterization of the group in terms of, e.g., roles and hierarchies may be useful for such an analysis. What we mean is that such a characterization in itself does not say much about the activity of writing.

4.7 Discussion

The findings and analysis above highlight the conscious strategies and non-contemplated routines that people apply to make cooperative work function. Most of the examples presented highlight what makes a collaborative academic writing endeavour successful (or at least functioning) in a group dynamics perspective. This is not to imply that present-day collaborative writing has the perfect conditions. The bias in our findings toward stories of what makes group work function as opposed
4.7. DISCUSSION

to what breaks it is likely in part due to well-functioning groups being more likely to sign up for a study like ours. Bad writing collaborations do occur (probably frequently); several participants related current experiences to other often less well-functioning collaborations. One source of conflict is misalignment in territorial functioning, such as misaligned expectations regarding behavior around other people’s text which then leads to boundaries being overstepped. The document’s role as an intermediary object in this case becomes that of mediating the expectations and opinions that co-writers bring into the collaboration, so that new, shared conventions can be established [41]. This mediation is ongoing, even after the establishment of conventions [159] and no matter if the collaboration is or becomes well-functioning or not.

Our findings are grounded in 23 interviews and the quotes presented have been selected from all of these. However, the visualizations come only from a subset of the people we interviewed and we cannot know whether visualizations of the remaining collaborative documents would also confirm what we have found in the interviews, although we expect that they would. Furthermore, we have only been able to conduct the visual analysis on Google Docs documents, despite participants working in other tools offering to give us access to their documents. We suspect that we may find subtle differences between Google Docs documents and Overleaf projects, to take an example. Future work in this direction could shed light on how various writing tools may influence the collaborative process in different ways.

Only having visualizations of documents written in a real-time tool may also have skewed the analysis to focus on findings relating to this form of collaborative writing.

This study, furthermore, presents collaborative writing in a particular setting, namely academia. By focusing on academic writing we have been able to interview a sample of people which covers that type of writing better, but which does not represent the wider spectrum of collaborative writing. It is likely that some findings will carry over while others, such as the emphasis on the main, or first, author for some groups, may be specific to academic writing.

4.7.1 The Social Collaborative Writing

The work presented here adds to the corpus of empirical work documenting social workings of collaborative writing, such as Birnholtz and Ibara [23] and Wang et al. [252]. We extend their work by framing those social workings as territorial functioning. This framing jointly explains both Wang et al.‘s findings on writers’ desire for privacy and Birnholtz and Ibara’s findings on the relational effects of edits. It has, furthermore, helped us to identify the significance of timing and local expertise to both of these.

Taylor’s understanding of territorial functioning de-emphasizes power dynamics in favor of a wider focus on all sorts of social dynamics. This means that our analysis, akin to Cerratto-Pargman [54], focuses on social motivations for sustaining good relationships with co-writers as opposed to the potential significance
of hierarchies, power structures, and predefined roles, although we acknowledge this dimension of collaborative work. Wang et al. present a much more hierarchical view of the collaborations in their study.

4.7.2 Territorial Behavior and Motivations

Thom-Santelli et al. describe writers’ motivation for secluding their work as a drive to remain in control. We have described different and more diverse motivations, such as making sure that feedback is provided at an opportune time. Active monitoring of articles, which Thom-Santelli et al. describe, is not something we have encountered and may, in combination with the emphasis on being in control, highlight a central difference between long-term collaborative maintenance of online writing on Wikipedia and collaborative academic writing towards a deadline. This difference is also evident when Wikipedia maintainers’ desire to avoid tampering by other editors is contrasted with the academic writers in our study striving for everyone to feel ownership of the text in the end.

Wang et al. describe motivations similar to some of the ones expressed by our participants, such as privacy and distractions, but Wang et al. simplify their description of the resulting behavior to writers using Microsoft Word for asynchronous work and Google Docs for synchronous work. Our findings show that the dynamics are more intricate than that; involving respect for co-writers’ demarcations and personal space in the text.

Counter to our findings, Olson et al. report that their participants would freely edit each other’s text, which they take to be a sign of trust. The collaborations studied by Olson were short-term (less than two days) and although we, too, find it likely that trust may influence editing behavior, we find it odd to assume the development of trust in such a short-term collaboration, particularly given that Olson et al. do not specify whether participants knew each other or had worked together before. Given our findings and discussion of territorial functioning above, it may be that Olson et al.’s participants did not feel as attached to their produced text as some of our participants, considering the difference in project duration. Another possibility is that the work in Olson et al.’s study took place so close to the deadline that their participants simply adopted a less territorial way of editing from the start.

4.7.3 Writing Strategies

Although it was not part of our focus, we have from our interviews and cursory overview of the visualizations noticed patterns similar to some of those described by, among others, Yim et al. Although we do not discuss them in terms of writing strategies, our findings regarding the evolution of territorial functioning towards the deadline adds to the work by Yim et al. by highlighting the transitions between different styles of writing. This is likely due to the longer duration of the writing projects we have studied.
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4.7.4 Ownership

Ownership is a recurring theme in much of the work on segmentation and interpersonal relationships in collaborative writing. Mockus et al. [170] describe code ownership; however, emphasizing that this ownership gives the ‘owner’ more respect but not additional (formal) rights with respect to the code. In that case, we find that ownership as a concept does not add much analytic value.

As we have argued in our analysis, although ownership and territorial functioning are closely related they are not the same thing. Birnholtz and Ibara [23] likewise state that respect for co-writers’ opinions on work that is theirs or which they have a stake in is about more than ownership in that it has a ‘distinctly social element’ [23, p. 813] to it. The same can be said about the respect that Mockus et al. [170] describe.

We argue that territorial functioning and ownership are two different lenses. Ownership in collaborative writing or coding says something about the individual’s or the group’s relationship to their own creation, while territorial functioning says something about the interpersonal dynamics surrounding the creation (for instance, behaviors resulting when someone intrudes on what is perceived to be someone else’s territory).

4.7.5 Collaborative Writing as a Fragmented Exchange

The ability to withdraw or to manage boundaries puts writers in control of their current activity, including how co-writers may affect it, which in turn enables them to more freely carry out that activity [233]. As Clement and Wagner [59] put it, regionalization can help the individual writer focus and protect their view, so as to build the text through their local expertise without undue interference from co-writers.

Fragmentation of the writing also facilitates necessary coordination among writers. The elaboration of the text as a common product depends on this coordination of writers’ local production and expertise along with processes of integration [54]. This is reflected in other findings, such as Yim et al.’s [261] observation that a ‘divide and conquer’ style of collaborative writing produced better text than other styles.

The reason that collaborative writing becomes a fragmented exchange can be put simply as people needing space and time to do their work. Despite collaborative writing being centered around one, common object of work it usually involves a large degree of separation, as previous identifications of document production strategies in collaborative writing have shown [11, 197, 261]. Our contribution with this work has been to characterize the nature of this separation. While the aim of this study has not been to determine whether fragmentation is beneficial to the outcome of collaborative writing, we will stress that territorial functioning is part of the inevitably social nature of collaborative work and is not inherently dysfunctional. In settings discussed by Clement and Wagner [59], zoning of work does not necessarily hinder or impede its accomplishment. Likewise, fragmentation
itself does not appear to be disruptive of collaborative writing. Tying together the contributions from multiple co-writers requires effort [261], but our participants are clearly aware of this and are able to accomplish it. Rather, disruption occurs when tools do not adequately support the natural interaction patterns of territorial functioning.

4.8 Implications for CSCW

Current solutions do to a certain extent support writers’ articulation work, as exemplified through the instances of double-level language presented in our findings. However, this is to a large extent achieved by users themselves through appropriations of the tools.

In Robinson’s words, drawing on ‘the power of human dialogue and imagination’ applications should ‘ground and focus’ writers’ cultural language [203, p. 55]. This cultural language rests on unspoken awareness and navigation of territories. But while we advocate thinking about tools for writing as double-level languages when designing them, designers should be careful not to transform users’ articulation work into explicit declarations of the work. For example, a design that take the many possible roles at play during writing into account should not hinder writers’ natural transitions between roles by demanding that they explicitly declare and switch roles. As Olson et al. state, a collaborative writing tool should allow writers to ‘creatively and flexibly use the tool without declaring what activity they are performing’ [188, p. 29].

4.8.1 Awareness and Timing

Allowing people to socially navigate common information spaces requires support for the timing of actions on a moment-to-moment scale. Some of the early work on tools for collaborative writing describe project management features [93, 197] which can be seen as support for timing on a larger scale. Timing on a shorter-term scale requires a common awareness of the work as it is in the moment.

Considering the role that timing plays for the acceptability of edits, a solution could involve visualizing the recency of each writers’ editing activity in all parts of the document, split into small segments, as a form of ‘heat map’. This would enable co-writers to interpret the timing of activities (and thus which parts of the text have been edited at the same time and are likely logically connected) as well as to time their own editing according to the state of co-writers’ contributions. This idea is similar to Hill and Hollan’s [120] graphical depictions of edit activity in the scroll bar of a writing application.

As an extension of the idea that writers could indirectly infer logical connections in the text from heat maps, another suggestion would be to allow users to specify links between different parts of the text, in a way providing an explicit mapping of local expertise that would help co-writers avoid or follow up on edits that may negatively affect the coherence of the text. Such a feature should not aim to replace
writers’ awareness of local expertise but could, for example, support it early on in a project when writers may not yet have a good overview of the text. Furthermore, creating such links should of course not require a disproportionate effort for co-writers. Gehrmann et al. [97] describe preliminary work on automatic detection of changes and which paragraphs they may cascade to in a collaboratively authored document. This may be an alternative approach to mapping local expertise.

4.8.2 Private Spaces

The practice of separating work has many motivations but comes down to a desire for a space over which the writer has more control and, in some cases, privacy. The workarounds that writers currently apply to achieve this decouple their work from the common work process and from the object of work. As both social and practical aspects of the process rely on writers’ interpretations of the current state of the text, this decoupling is undesirable as the shared content does not reflect the actual state of affairs.

Recommendations for private workspaces in collaborative settings [69, 75, 180] have been overlooked for a couple of decades and have yet to find their way into publicly available systems. Wang et al.’s [252] recent work has revived the idea and we support this. In software development, a different field concerned with the production of text, separation of individual work has become a natural part of collaborative work [65], mediated through the use of version control systems. But while version control systems seem to, by and large, fare well when used in software development, this model seems too restrictive for collaborative academic writing. Facilitating both articulation and disarticulation requires that transitions between the two be made easy (as also pointed out by Cerratto-Pargman [54]). We also wish to caution that disarticulation should not be accomplished by decoupling private activities from the shared work. A design challenge lies in allowing disarticulation in place, in a way that supports contextual awareness. This could also allow writers to balance the need for disarticulation with the need to signal to co-writers that they are currently working and potentially what they are working on [124, 252]. This would be helpful for both coordination and relationships between co-writers.

4.8.3 Disarticulation and Ambiguity

Clement and Wagner [59] argue that communication spaces should permit zoning through rearrangement, drawing an analogy to physical space. There is a problem in this spatial metaphor: While physical arrangements are usually due to an assortment of needs and incidental occurrences, this is less frequently the case in computer-mediated information spaces. It is not as easy to casually bring something out of collaborators’ view without it calling attention to the disarticulation that is taking place. In other words, computer-mediated common information spaces do not present the same possibility for ambiguity that physical space does. In addition to facilitating awareness of the current state, we therefore urge design-
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4.9 Conclusion

Based on a mixed methods study we have presented findings that outline the role of territorial functioning in collaborative writing. Territorial functioning of this kind is socially motivated and serves to develop and maintain social structure for cooperation. Writers’ territorial cognition and resulting behaviors are mediated by the object of work itself, which thereby feeds into the simultaneous, ongoing processes of producing the text and negotiating the collaboration. That the tools in use are able to act as double-level languages is important for the interpersonal functioning involved in this.

Our findings suggest that the interpersonal dynamics, of which territorial functioning is an example, require a rethinking of the way we frame collaborative work as a design challenge. Currently, the central problem to be addressed is usually conceptualized as the work situation, given by the physical context and the mode of collaboration. This understanding does not enable us to support the social needs that people bring with them from other aspects of social life into digitally mediated collaborative work. We see potential in framing the problem in terms of the transitions required for articulation and disarticulation of the work. This includes the timing of actions and interactions, which are essential in the enactment of social etiquette. Since collaborative work is by nature a social endeavour, these interpersonal aspects cannot be ignored.

We suggest that designers of collaborative writing tools consciously aim for tools to be double-level languages. Designs should also strive to support the timing involved in territorial etiquette by facilitating awareness of the current state of the text. Finally, disarticulation should not require writers to provide rigid declarations about their current work situation, it should not decouple writers from the collaborative situation, and it should support socially sustaining ambiguity.

4.10 Acknowledgments

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Chapter 5

Collaborative Writing Across Multiple Artifact Ecologies

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Abstract

Research focusing on how collaborative writing takes place across multiple applications and devices and over longer projects is sparse. We respond to this gap by presenting the results of a qualitative study of longer-term academic writing projects, showing how co-writers employ multiple tools when working on a common text. We identify three patterns of multi-application collaboration as well as four common types of motivations for transitions between applications. We also extend existing taxonomies of collaborative writing by proposing a categorization of the functions served by the text as object and backbone of the collaboration. Together, these contributions offer a framing for understanding transitions within and across artifact ecologies in work around a common object. Our findings highlight ways in which features like concurrent editing may in fact challenge the collaborative writing process, and we point to opportunities for alternative application models.

5.1 Introduction

Collaborative writing has been an important research topic in Human-Computer Interaction and Computer-Supported Collaborative Work for decades. There have been vast technological developments, from the early text processing tools in the 1980’s providing basic means for communication and shared viewing [82, 93], to current text editors with capabilities for crowd sourcing [22] or automatic prediction
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of needs for changes [97], and well-known collaborative editing platforms like Google Docs [101], Overleaf [190], and GitHub [99]. The crucial work by Gibbs and Ellis [78] on operational transformation (OT) has made real-time collaboration possible and key work on communication support and awareness have influenced the design of today's platforms.

Despite this development and how commonplace collaborative writing is, some areas warrant further study. Few have looked into how collaborative writing happens across multiple applications and devices: How co-writers negotiate, deal with, and use multiple applications in the writing process; and why and how this influences the process and outcome. Collaborative writing is often studied from the angle of a single tool and/or document in projects lasting only hours, days, or weeks at most, which does not reflect how collaborative writing is currently practiced. We present a qualitative study of co-located and distributed academic writing projects lasting for extended periods of weeks, months, and years, involving co-production of a joint report, research paper, or book.

First, we examine the collection of applications mediating the writing process. Collaborators use and depend on a number of different applications, e.g., for sharing documents and text, and for coordinating and communicating throughout the process. They use particular applications for doing layout or producing figures, etc. These applications are partly chosen with a basis in past experiences, partly due to functional needs, and partly based on co-writers’ personal preferences [260]. We use the concept of artifact ecology [33, 127, 207] to map the collection of collaborative writing tools and analyze how co-authors use and appropriate these. Based on this analysis, we identify three patterns to describe strategies for collaboration with and across multiple applications: collaborative home, repository, and hand-over.

Second, we identify and discuss four common types of motivations for application transitions occurring throughout the writing project: functional, personal space, aesthetic and user experience, and communication. Application transitions refer to collaborators switching between multiple applications when writing, e.g. moving text from a shared document into a personal text editor, transitioning from writing to layout applications, or tracking down co-authors through in-editor comment features and communication applications. These transitions are rarely motivated by utility and availability alone. Need for personal space and collaborative “noise”, such as jumping text, are additional examples of reasons for transitions between applications in collaborative writing. Third, in the kind of collaborative writing projects examined here, the text itself serves multiple roles in the writing process, something not addressed in existing taxonomies of collaborative writing. As pointed out by Neuwirth et al., “[…] experienced writers typically engage in many acts of writing (e.g., jotting down ideas, drawing) that bear no direct relation to the text product, but serve as inexpensive, intermediate external representations to remind writers of their plans for audience, purpose, and procedure as well as content.” [181, p. 540]. Building on the interviews, analysis, and related work [119][194], we propose a categorization of the roles played by the text as common object of work into seven functions that may overall be divided into interim material outcome,
locus of coordination, and epistemic object.

The three focus areas above contribute to our understanding of collaborative writing as a practice that is dynamic and complex in the applications it involves and the roles applications and text play in the process. We see application transitions as a useful addition to existing work on artifact ecologies, as well as consolidating prior work into a coherent model depicting personal artifact ecologies [33, 127] in relation to potential and aligned artifact ecologies [189, 207] (see figure 5.1). The identified text functions extend existing taxonomies on collaborative writing, in particular Posner and Baecker’s [197] work on document control styles and writing strategies, as well as others’ contributions to the latter [156, 261], and Wang et al.’s [250] identification of text production patterns.

Several of the application transitions we have observed move away from the primary collaborative platform. Our findings suggest that application symmetry (everyone having the same level of access, features, notifications) and real-time editing challenge aspects of (collaborative) writing; for example causing disruptions that compel co-writers to periodically abandon the common object of work. We see significant challenges in supporting collaborative writing across artifact ecologies rather than contained within individual tools, with transitions largely happening through copy-pasting. This points to the exploration of document- and activity-centric [121, 130] alternatives for application design as an avenue for future work.

5.2 Artifact Ecologies and Collaborative Writing

The focus on artifact ecologies in collaborative writing necessitates a brief introduction to the concept of and key perspectives on artifact ecologies and common objects. This provides a foundation for presenting the findings from the study.

5.2.1 Conceptualizing Artifact Ecologies

The concept of artifact ecologies is drawn from works discussing and conceptualizing multiple artifacts and their relation to concrete practices. The term is one of several examining how (interactive) artifacts, e.g. devices and software applications, are part of a specific ecology that influences how people make sense of, combine, substitute, and appropriate technology (e.g. information ecologies [176], personal artifact ecologies [33, 127], community artifact ecology [36], digital assemblies [211], constellations of technologies [207]). While the background and terminology vary, we see the concepts as closely related and complementary. As a unified concept, the notion of artifact ecologies allows for examining the multiple interactive artifacts in use throughout, e.g., a collaborative writing process. In particular, it highlights the multiplicity and dynamics of computer-mediated collaborative writing, including the interplay between the personal and the shared, and how they shape the ecology and its use.

Artifacts typically originate within a personal artifact ecology defined as the collection of artifacts a person owns, has access to, and uses [127, p. 201]. Familiarity is
key, and artifacts are understood in relation to common uses and complement other artifacts within the ecology. A personal artifact ecology is dynamic and changes as new needs and desires arise and/or when people learn from — or collaborate with — others [34]. In collaborative writing, the potential artifact ecology is the sum of co-writers’ personal artifact ecologies, from which they negotiate an aligned artifact ecology consisting of the tools and applications to be used in the work [207]. Rossitto et al. [207] use the term orchestration to describe the (meta-) activity of aligning the group’s work ecology and describe how alignment of the ecology happens both at the onset of the group’s formation and in relation to different contextual, temporal, and task-specific constraints throughout the work. Oulasvirta and Sumari [189] discuss similar activities in multi-device management and configuration, however, focusing on the pragmatics of setting up in a physical setting, rather than negotiating.

**Figure 5.1: Overview of artifact ecologies in collaborative writing.**

In figure 5.1 we integrate work on artifact ecologies into a model that shows the overlaps between personal artifact ecologies, the potential artifacts, and the aligned parts of the ecologies, as well as activities that are carried out using these artifacts. Figure 5.1 depicts the simplest possible collaboration structure but generalizes to the more complex patterns common in collaborative writing. In figure 5.1, the potential ecology (bold) is a combination of co-writers’ personal artifact ecologies and any additional tools available at the time and place of the activities (see also [68, 189]). The active parts are the particular artifacts in use in a given activity. Although Rossitto et al. [207] focus on how the aligned ecology is a result of the potential ecology — that is, the available and familiar artifacts to the users — we find that activities and tasks do not always happen within the aligned ecology alone (elaborated in the findings section). Work towards the shared goal can happen using artifacts from one participant’s ecology alone, e.g. when this co-writer is the only one with access or the necessary expertise to use an artifact (figure 5.1 activity A). Work that requires that all the participants use an instance of the same tool happens within the aligned ecology, e.g. writing in a shared document or communicating (figure 5.1 activity B). Activities can also happen at the intersection of ecologies (figure 5.1 activities C and D), e.g. reviewing and editing a shared document displayed on a projector in a meeting space. While the model captures trivial observations (e.g. Raptis et al. [200] propose a similar model from a single-user perspective), the present work is particularly concerned with how different artifacts support and
introduce transitions between technologies spanning multiple ecologies. This is part of the analysis and findings we present.

The combined model does not capture how the ecologies change as people become familiar with other tools through collaborating over time. Although development over time is an important aspect of artifact ecologies (see [33, 36, 176]), integrating this is outside the scope of the present work.

**Common Objects**

With inspiration from activity theoretical HCI [30] and instrumental interaction [17] we see human activity as mediated, by artifacts and artifact ecologies. Writing is, as we analyze and discuss it in detail later, mediated by a variety of artifacts from pens to word processors, and even spellcheckers and formatting tools. Users are simultaneously working, collaborating, and focusing on the objects of their activity [30] (see figure 5.2). Borrowing terminology from Robinson [204] or Heath and Luff [114] these objects are held in common. Heath and Luff address ways of collaboratively accessing objects or “[…] a range of capabilities from the simple exchange of objects, through the sharing of objects and to common views of the same object.” [114, p. 361]. Such objects are always intermediary in several meanings of the word:

First, they are a result of the current state of the activity as the object moves from (shared) materials to product, as discussed by Engeström [84] and by Sørgaard [223]. This is the case, e.g., when bits of text are edited together into a coherent, shared document, or when data is turned into a table. Second, the common objects are epistemic in the sense that they contain and represent for the user an idea of the end product (or intermediate products along the way). This can be an idea of the contents, of the message, etc., or it can be the mere fact that the paper needs to be, e.g., six pages long. Co-writers are mutually responsive to one another and have a more or less shared goal that they all identify (with), while they coordinate their plans of action and intentions. Tenenberg et al. [235] discuss how the goals and intentions of each participant partly incorporate the goals and intentions of the other collaborators. Finally, since such activity is complex and collaborative, every once in a while the co-writers, alone or together, have their activity focused on objects that are parts of the whole, or interim steps towards the whole, such as when drafting an outline without worrying about the text or the format. In this manner the common objects form the backbone of the communication and coordination happening in the co-writing process, or in the terms of Nicolini et al. [183], they are the fundamental infrastructure of the activity.

A large body of work has addressed the roles of documents and other artifacts in collaborative activities [87, 119, 193, 194]. These roles include communication [185, 193, 194], coordination [119, 193, 194], and consolidating the work [87, 194]. Other work has studied how documents and other artifacts are used across devices [185, 207]. While informative, these works do not address or capture the nuances of (collaborative) writing.
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Figure 5.2: The collaborative activity is mediated by the artifact ecology and focuses on the common objects at play in the creation of the text.

5.2.2 Collaborative Writing

Research from the early 2000s indicates that academic writers, at the time, did not use writing tools designed for collaboration, even when available [129, 184]. Based on an interview study and an online survey, Kim and Severinson Eklundh [129] and Noel and Robert [184] found that co-writers stayed with their preferred word processors, even though these were designed mainly for solitary use. Coordination by these writers happened mainly through e-mail and face-to-face meetings. Kim and Severinson Eklundh [129] note that even though the tools used by co-writers had features for collaboration, such as comments, these were not used. In recent work, Birnholtz and Ibara [23] and Wang [249] provide an updated view of co-writers’ writing practices. Wang’s findings show a more diverse use of tools including designated collaboration tools and features. Both also discuss synchronous writing as more common than what has previously been described [53, 62, 129, 184].

We have previously discussed (text) state as a dimension of collaborative writing [145], implying a coordinating role of the text which has inspired the notion of text function presented in this paper. That work additionally showcased socially sustaining behaviors in the writing process, in parallel with Birnholtz and Ibara’s [23] description of how features for change awareness can impact relationships between co-writers. The relational side of collaborative writing is further explored by Wang et al. [252] and Allen et al. [6], both emphasizing technology’s effect on the production of shared writing. Mitchell et al. [169] present a study of collaborative writing by school children, focusing on ownership and control.

Neuwirth et al. [181] note that collaborative writing involves many activities other than synchronous writing and that these are not always supported by the writing tool. Kim and Severinson Eklundh [129] report how co-writers would typically agree on a writing tool at the start of the process but may individually use additional tools. Boellstorff et al. [39] recount the emergence of a toolkit of multiple applications to support different needs during the collaborative writing process. These observations are closely related to those discussed by Rossitto et al. [207], and stress a need to focus on the artifact ecologies of collaborative writing and how these influence the writing.
## 5.2. Artifact Ecologies and Collaborative Writing

Table 5.1: Writing Strategies, Document Control Styles, and Text Production Patterns from related work, with the addition of Text Functions as developed within this paper. Activities, roles, and work modes from related work have been omitted as they are not used directly in the analysis. **Note:** A few phrasings have been altered slightly, compared to the published paper [146].

<table>
<thead>
<tr>
<th>Category and Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WRITING STRATEGIES</strong></td>
<td></td>
</tr>
<tr>
<td>Single writer [197]</td>
<td>One person writes the document based on group discussions.</td>
</tr>
<tr>
<td>Scribe [197]</td>
<td>One person writes down the group's thoughts during a meeting.</td>
</tr>
<tr>
<td>Sequential writing [156]</td>
<td>The writer role is passed from person to person, one at a time.</td>
</tr>
<tr>
<td>Parallel writing [156]</td>
<td>Each person is responsible for a different part of the writing.</td>
</tr>
<tr>
<td>– Horizontal [156] forms:</td>
<td></td>
</tr>
<tr>
<td>. . . divide and conquer [261]</td>
<td>Writers divide their parts and rarely edit each other's text.</td>
</tr>
<tr>
<td>. . . cooperative revision [261]</td>
<td>Writers work on their own parts, but freely edit each other's text.</td>
</tr>
<tr>
<td>– Stratified division [156]</td>
<td>Each participant plays a particular role based on their expertise.</td>
</tr>
<tr>
<td>Joint writing [197]</td>
<td>The group jointly decides on the wording and sentence structure.</td>
</tr>
<tr>
<td>Reactive writing [156]</td>
<td>Writers react and adjust to each other's work in real time.</td>
</tr>
<tr>
<td>Consulted [197]</td>
<td>The writing is guided by a person who does not take part in the writing.</td>
</tr>
<tr>
<td><strong>DOCUMENT CONTROL</strong></td>
<td></td>
</tr>
<tr>
<td>Centralized [197]</td>
<td>One person is in charge of the document throughout the project.</td>
</tr>
<tr>
<td>Relay [197]</td>
<td>Control passes between one person at a time.</td>
</tr>
<tr>
<td>Independent [197]</td>
<td>Individuals maintain control of separate parts of the document.</td>
</tr>
<tr>
<td>Shared [197]</td>
<td>Multiple people are in charge of the document with equal privileges.</td>
</tr>
<tr>
<td><strong>TEXT PRODUCTION PATTERNS</strong></td>
<td></td>
</tr>
<tr>
<td>Outline [250]</td>
<td>Work is distributed through the creation of an outline in the document.</td>
</tr>
<tr>
<td>Example [250]</td>
<td>The content of a similar type of text is replaced with new content.</td>
</tr>
<tr>
<td>Best-of-each [250]</td>
<td>Each person writes the full text, and the group selects the best of each.</td>
</tr>
<tr>
<td><strong>TEXT FUNCTIONS (PRESENT CONTRIBUTION)</strong></td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>The text is the material being worked on.</td>
</tr>
<tr>
<td>Interim outcome</td>
<td>The text allows interpretation about its current state.</td>
</tr>
<tr>
<td>Outline</td>
<td>The text functions as an outline of the text-to-be.</td>
</tr>
<tr>
<td>Plan</td>
<td>. . . an overview of work to be done.</td>
</tr>
<tr>
<td>Division of work</td>
<td>. . . a reminder of how work is divided among co-writers.</td>
</tr>
<tr>
<td>Pointing ahead</td>
<td>The text is an embodiment of the common vision.</td>
</tr>
<tr>
<td>Reflexivity</td>
<td>The text allows reflection on and alignment of the text-to-be.</td>
</tr>
<tr>
<td>Reactivity</td>
<td>The text enables co-writers to become involved in each other's work.</td>
</tr>
</tbody>
</table>

### Taxonomies of Collaborative Writing

Several works present taxonomies of collaborative writing, parts of which are summarized in table [5.1]. Allen et al. [6] present a typology of shared-document collaboration. Posner and Baekcker [197] outline a taxonomy that includes four categories: **Roles** refer to the kind of work each individual is doing, such as writing or editing, and **activities** are a set of sub-activities such as planning or writing. **Writing**
strategies and document control methods describe how the work and the control is distributed throughout the document and the writing process, such as through joint writing and shared control. Lowry et al. [156] include additional writing strategies, such as the reactive writing strategy. While Posner and Baecker describe joint writing as involving group decisions even on “minute components of the text” [197, p. 134], Lowry et al.’s reactive writing is presented as co-writers “reacting to and adjusting to each other’s changes and additions” [156, p. 78], such as when co-writers review a section as it is being written and respond by writing new sections of their own. Both strategies are hence considered here. In more recent work, Yim et al. [261] identify a number of writing styles, including two versions of Lowry et al.’s horizontal parallel writing (table 5.1): divide and conquer and cooperative revision. We use the latter to refer to asynchronous writing, and reserve reactive writing for cases with simultaneous writing. Wang et al.’s recent work [250] identifies strategies for text production, also included in table 5.1. Finally, ways to implement these concepts have been explored [93, 110, 178, 234], such as by allowing activities and roles to be specified and managed alongside the writing [253].

We find it surprising that none of this prior work addresses the text itself. Through our current study we have become aware of the multiple levels of meaning that the text holds for co-writers during their work. At any given moment, the function served by the text is highly significant to how work on and around the text is carried out. For example, the text may serve as a coordination tool for dividing up the work or achieving an awareness of who is currently working and on what. Hence we introduce the notion of text functions, summarized along with related work on writing taxonomies in table 5.1, which we elaborate further in the findings.

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**Table 5.2: Study participants: Collaboration history and duration. St = students, Re = researchers. # means that the group worked solely distributed.**

<table>
<thead>
<tr>
<th>ID</th>
<th>G01*</th>
<th>G02*</th>
<th>G03*</th>
<th>G04*</th>
<th>G05*</th>
<th>G06</th>
<th>G07*</th>
<th>G08#</th>
<th>G09#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>St.</td>
<td>St.</td>
<td>St.</td>
<td>St.</td>
<td>St.</td>
<td>Re.</td>
<td>Re.</td>
<td>Re.</td>
<td>Re.</td>
</tr>
<tr>
<td>Size (# interviewed)</td>
<td>4 (3)</td>
<td>2 (2)</td>
<td>3 (3)</td>
<td>3 (3)</td>
<td>2 (2)</td>
<td>4 (2)</td>
<td>4 (2)</td>
<td>6 (2)</td>
<td>5 (2)</td>
</tr>
<tr>
<td>Collab. history (years)</td>
<td>1–5</td>
<td>1</td>
<td>1–5</td>
<td>4</td>
<td>1–5</td>
<td>0–5</td>
<td>0–1</td>
<td>0–12</td>
<td>0–6</td>
</tr>
<tr>
<td>Duration (weeks)</td>
<td>34</td>
<td>17</td>
<td>19</td>
<td>19</td>
<td>24</td>
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<td>5</td>
<td>13</td>
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</table>

<table>
<thead>
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<th>ID</th>
<th>G10</th>
<th>G11#</th>
<th>G12</th>
<th>G13</th>
<th>G14</th>
<th>G15#</th>
<th>G16*</th>
<th>G17</th>
<th>G18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Re.</td>
<td>Re.</td>
<td>Re.</td>
<td>Re.</td>
<td>Re.</td>
<td>Re.</td>
<td>Re.</td>
<td>Re.</td>
<td>Re.</td>
</tr>
<tr>
<td>Size (# interviewed)</td>
<td>2 (2)</td>
<td>3 (2)</td>
<td>2 (2)</td>
<td>4 (2)</td>
<td>3 (1)</td>
<td>3 (1)</td>
<td>5 (3)</td>
<td>40 (1)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Collab. history (years)</td>
<td>&lt;1</td>
<td>2–10</td>
<td>1–6</td>
<td>–</td>
<td>0–3</td>
<td>–</td>
<td>0–</td>
<td>–</td>
<td>13</td>
</tr>
<tr>
<td>Duration (weeks)</td>
<td>18</td>
<td>19</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>56</td>
<td>28</td>
<td>32</td>
<td>183</td>
</tr>
</tbody>
</table>
5.3 Study and methodology

Our findings come from interviews with researchers and Master’s degree students involved in collaborative writing projects. The projects around which the interviews centered comprised joint master’s theses, a student project, scientific papers, books, and a magazine article. The interviews covered a total of 18 different projects, with five participants being involved in more than one of these. The writing part of these projects lasted between 1 week and 2.5 years (see table 5.2 for an overview). The study was approved by Aarhus University’s research ethics committee and participants have been informed and have given full consent per European Research Council ethical guidelines.

The questions posed to participants focused on both practical and social aspects of the collaborations, such as the applications used, strategies for text production and division of work, ways of editing text written by co-writers, draft writing, and decision-making. Each interview centered around a particular recent writing project undertaken by the participant(s) but we did not enforce a strict focus on only those cases when participants included other examples. The conversation was allowed to flow naturally, but at opportune moments participants were steered towards topics of interest. Each interview lasted between 50 and 86 minutes, for an average of 64 minutes.

The interviews with students’ groups were conducted as group interviews with all participating members present, as we valued the potential for participants’ collective recollection and for them to spur each other on in the conversation. By contrast, the interviews with groups of researchers were conducted individually. The rationale for this distinction was a concern that the power and seniority imbalance in relationships between researchers working together in a professional environment (e.g. PhD students and supervisors) would inhibit participants from speaking openly. While we acknowledge that Master’s degree students have equally complex relationships with collaborators, we weighed collective recollection over this concern because of the more equal nature of the students’ relationships. Ways of accounting for potential bias in the student groups included asking about hypothetical scenarios and experiences in other collaborations, giving the participants a way of expressing viewpoints and sharing experiences without necessarily criticizing collaborators.

The follow-up interviews (marked * in table 5.2) elaborated on topics from the initial round of interviews. They focused on collaboration in Google Docs, due to an overlap with an additional research focus. All follow-ups were conducted as group interviews to support collective recollection. This was further supported by consulting a document co-authored by the group. The average duration of the follow-up interviews was 58 minutes, ranging between 39 and 75 minutes.
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5.3.1 Participants

The 32 participants comprised 13 Master’s degree students and 19 researchers. In most cases only some group members were available for interviews, and in the case of G16 one of the group members only participated in the follow-up interview. In table 5.2, the number of group members participating in the study is indicated in parentheses next to the group size. The researcher participants were of ten different nationalities and were employed at four different universities, while all student participants were Danish and studied at two different universities. 9 of the participants identified as female, the rest as male. A majority of the groups were co-located during most of the writing, with four groups working distributed (marked # in table 5.2). Participants were recruited via social media postings, face-to-face contact, e-mails to various departments at the authors’ university, as well as through personal contacts and contacts of participants.

5.3.2 Analysis

The first round of interviews was transcribed and analyzed through bottom-up thematic coding and meaning condensation [142]. We included both semantic and latent themes [42] in the coding. After coding all transcripts we manually clustered the codes into overarching themes that were prevalent across interviews. The follow-up interviews were not transcribed but codes were noted with time stamps and annotated, since these interviews were not analyzed to provide new codes but to supplement insights from the first round of interviews.

From the above we identified patterns in the ways that co-writers and content move across artifact ecologies. We use pattern in relation to collaborative technologies. As opposed to a complete vocabulary [67], patterns address an intermediate-level abstraction of a socio-technical situation, capturing possibilities and bottlenecks of that situation. This understanding is based on discussions by, e.g., Hermann et al. [118] according to whom patterns refer to the interplay between a technical system and users as well as users’ tasks and organizational constellations. We use the notion to aid the discussion of our findings and to open up for future generative outcomes [67].

5.4 Findings

We start by presenting the artifact ecologies of the interviewed groups, based on figure 5.1. The types of tools included in such a writing ecology are outlined and we consider participants’ motivations for including these tools, in particular tools with overlapping functionalities. This descriptive step is necessary before characterizing patterns of transfer of content between applications and motivations for these. In the subsequent section, we then turn our attention from the tools to the content and to the role of the text in collaborative writing as an intermediate artifact and common object.
5.4.1 Mapping the Ecologies of Collaborative Writing

The applications and services used by the participants cluster around the primary functions of writing, layout, communication, and file and version management. The tools used can be divided into roughly three categories: 

- **a) Asynchronous locally installed word processors and desktop publishing applications**, such as Microsoft (MS) Word and Adobe InDesign. When these are used as the main tool, documents are shared through a shared drive and/or via e-mail.
- **b) Asynchronous locally installed LaTeX editors**, such as TeXstudio, combined with version control systems, like SVN and Git. The version control systems allow the publishing (pushing) of chunks of changes (commits) to a repository, for instance GitHub or a locally hosted one. The editors have no collaboration capabilities aside from the sharing and tracking of changes (including comments accompanying the commits).
- **c) Real-time web-based text editing applications** with built-in support for collaboration. Among our participants these include Google Docs (and Drive), for rich text editing, and Overleaf and ShareLaTeX (now Overleaf) for writing LaTeX documents. The writing projects deployed different approaches to writing and collaboration on a project level (see table 5.2), with three patterns for supporting collaboration emerging from the interviews:

  - **Collaborative Home**: A majority of the projects (n=12/18) employ a collaborative home pattern, where the co-writers write within an online platform that persists and synchronizes the text across multiple clients (e.g., Google Docs or Overleaf). In this pattern there is a high degree of tool and content symmetry, as the collaborators share both the text editor (interface) and how the content is rendered, in real-time. Document control (see table 5.1) is usually independent, or centralized in the case of a PhD student working with their supervisor and perhaps other collaborators. We encountered only few cases of relay control, and shared control was rare [145].

  - **Repository**: A few projects use a repository pattern for collaboration (n=5/18). Here the collaborators decide on a common service for persisting and synchronizing files across computers, either automatically or through user-initiated uploads or commits (e.g. using Dropbox or Git). Depending on file formats, this approach offers the possibility to separate the text editor used by each co-writer from the common text (tool asymmetry). Depending on the synchronization model, it is sometimes not possible to work in the same file simultaneously, in which case co-writers often used version control features or negotiated different ways of organising the writing process around merge and versioning issues. Text symmetry (all writers having the same version) is maintained to varying degrees depending on the file sharing platform: When a document is saved directly to a Dropbox, co-writers can maintain a high degree of symmetry, while symmetry is lower, e.g., in the case of a group storing the document in Google Drive and manually downloading and uploading document versions.

  - **Hand-over**: A single project used a hand-over pattern with relay control where the co-writers decided on a file format and then exchanged files via e-mail or similar.
This pattern shares the potential for tool asymmetry (depending on file format) with the Repository pattern, but may also introduce complete text asymmetry, as there is no centrally available maintained version of the text.

### 5.4.2 Transitioning Between Multiple Tools

![Figure 5.3: Application transitions within and across ecologies. Left: Back-and-forth transitions. Right: Chaining across applications](image)

Participants’ aligned ecologies (figure 5.1) arose from a mix of co-writers’ prior experiences and negotiations (see also Rossitto et al. [207]), as well as familiarity and individual preferences for text format (e.g., formatted text or LaTeX) or application features, weighed against advantages and disadvantages. One group started in Google Docs, mainly due to a limit to how many can collaborate in the unpaid version of ShareLaTeX, but moved into ShareLaTeX once they figured out a workaround. Whereas writing tools were subject to early alignment, communication tools were more fluent and subject to ongoing negotiation based on availability, e.g. seeing someone online in a chat application or trying e-mail first and then direct messaging afterwards.

The aligned ecology is rarely the ecology or the only applications used throughout the writing project (see also [39][129]). Participants for example reported using additional text editing applications briefly throughout the process. One participant’s statement highlights this application multiplicity:

1: “I will sit in [MS] Word for a bit and also [Apple] Pages from time to time, just to sit for myself. Then I will insert [the text] into Google Docs, when I am done with my bit. But I also work directly in [Google Docs] at times.” (G02)

Alongside tools used for writing and formatting, all groups reported using multiple tools for coordinating the writing process and collaborating around the document(s) held in common. In addition to their intended uses, applications and features were used in alternative ways to coordinate and communicate. For example, chat applications were used to exchange files and bits of text during
parallel writing, or with supervisors during consulted writing. Comments and built-in messaging were used to communicate between collaborators for light banter or for grabbing a co-writer’s attention.

Transitions among both writing and communication tools are linked with preference and availability (installed, free, already open), but also associated with differences in the devices and platforms individual co-writers use. Some transitions are substitutions of applications or features available in the aligned ecology, whereas others represent additions brought in to cover specific needs in the process. All of the groups working in Google Docs would, for instance, switch to another tool, such as ShareLaTeX or MS Word, to format the text and add references. Despite the intention of some of these groups to use the new application solely for formatting, rendering, and references, participants described how they would often make changes to the text after having moved it:

2: “It ended up not being the last pass, but the plan was for it to be the final pass. […] We ended up having to edit in [Adobe] InDesign.” (G02)

Other groups would simply plan for the writing approach to change, effectively transitioning from the collaborative home pattern to one of the other two patterns. Most commonly the repository pattern would be adopted instead, or the group would switch from a parallel or reactive writing strategy (see table 5.1) to a single writer strategy.

Figure 5.3 (next page) overall identifies two high-level transition types. Like figure 5.1, it shows the simplest configuration. Some transitions are closely connected to the progression of the writing process from outline, over text production, to layout, etc., forming a chain of transitions (figure 5.3, right). Examples include moving from a personal editor to a shared platform to “add collaboration”, and then later copying text to a designated layouting application. Other transitions involve moving back and forth between applications, e.g. drafting in a plain text editor. This happens within the aligned artifact ecology as well as between the aligned artifact ecology and members’ personal artifact ecologies (figure 5.3, left).

5.4.3 Categorizing the Transitions

Functional Transitions

Application transitions motivated by a need for different, better, or more familiar features are common in the empirical data. Such range from smaller features to better general task support. One group discussed how they moved text from Google Docs into MS Word because they found the spell-checker in MS Word to be more accurate than the one in Google Docs, and others described reference management as a reason for moving from Google Docs into ShareLaTeX. Several projects made a move from Google Docs into ShareLaTeX or Adobe InDesign when needing to do layout and formatting.
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Personal Space Transitions

A majority of the interviewed co-writers describe how they have been starting drafts or moving text outside the master document and/or the collaborative environment in order to produce or revise text on their own. Some discussed seeking solitude to focus on specific parts and/or create a space for working with the text, or for reasons pertaining to self-presentation, as one respondent who did not want a student of hers to see spelling errors in a draft phase. Another participant explained why he needed a thinking space for drafting text:

3: “I can't really formulate stuff in my head, so I need to write it down and do a few iterations. [...] If I intend to write something that I have not presented to the others yet, and don't know if it makes sense, then it can push me to do it outside, in my own editor.” (G11)

Transitions to a personal space may also be motivated by a desire for control, such as not sharing drafts with co-writers before “mak[ing] sure that I've done everything to make it as likely as possible that the feedback I'm getting is useful to me” (G10). Particularly in cases with independent document control, participants described moving to a separate document to be able to work in the way they preferred or shape the text in a particular way. For participants working in a repository pattern concerns of control or self-presentation influenced the timing of uploads, sometimes resulting in a “huge [Git] commit which [...] other people don't appreciate.” (G12) Issues include the shared text not being up-to-date, and down-time due to using sequential writing to avoid merge conflicts.

Aesthetic and User Experience Transitions

Transitions to a separate editing environment were also motivated by preferences related to comfort, e.g., being more familiar with MS Word than with Google Docs or needing a “blank slate” (G10) where co-writers’ comments would not be visible. A participant stopped using the comment feature in ShareLaTeX because the individual color assigned to each collaborator made it “a real crayon mess” (G10). In some cases such aesthetic experiences of chaos or lack of overview was what drove groups to spend the majority of their writing time in Google Docs despite their plans to do the final formatting in ShareLaTeX, e.g., due to a publication venue requiring the use of a particular template. Many also described Google Docs as more approachable due to its WYSIWYG style. As one participant put it: “ShareLaTeX is for papers and Google Docs is for when working with the others is more important than formatting.” (G12) Another participant linked this to disruptions from the additional compilation step in ShareLaTeX:

4: “For instance, making figures, that always breaks things. [...] I sometimes use this online table generator and get the table set up outside, and then paste it into LaTeX when I know that it can compile.” (G09)
5.4. FINDINGS

Similar issues related to experience were distractions and the felt presence of co-writers mediated by the collaborative tool and/or document, in particular in the collaborative home pattern. A frequent example in real-time editing environments is text “jumping” when co-writers add or remove text and the presence of co-writers’ cursors within sight and/or blocking the view: “It’s very distracting to have a cursor appear and write right above you.” (G04). Distractions caused by features of the tool are supplemented by more subtle senses of being surveilled or aspects of the writing process, e.g. being “[a]ffected by seeing others being productive while you’re struggling” (G04). Some participants also described how the text “becomes something else” (G05) when moved to a different environment. One example would be that writing in a plain text editor makes the text less set in stone – “it was easier to throw out again, or easier to discard if it was bad” (G01). Whether for reasons pertaining to personal space or user experience, co-writers usually insert text they have produced elsewhere by copy-pasting it into the master document. This is often followed by communicating to the others that something is done and ready for review, frequently via another channel.

Communication Transitions

Transitions were also motivated by communication needs. Several groups reported that they used multiple ways of reaching co-writers, and would select the application based on the chance of getting a co-writer’s attention. One group described starting with Slack, then using the Google Docs chat asking: “Did you see my message?” There were also examples of appropriating the text production environment as an ad hoc messaging channel (real-time synched or not), for instance by locating a co-writers’ cursor or text and writing messages at its location, e.g. “Is this okay? Yes, it’s fine” (G04) or “STOP CORRECTING I'M NOT FINISHED!” (G02). In many cases this would help facilitate a form of reactive writing. An additional challenge lies in linking communication with in-document content (also discussed by Pearson et al. [193]):

5: “But where it gets difficult is when you need to refer directly to something in the text. […] Then you make a comment and then you go into Messenger and say: Could you go and check this comment?” (G04)

5.4.4 Summary — Transitions Within and Across Ecologies

Transitions between tools are common, with co-writers moving between applications in the aligned ecology as well as applications that only some of them have access to or are familiar with. Applications used for writing are supplemented with additional tools, for producing figures, for doing layout and formatting, for communicating, etc. The same application may play different roles in different collaborations and at different times during the process, mirroring the more individual-focused discussions of Bødker and Klokmose regarding dynamics of artifact ecologies [33]. We have observed transition patterns spanning both personal artifact
ecologies and the group's aligned artifact ecology. Whereas motivations for chained transitions are closely coupled to how the shared text and outcome progresses, back-and-forth transitions are linked to a broader set of motivations and needs throughout the process, e.g. self-preservation or avoiding distractions.

Transitions introduce challenges into the writing process. When writers work outside the common documents and applications, their co-writers lose sense of the progress and who is working on what. This is mitigated through ongoing communication and coordination and by maintaining a general sense of responsibility and division of work through the document structure and the text itself (see below). Moving text between documents and applications is usually done by copy-pasting. The participants experience that differences in how each tool, or each software version, interprets file formats and formatting makes other approaches bothersome and error prone. Finally, transferring text between applications (and documents) introduces two issues frequently discussed by our participants: First, knowing which version is the most up-to-date across multiple applications can be difficult (e.g. quote [12], especially when the differences are small as in the case of spell-checking. Second, and related, ensuring that all sections and figures are moved into the right positions, e.g. when finalizing the layout in ShareLaTeX or InDesign.

5.4.5 Text Function(s) in Collaborative Writing

The above patterns hint at the functions served by the text as a common object during the writing. These echo the three functions of common objects named earlier: The object in its transitional state from materials to product; as epistemic and pointing towards the end product; and as the backbone of communication and coordination (see also [119, 185, 194]). The text is the interim material and outcome of work, a locus of coordination, as well as epistemic and pointing ahead. These functions are further subdivided (see table 5.1 and below).

Previous work on collaborative writing has emphasized the work around and on the text but less so how the text itself mediates the work as a common object. By explicitly addressing the ways in which the text itself supports the writing – the multiple roles it plays in the writing – we aim to characterize the writing activity as taking place through a common object, and examine how this alternative lens may be used to understand the collaborative writing situation.

The Text as Material and Interim Outcome of Work

The text is naturally in focus for the co-writers as material and product. In addition to molding words and sentence structures, writers continuously interpret additional layers of meaning for information about activities, and where the text is currently at and where it has come from. Through the text they are able to assess how work is progressing, what is there and what has yet to be done, and how finished the text is, etc.
Even if the text exists in multiple versions, of which some older parts may be waiting to be re-used or changed, co-writers (try to) maintain an overview of what the text is. Sometimes the whole text, sometimes sections, exist in multiple places, e.g., when a Google document is moved section-by-section into ShareLaTeX or when a supervisor provides feedback on a printed (old) PDF version while work continues in LaTeX. Different versions or parts in different applications may offer different possibilities for e.g. creating an overview. As an example, it is not as easy to get an idea of the length of a formatted paper in Google Docs as in MS Word or ShareLaTeX, as illustrated here:

6: “[We] needed to know how long the paper was, and we noticed that we were over the limit if we put it in [MS] Word. […] [The] spacing is somewhat off and different. […] [We] had to cut almost two pages.” (G08)

The Text as a Locus of Coordination and Communication

Interpretations of the text as an interim outcome of work are facilitated by its function as an outline (not to be confused with Wang et al.’s [250] outline pattern, which describes how co-writers materially build up the joint text) or a blueprint providing co-writers a material awareness of the form of the text-to-be. Far into the writing process when the originally envisioned structure may have changed, the text continues to serve this function, allowing assessment of progress with respect to the structure of the unfinished document. Likewise, the careful coordination required for keeping track of versions is anchored in the text. Whether in the form of an actual outline in the document, participants’ recollections of a meeting, or bullet points in an e-mail, co-writers are enabled to plan how the emerging text will be created and what will happen to it. The common object’s function as plan has multiple granularities and abstraction levels, from choice of words to the prospective audience. Sometimes one person is largely in charge of planning and their co-writers’ mostly tag along, as in the consulted strategy, while it is a shared and even democratic process in other collaborations. This quote exemplifies how co-writers move back and forth around the text to coordinate:

7: “[Co-writer] took over and made a longer draft, that went through headlines and our vision for the content in detail. Then, as we got a better idea of what the contents would be, that was then adapted.” (G04)

This sense of how to go about forming the text in turn enables division of work. This is not a one-off, transient event: The division of work is manifested in the structuring of the work, be it name tags in the document, simply the current placement of co-writers’ cursors, or the fact that the main writer has the document on her hard drive for the first week of the writing. We understand from our participants’ accounts that they achieve an awareness of the division of work, including what co-writers are currently doing, through the text:
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8: “We’ve had some [sections] where we’ve been writing more than the other person. […] In the end it was pretty clear who was taking care of what.” (G05)

The Text as an Epistemic Object

The text’s function as an epistemic object is, first, to point ahead. The common object of work is not just the material text in the document. Even before the first character is typed, the (eventual) writing is focused on the text-to-be. This is different from the text as a plan laying out the work to be done. The text’s epistemic function is that it embodies the common vision and motivation (see quote 9). The previously described text functions all take their outset in this text-to-be.

The text pointing ahead to its envisioned state allows planning and assessments described above as well as a reflexivity regarding the way the common object is taking shape. The text-to-be is not a fixed vision, as seen in quote 9, but rather one that will change as text is produced. In moving from a common vision to where the manifestation of (and individual ideas about) the object become aligned, co-writers engage in reflection about, with, in, and through the common text:

9: “[At] some point it grew to a hundred pages and then people jokingly called it a book. And then at some point people said: ‘Well, why don’t we actually make it into a book?’” (G17)

Finally, the text is a common space for reactivity: A place where co-writers respond to each other and can involve each other in their individual processes by reaching out and asking for help. The term “reactivity” is taken from Lowry et al.’s notion of reactive writing, as described in section 5.2; however, the reactive function of the text is present in any writing strategy, as illustrated in quote 10 where the interviewee acts reactively by both looking in the text and poking a co-writer.

10: “[If] you remember: ‘Oh, this could be relevant to use in that section!’ then just scroll up and check if it is in a bullet point or if the person is currently writing it, and otherwise poke the person and say: ‘How about we do this?’” (G04)

This sort of reactivity is possible because the text as an object is held in common, accessible to and accessed by all co-writers at some point or another. By virtue of the text’s multiple functions coming together in a shared sense of the common object (quote 10), co-writers are able to maintain a common object in mind as well as on the screen. Of course, the sense of a common vision is sometimes challenged as in quote 11:

11: “There were meetings where everyone was like: ‘Wait, so are we saying that [topic] is good or is it bad?’ […] Maybe our initial idea was: ‘We’ll just write separately and then come together and it will just merge,'
but I think it didn't and it was all different aspects and we didn't really know what our joint message was.” (G16)

In these cases, the role of reflexivity and reactivity in steering and aligning the work become very clear. Writers may in fact apply explicitly agreed upon strategies for reflexivity or reactivity, as when G16 each wrote an abstract to align their thoughts about “what we thought the article should be”.

The Common Object of Work

Not only does the text serve multiple functions in the collaborative work. As we see in quote[12] the degree to which the text is held in common at a certain point in time varies. Motivations such as quote[3] contribute to this.

12: “And then [co-writer] asked me: ‘Well, is the current version online?’ and I say: ‘Yeah sure it’s all committed,’ but I forgot to push. And then he gives me comments on something and I’m like: Wait, what? No no no, that’s not the version I’m in.’ ” (G15)

In a parallel, divide and conquer writing situation the common object may only be epistemic at certain moments or, perhaps it is more likely epistemic and coordinative. This means that the common object lies in the future, that the writers share some form of understanding of what the common object will be eventually (see e.g. quote[7]). In addition, the writers have some understanding of where their contribution is made, and how this relates to the contribution of the collaborators. Once co-writers consolidate themselves with each other’s recent contributions the common object changes and becomes material and manifest. However, the quote below illustrates that this is not always unproblematic and that the choice of tools matters.

13: “One of the big problems with LaTex is that you don’t see what has changed. Unless you do a diff, which is hard (...) I actually used software to create a visual PDF, so I could see what the differences between versions were. I’ve had problems working with people where some of us would suggest like oh, this need to be changed in this way, and then that change was incorporated but not actually in the way that it should have been or the way that the rest of us understood it. But none of us saw it until the paper was at the very final stage.” (G08)

During joint writing the text is in common down to paragraphs or even commas and white space. Multiple representations of the text can of course introduce discrepancies, as in Overleaf where the compiled PDF on the screen is not guaranteed to be the same for each co-writer. Whether working together on documents, paragraphs, or commas, these different granularities reveal the multiple levels at which the object of work may be understood and examined, be this by co-writers while
collaborating, or by researchers analyzing the collaborative activity. As we have illustrated, the multiple levels are closely tied also to the variety of different tools used, and hence the analysis showcases the effect of working and transitioning within an artifact ecology on the object of work: E.g. checking out a paragraph to use the spell-checker of MS Word means that the particular object cannot be shared meanwhile and needs to be brought back into the common artifact and object.

5.4.6 Summary — Text Function

In summary, collaborative writing involves text production both together and apart. It involves sharing materials and interim text as objects of work, and importantly it involves collaborating on the epistemic, the joint understanding of the text-to-be. Both the text in production and the many tools around it serve coordination, communication, and division of work. Transitions can occur smoothly, but we have also been introduced to hassles such as coupling content to communication, reaching collaborators, and keeping track of versions. This overhead (in CSCW also known as articulation work) can be described with respect to the practical means that writers must utilize (traversing the ecology, implementing manual version control, coordinating through various channels) but can also be described as an effect on the common object and its granularity, in the various functions served by the text.

5.5 Discussion

Our findings highlight ways in which tool use in collaborative writing has changed compared to a couple of decades ago [249]: We corroborate earlier findings [53, 129, 145, 181, 184, 252] on co-writers’ habits of and motivations for working in applications intended for individual use, but we have also showcased a wider and more nuanced range of patterns for collaboration which is facilitated (and perhaps spurred on) by collaborators’ expansive and overlapping artifact ecologies. While some prior work mentions the inclusion of additional applications in passing [39, 129, 181], only Rossitto et al. [207] have focused on the topic, and unlike us they have not addressed transitions to a personal ecology that is not part of the aligned.

Rossitto et al. [207, p. 156] name Google Drive as an example of a platform that meshes multiple tools to support collaborative writing. They rightly point out that such a pre-defined constellation usually does not stand on its own in co-writers’ ecologies, but they leave the example as anecdotal. In many of the groups Google Drive serves as a base in the Collaborative Home pattern until the group makes a chaining transition to an application they find better suited for layouting. This disconnect between different aspects of the text, such as content and layout, means that writers must piece together, and do not always have, a sense of the full interim object of work – for example they may not know how long the paper is, without moving to MS Word (see quote 6) which instead diminishes epistemetic functions of
5.5. DISCUSSION

The text because of the asynchronous nature of working in MS Word on separate devices.

This cursory analysis shows how the notion of text function lets us articulate more precisely which aspects of collaborative writing are affected by the different applications in use as well as by co-writers’ approach to the writing. It also highlights the significance of examining not just the central hub of the writing, as has typically been done (e.g., [24, 140, 188]), but the full, aligned ecology [207] as well as the interplay with personal ecologies [207]. Such an analysis (in its extended form) is not necessarily intended as a critique of the individual tools as such. Rather, like the presented study, it highlights significant challenges still remaining in supporting collaborative writing that transcends individual applications and devices. As previous work (e.g., [45, 188, 234]) has mainly addressed single-tool scenarios, the problem of supporting transitions as a developed practice in collaborative writing has been left unattended, the consequence being a striking lack of interoperability.

Multiple studies have examined task and application switching from the perspective of recovering from interruptions and supporting more activity-centric configurations [49, 117]. While the current study does not focus on these issues explicitly, it highlights a) that transitions between applications are a fundamental aspect of collaborative writing (cf. [69]), b) that some of these transitions are prompted by collaborative noise (text jumping, cursor presence, etc.) and a somewhat simple understanding of text production and people’s occasional need for personal writing space, and c) that transitioning between applications is done with copy-pasting and manual re-typing as the primary methods for moving text between applications. In addition to obvious avenues for improving transitions in a current context, such as object embedding for simultaneous editing and forking/merging text, our results lend merit to alternative paradigms, such as document-centric models [130], instrumental interaction [17, 136], or activity-centric perspectives [117, 121], that more fully than the application-centric model acknowledge artifact ecologies as the stage for work and other activities, collaborative or individual. Some of our findings parallel issues found in group reading [193] and library group work [163], indicating the relevance of the current study beyond collaborative writing specifically.

How co-writers form their “default” ecologies remains an open area of inquiry, along with how adaptation of the aligned ecology takes place. The work by Rossito et al. [207] is an important take on the contextual nature of this process, but further work is needed to cast light on the influence of mainstream applications and software infrastructures on this. The theoretical contributions of this paper provide a basis for this future work: By focusing on the transitions between artifacts in the ecology, rather than just on the artifacts themselves, we are able to understand shifts between aligned and personal, as well as the shifting borders of the aligned ecology within the potential ecology. Likewise, as demonstrated, our characterization of text functions enables us to examine how transitions and the multiplicity of particular artifact ecologies and co-writers’ particular ways of dealing with these impact the common object of work and thereby the continued writing. This framing aims to direct attention to the text as part, rather than merely product [85, 188, 261], of the
collaborative process.

5.6 Conclusion

In this work, we have described academic co-writers’ motivations for involving multiple tools in their collaborative writing practice. We have used artifact ecologies as a lens for characterizing the transitions that take place within and across aligned and personal ecologies. In doing this, we extend observations from prior research on collaborative writing with more detail while also contributing a categorization of transitions to the literature on artifact ecologies. Based on our findings we also propose the notion of text function to describe how the text as the common object of work is part, not merely product, of the writing; a novel addition to existing taxonomies of collaborative writing.

5.7 Acknowledgements

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Chapter 6

“It Looks Like You Don’t Agree”: Idiosyncratic Practices and Preferences in Collaborative Writing

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Abstract

This paper addresses collaborative writing in academia. Recent research has indicated that while many tools for collaborative writing exist and continue to be developed, co-writers frequently employ workarounds and cumbersome substitutions to accommodate their writing approaches and collaborative needs. As part of a process to address these issues, we conducted a co-design study on collaborative academic writing with eighteen participants. During a three-stage workshop series, participants discussed needs, frustrations, and desires in their experiences with collaborative writing. These discussions revealed how participants’ different ways of practicing and experiencing collaborative writing entail contrasting needs that are difficult to balance. Based on an analysis of discussions and artifacts from the workshops, we argue that researchers and designers should aim to support diverse practices and propose a protocol for examining and drawing on the contradictions that arise from co-writers’ idiosyncratic preferences.
6.1 Introduction

The practice of collaborative writing is commonplace in the academic field: Starting with undergraduate students collaborating on assignments and theses, over graduate students writing scientific papers, up to professors and senior researchers who also write books. As diverse as the co-writers carrying out collaborative writing processes together are the tools they bring together to support them in their endeavor. However, as recent research has indicated [65, 146, 188], these tools often do not fully support the idiosyncratic workflows of co-writers and push them towards workarounds and compromises to overcome these limitations. The questions that we address in this paper are: What do co-writers experience as challenging in collaborative academic writing, and what steps can be taken to address those challenges?

While previous work has applied many approaches to investigate these issues (see section 6.3), the implications they present for tool design are mostly based on the analyses and interpretations of researchers without direct involvement from co-writers. To fill this gap, we conducted a three-stage co-design study with 18 participants that consisted of a series of workshops.

We worked together with academic writers and involved them directly in the ideation and design process for tools to support their writing practices. Our goal was to identify themes of what they liked and disliked in their collaborative writing experiences, to generate ideas for possible design solutions, and to, finally, use a high-fidelity research prototype to experience how their ideas would pan out. In conducting the study, we found that individual idiosyncrasies result in contrasting needs and desires among co-writers. Our findings point to a more general problem, namely that these idiosyncratic ways of writing collaboratively are often hard, if not impossible, to accommodate in a standalone solution [230]. Accordingly, our contributions are: (i) an identification of themes in the challenges experienced by academic co-writers; and (ii) a proposal to supplement design guidelines by framing the design problem of collaborative writing in terms of contrasting needs and desires. We propose a protocol to help designers and others approach and draw on these contrasts.

6.2 Related Work

6.2.1 Guidelines for Collaborative Writing Tools

A number of authors have provided guidelines and recommendations for the design of collaborative writing environments. One theme in these guidelines is the content and format of communication [11, 202]. Suggestions include, for instance, means for grabbing co-writers’ attention (and cautioning about the potential obtrusiveness of such features) [188]. Related to this are commendations to provide an overview [202], typically of a document’s revision history [65, 129, 197] or of other writers’ current activities [11, 252]. Considerations about this have, among other things,
6.3. CO-DESIGN STUDY

included the granularity of what is recorded [129] and how to represent authors’ identities [252].

A prevalent theme has also been planning and structuring the writing according to divisions of work in the writing [11], including various degrees of enforcement by the software. Yet another theme is support for multiple ways of writing, such as by facilitating regulation of co-writers’ access to individual parts of the writing [129] [252] and enable different and potentially solitary activities that are part of the writing [197]. The general need to accommodate individual needs and preferences has also been acknowledged [65] [230] [252].

6.2.2 Tools for Collaborative Writing

Collaborative writing tools have a long history and numerous features have been explored by authors during the last decades, covering a range of purposes. We name some of these here, along with significant examples.

Features for communication and planning were among early developments. For example, the tool Quilt [93] added the ability to make annotations and comments as well as suggesting changes in the text. Later tools included chat functionality directly in the editing environment [98], e.g. to support the planning of writing tasks [85]. A related theme is embedded information, such as highlighted background color in the text to indicate authorship [241] or “the age of a modification” by a background color fading over time [242].

To support tracing and explanation of the development of the text, Neuwirth et al. [178] investigate diff-ing and annotation of edits while others have shown how adding “meta-commentary” to documents could be used by co-writers to clarify edits [283] and how a “rational version control” could allow users to enrich their edits with explanations of the underlying rationale [255]. Other exploration has involved utilizing the revision history to visualize the development of a document [140] [164] [224] [244]. Finally, privacy has also been addressed, such as in the above-mentioned Quilt [93] that featured “direct comments” to provide co-writers with a way to write private messages to each other. Shortly thereafter, ShrEdit [162] introduced shared and private windows, the latter to be used for notes and unfinished text, as described by Dourish and Bellotti [75]. Ignat et al. [124], e.g., proposed several privacy levels that include features like “anonymous changes” and “ghost operations” to hide edits from other co-writers until authors decide to commit them.

6.3 Co-design Study

We conducted a three-stage series of co-design workshops over the course of five months. In this section, we first introduce our understanding of co-design and our motivation for employing the approach in this study. Next, we describe each of the three stages of workshops and how they connected to each other. Finally, the last
subsections provide an overview of the participants and the data collected during the study, as well as how the data was analyzed.

6.3.1 Why Co-Design?

We use co-design to mean acts of joint creativity [210] [262] where we as researchers work together with end-users in a design process [35]. Following the Scandinavian tradition [9] [14], we aimed to empower co-writers to take part in shaping the tools they are using by actively participating in the design process. We invited people with experience in collaborative academic writing to contribute and apply their perspective on the topic, as experts of their practice [210]. In this study, it was not a case of the authors not possessing experience with the domain in question, seeing as a large part of our own work involves collaborative academic writing. Rather, the aim was to include a broader set of perspectives than merely those of the authors. The primary purpose for us was to enhance our understanding of what works and what does not work for academic authors writing collaboratively, while ending up with a design or a prototype was secondary and part of the process to increase the participants’ and our understanding of their preferences. The research project of which this study is part will, in the long run, contribute to improved support for collaborative academic writing — this study is one stepping stone among several carried out or planned.

Collaborative writing has frequently been studied using interviews [e.g. 6, 65, 129, 197], lab studies [e.g. 11, 24, 27], and in recent years also visualizations of writing activity [e.g. 145, 224, 250]. Other approaches include questionnaire surveys [19, 184], field experiments [53, 139], document analyses [74, 77, 261], ethnographic inquiries [64, 169], and auto-ethnographic reflections [e.g. 16, 186]. Finally, collaborative writing tools have been described and assessed in lab evaluations [e.g. 141, 244, 263] and deployment studies [5, 164, 230]. While these bodies of work all shed light on collaborative writing practices and outcomes, their implications for the design of collaborative writing tools are generally derived from analyses of the main findings, i.e. they are second-hand interpretations, and are rarely confirmed with participants. Our study is filling this gap by involving participants directly in ideation and design for collaborative writing.

Co-design in a way sits in-between methods such as field studies, that obtain accounts and observations of practice, and evaluations that obtain opinions on and assessments of technological artifacts [35]. We have been unable to identify previous research on collaborative writing using co-design.

6.3.2 The Workshops

The workshops followed a three-stage process with each consecutive stage building on the previous. We conducted five workshops in total (see Figure 6.1), two in stage one (W1a and W1b), one in stage two (W2), and two in stage three (W3a and W3b). The authors acted as the facilitators in all five workshops. The date and time for
each workshop were based on an indication of availability from each participant, to ensure that as many as possible could join. Some participants were unable to attend workshops in all three stages but participated in the ones they were available for. The first and the last stage were each split into two workshops, to accommodate a large number of participants without overcrowding the workshops. We opted to keep the workshops short — each lasting two hours — seeing as participants volunteered to take time out of their working days or free time in the evenings to participate in the workshops without any monetary compensation or relief from duties [35]. We invited participants to attend a joint meal after each workshop to thank them for their time.

The three stages were characterized by divergence (Stage 1) and convergence (Stages 2 and 3). The first stage aimed to identify themes in collaborative writing through discussions and creativity exercises. The second stage built on these themes to generate ideas for possible design solutions on paper. Between the second and third stage, we prepared a software prototype implementing some of the ideas generated during the second stage. The prototype was used in the third stage of the study where participants could use and modify the prototype, to let them discuss something tangible.

By involving the same participants in several stages of ideation and design, we aimed for participants to experience their ideas evolve and come to life. Hence, bringing material from one workshop to use in the next was important. The project promised no direct benefit to participants; however, we were hoping for participants to still take something home from the workshops: by exchanging writing experiences with other participants, by getting insights into their own approach to writing collaboratively, and by being able to see their ideas manifest in a prototype, participants could reflect on and perhaps improve their own writing practice. In the following, we will describe the individual stages of workshops. An overview of the goals, employed methods, and outcomes of each stage is outlined in Figure 6.2.

**Stage 1:** The aim of the first stage was the identification of themes in participants’ experiences with collaborative writing, as well as divergent thinking and ideation about how to address those themes. We wanted to help participants think beyond familiar tools and interfaces, to move away from suggesting feature improvements and instead envision freely what a desirable collaborative writing practice looked like, or could look like, for them. To accomplish this, we made use of a technique inspired by Fauconnier and Turner’s notion of conceptual blending [89], and brain writing [247].
The workshops started with a short introduction of the facilitators as well as a plan for the three-stage study for the participants. To stimulate reflections and conversation, participants were paired up and asked to briefly discuss their most recent collaborative writing experiences. Then followed a group discussion where participants described and discussed “ups and downs” in these experiences as well as desires and wishes for collaborative writing tools. After this, participants were given a short introduction to the notion of conceptual blending and were then asked each to select one of the wishes (which had been noted on a board by a facilitator) to work with. Participants individually sketched diagrams of conceptual blends (see Figure 6.3 for an example), depicting their perception of the wish they selected. They were asked to include a counterfactual mental space [89, ch. 11] in which their wish was not fulfilled. This was inspired by Pierce and Paulos’ [195] idea of counterfunctional things as a means to explore and design alternative experiences.

Based on their counterfactual mental spaces participants were asked to phrase a design challenge aiming to make the counterfactual wish a reality. For example, P11 who created the mental space diagram in Figure 6.3 phrased the challenge to design “some structure where everybody will work independently without discussing the structure or the content” since his actual wish was to help co-writers create a structure before writing. We provided instructions on the brain writing method [247], where participants wrote ideas on index cards (henceforth idea cards) and passed them around to each other in silence, using others’ idea cards for inspiration. To further stimulate ideation, participants were instructed to always include an image as inspiration for each new idea, by picking a random image from a pile on the table containing 100...
New Metaphors: Thing 2 image cards \[155\] (see Figure 6.4a).

Stage 2: In the second stage, the focus was on convergence and the refinement and elaboration of concrete ideas to support collaborative writing. As preparation for this stage, we grouped the idea cards created in the first stage into themes to be used in the *Flip & Integrate* exercise (described below).

Participants started by discussing, in pairs and then in plenary, what they considered essential for collaborative writing. The facilitator took notes about the participants’ discussion on a whiteboard. Thereafter, the participants and the facilitator jointly identified focal points in the whiteboard notes after which the participants formed groups of two to three participants — four groups in total — based on which focal point they would most like to work with.

First, the groups carried out an exercise that we termed *Flip & Integrate*. The exercise was inspired by the SIL method, or *Successive Integration of Problem Elements* method, in which ideas are integrated into a joint idea one by one \[247\]. Each group was supplied with a folder for each of the pre-identified themes, containing copies of the idea cards in that theme. In the *Flip & Integrate* exercise, the groups were asked to pick the theme they felt was most important to their chosen focal point. From that theme they then selected one idea and “flipped” it into a useful or realistic idea. In the first round of the exercise, the flipped idea was described in more detail as a design solution for the focal point. In later rounds, the current flipped idea was integrated into the design idea. When a new round started, participants picked the theme most important to their current design idea. The exercise was repeated, integrating more and more idea cards into the groups’ design ideas, for about 20 minutes. During the exercise, the groups were also asked to consider how to adapt their current design idea to three scenarios (see Appendix D) between each round.

Second, we employed the *Lotus Diagram* exercise \[165\] (see Figure 6.4b). In this exercise, the groups had to reflect on eight concepts concerning their design idea. We had selected the eight concepts based on previous work by Larsen-Ledet and Korsgaard \[145\]. The concepts were: Alignment; Distractions; Presentation of...
Stage 3: The last stage of the study focused on giving the participants something more tangible than notes on paper. We developed a prototype in between the second and third stage (see Figure 6.1). The prototype was implemented using the Webstrates [135] and Codestrates [198] platforms including the latter’s package management [40]. Using these platforms allowed us to create an extensible and malleable prototype for participants to use as a sandbox to play with their ideas. While extensibility enabled participants to add or remove tools from the prototype while they were using it, malleability allowed them to re-program and modify the tools on a source code level directly within the platform.

The prototype included the following tools that were based on participants’ ideas: Edit Display; Edit Overview; Edit Overlay; “Where am I needed?”; Paragraph State; Paragraph Voting; Comments; Meta Notes; Paragraph Locking; and Inspiration Prompt. To give participants an overview, we created a pamphlet describing how to access and use the prototype and summarizing which tools were available — including scans of notes of the previous workshops to indicate the tools’ originating ideas. Giving participants a nice-looking pamphlet showcasing implementations of their ideas was part of our effort to show participants that their contributions were valued and taken seriously. After introducing the prototype and its tools to the participants, they were divided into groups of two to three participants — three groups per workshop, six groups in total. Each group was provided with an electronic document and were first asked to explore the prototype and the provided tools (participants used their own laptops for this; see Figure 6.4c).

Next, each group selected one of three scenarios (see Appendix D) and started (1) choosing which tools to use for their ideal editor for their scenario, (2) modifying tools to better fit the scenario and their own needs, (3) creating storyboards for modifications and ideas that they were unable to implement within the allotted time, and (4) filling out a questionnaire about the features and the malleability of the prototype (as part of a separate research focus of one of the facilitators). Halfway through the exercise, we introduced a disruption for every scenario, that changed the task slightly (see Appendix E). During the second half, the participants continued to further adjust their editor to this change. Finally, the participants presented their results and discussed the topics of the questionnaire.

6.3.3 Participants

18 people participated in the co-design process (see Figure 6.5). Five participants described their gender as female, 13 as male. Seven different European nationalities were represented, although most (11) participants were Danish. Participants had different native languages; thus, all workshops took place in English. Participants’
ages fell within the span 18–55 with the majority (10) being between 26 and 35 years of age. Participants’ occupations fell within the following categories: Master’s students (2), Ph.D. students (5), postdoctoral researchers (3), assistant professors (2), associate professors (2), recently graduated Ph.D. (1), and software engineers recently graduated from their master’s (3).

Participants were recruited with a focus on current or recent experience with collaborative academic writing. Since participants needed to attend multiple workshops in person, we only recruited people from our own university (the only university in the region). We placed posters and flyers in departments in all of the university’s faculties — each slightly re-phrased to explicitly address the community that the poster was placed within, in the hopes that this would increase people’s motivation to sign up. Some departments circulated a recruitment email or shared a Facebook post. Additionally, some of our colleagues with students, for whom experiencing a co-design process could be relevant, informed their students of our study and encouraged them to participate. We also invited participants from a previous study on the same topic, of whom 11 participants also participated in the present study. Despite the efforts to reach a diverse range of academic communities, six of the seven new participants, as well as all 11 returning participants, were studying or working in a technology- and/or design-related field. Most of the participants knew at least one of the other participants in advance. Only one had never met any, and one knew a couple by name but not personally.

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Figure 6.5: Overview of the participants’ attendance in the five workshops.

### 6.3.4 Data Collection and Analysis

During the co-design study, we recorded video and audio, and took photos. We also collected artifacts made by the participants during the workshops: notes, mental spaces, and idea cards (Stage 1); notes and lotus diagrams (Stage 2); storyboards, a questionnaire with each group’s reflections, and the documents participants had used in the prototype as well as their changes to the code (Stage 3). Each participant also filled out an anonymized demographic questionnaire in the first workshop they participated in. The study was approved by Aarhus University’s research ethics committee and participants have been informed and have given full written consent per European Research Council ethical guidelines.
6.4 Findings

The findings are divided into five themes: First, we discuss participants’ ideas for supporting the alignment of individual contributions. Second, closely connected with this follows a discussion of planning and how to preserve an overview of past, present, and future activities throughout the writing project. Third, we outline participants’ reflections on communication, which can be divided into presentation, type, and purpose. Fourth, we present ideas about different views or modes for supporting different activities in the writing process. Finally, we discuss the spectrum between joint and separate writing, in particular addressing participants’ perspectives on managing boundaries. After the five themes, we end the section by drawing up the contrasting needs and desires in participants’ discussions and ideas. We refer to participants as P1–P18, to groups from the second stage as G2.1–G2.4, and to groups from the third stage as G3.1–G3.6.

6.4.1 Alignment

Not surprisingly, the alignment of work contributed by multiple individuals to a common product was brought up by several participants, and was continuously addressed during the workshops. In this section, we use alignment to refer to
aligning the text produced by writers [145], be it the content or the presentation of it. Planning and division of work — and hence alignment of expectations and of the work carried out — will be addressed in the next section.

For one, alignment entails coordinating the work of multiple actors towards a (more or less) shared goal. As P16 expressed it, “when you sort of delegate stuff [. . .] the problem tends to be that then you write some arguments that don’t follow each other.” Participants suggested solutions explicitly for this task in the form of automatic or semi-automatic detection of incompatible arguments, as exemplified by G2.3’s design (a joking reference to the unpopular Clippy character [258] from Microsoft Office), which the authors refer to as “the Mediating Clippy”, shown in Figure 6.6a. The group clarified that the idea was not for the automatic tool to fix misalignment but for it to instigate communication:

If you would say: “What is the main message of this paper?” and if you would ask every person that, you could say: “Oh, it looks like you don’t agree!” [. . .] And then you could actually coordinate and communicate about these things and agree on them, and align your points. (P7)

Participants were also concerned with coherence in the writing style, or with how to “align the outward presentation” as G2.1 put it. This involves, according to participants, using consistent terminology and creating a text that “reads as one” (P9). This concern, which is likely particular to collaborative writing, played into a more general concern for producing well-written text. Altogether, participants’ ideas served to develop a general notion of how features for language support could be augmented to support collaborative writing. For example, G2.1 played with the idea of an auto-complete feature that would suggest words or phrases based on a database of previous writing (e.g. the authors’ own writings or papers from target conferences). This group wrote in their notes about the idea that “(a)utocomplete can create a group identity” (G2.1). G2.4 came up with a tool that would enforce a style defined by the writers, or by a writer in charge. As opposed to the Mediating Clippy, this tool would relentlessly require writers to follow the style guide. The group’s motivation was that it would allow co-writers to focus on other parts of the work, “so that once you start writing you won’t waste time arguing about different styles” (P8). A participant from a different group argued that such a system would be cumbersome to work with, playing into a frequently encountered dichotomy between individual control and the convenience that automation or software-controlled procedures could provide.

Finally, G2.3 suggested that alignment is connected with joint accountability, as they described that by explicitly approving a piece of text written by a co-writer, one takes on part of the responsibility for that piece of text (construed as a positive thing, contrary to Wang et al.’s [252] findings). In addition to clear communication of a joint message, achieving alignment can thus also be about accountability and the individual’s and the group’s relationship to the text. P7 argued that a mechanism requiring co-writers to explicitly approve text passages for those passages to be
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included would “[force] everyone to actually look through the paper,” ensuring that everyone follows up on their commitment.

6.4.2 Planning and Overview

According to participants, planning serves to structure the text as well as the work that goes into creating it. At the beginning of a writing project, participants would try to align expectations among co-authors by outlining the structure of the text, agreeing on a writing style, and defining procedures. Many of them mentioned creating bullet points for each section as a way to ensure that meaning is not lost in the writing process (see Figure 6.6b). A suggested feature was a way to annotate sections with such bullet points without having them appear directly in the content text (P14).

While these steps create an overview of future work at the beginning of a project, this overview further needs to be preserved throughout the writing. Tools like version control (G2.4) or indications of what state individual sections or paragraphs are in (G2.3) were among participants’ ideas for facilitating this. Version control allows co-writers to see how the text has evolved, and manual tagging of the state of a paragraph enables an overview of how much still needs to be done in a document. P1 expressed it this way:

Traces of use. What has changed to a text over time? Who made the changes? At what point were changes made? Being able to check the traces in the document. (Idea card of P1)

A couple of groups suggested ways of tying writers’ identities to their contributions, as part of providing an overview. G2.2, e.g., suggested that “[each writer should] have a colour that the text written is marked by” and that “[each paragraph written should be] annotated with the authors profile picture”. While G2.2’s approach focuses on the who, G2.3 made the note: “from who wrote → to status of it,” suggesting to move focus away from the individual to the jointly written text. G2.3 furthermore described reactive writing as a benefit to live co-editing, noting how co-writers can “complete each other’s sentences” (G2.3’s notes), enabling them to keep up-to-date in real-time.

6.4.3 Communication

As mentioned, participants’ thoughts on communication mainly regard three aspects: presentation, type, and content. According to participants, the presentation of communication, e.g., how comments or suggestions are displayed, is significant for their collaborative writing experience. They brought up that while platforms often support comments, suggestions, and tracking changes, these features have no differentiation in granularity and can quickly clutter the interface. For example, P16 mentioned that all changes in Microsoft Word’s track changes feature look the
same, making it hard to distinguish small fixes of grammar errors or typos from changes to the overall meaning of a paragraph of text:

> All changes look the same and have the same space on the interface. So [...] an obvious error that just needs to change has the same space as a [...] discussion of the coherence. (P16)

Participants also discussed different types of communication, such as annotations and notifications. These discussions sometimes included the role of automation in communication. For example, P12 mentioned that he would like his “advisor to be forced to see whenever [he] make[s] a change.” In response to this, P3, who has supervised several students, replied that it would be better to get “a notification once something is finished” as “plenty of notifications all the time is actually pretty stressful.” This relates to the purpose of communication: In addition to communicating about plans or current activities, participants also stressed the ability to communicate their intentions, such as what they were aiming to achieve with a certain paragraph. They described how it can be problematic when someone loses track of the text’s connecting thread while editing:

> So I’ve often had the discussion of “what is the goal of a certain paragraph” or something. And then the goal stays pretty constant throughout the writing, but the text changes. [...] And sometimes I feel like, if you have co-authors they will sometimes forget the goal of a specific paragraph or subsection. (P12)

Making such goals or intentions explicit in the document were thought by participants to improve the coherence of the text, and hence support alignment. One suggestion was to allow “metatext”, as P16 called it (see also, e.g., Rimmer-shaw [202]). The bullet points mentioned in subsection 6.4.2 served a similar purpose. Participants further discussed automatic generation of such metatext. Communication of intention could be supplemented by communicating the state of different parts of the text. P1, for instance, suggested the phases: “In progress”, “Could you look at it? Suggestions”, “Don’t look at this yet”, “Don’t touch. Working on”, and “Finalized.”

6.4.4 Different Views

In their discussions and ideas, participants also addressed the different activities involved in (collaborative) writing. A recurring theme was having different views or modes for different tasks. P14, for instance, differentiated between what he called “a focused” writing mode and a review mode with a more elaborate set of features for annotating, providing suggestions, and discussing changes, along with other forms of communication and revision:
So, in the reviewing process I will have annotations and the ability to suggest changes and stuff. But in the writing activity […] you wouldn't have those tools available. And they also wouldn't clutter the interface. (P14)

Participants also talked about how different views of the text could impact their writing experience. For example, P4 suggested that “[a] txt file can also help you [to] sharpen your argument, because you look away from everything else and just [work on] the exact wording of that specific sentence or passage.” And P3 brought up how clutter can make it hard to switch to a reader's perspective — something that contrasts with the feature-rich reviewing mode suggested by G2.2:

S\wapping into reader mode [is] sometimes difficult if you have a text that is full of comments. Sometimes even exporting it to a different template or even a PDF version […] you start seeing all the spelling errors and things like that. So […] something that could help you become a reader rather than a writer of the text. (P3)

In addition to enabling different views on the document, ideas for tackling this issue also included starting off in a “bare-bones” editor with typing and deleting as the only available options, allowing authors to add necessary features as needed (suggested by G2.2. The idea is reminiscent of, e.g., CoDESK \[239\]).

Beyond the user interface, the desire for different views also applied to the representation of text. While some participants preferred a clear separation of markup and content as it is found, for example, in LaTeX, others preferred a WYSIWYG (“What You See Is What You Get”) interface, as found in, e.g., Microsoft Word or Google Docs. For some participants, the choice was based on their experience of the tools, such as P7 feeling more in control when using LaTeX's automatic placement of figures than when using the manual placement in Microsoft Word. For other participants, deciding on the tool was not so much a question of choice, but of theirs or co-writers' familiarity with certain tools, or of organizational regulations imposed on some co-writers effectively forcing everyone to use a particular tool. Optimally, both types of views on the text could be available at the same time, as P17 proposed in his thoughts on “workspaces”:

But we also were talking about having different workspaces, so if Elisa\[\text{\textdagger}\] for instance, [prefers] the LaTeX-way of doing things, with markup and such, she could do that. And if I want WYSIWYG I could have that. (P17)

6.4.5 Joint and Separate Writing

Participants also discussed benefits and downsides to different forms of writing together: Simultaneous editing in a document that is updated live was seen by some as making it easy to contribute to each other’s work (see also subsection 6.4.2).

\[\text{\textdagger}\]Name anonymized.
6.4. FINDINGS

Two groups thought of ways to tag co-writers in order to request help or feedback on a specific passage of the text. G3.3 created a storyboard for this feature (see Figure 6.6c) and G3.2 implemented a minimal working version of it during the last workshop. Some participants went even further and suggested ways to take over the viewport of other co-writers in a shared document and bring them to the paragraph where they are needed:

And we thought it would be really nice to actually, you know, request people's attention to a certain spot. (P18)

Overrule others' workspaces to focus on certain sections or work processes. Authors can lock other writers screens to their view, or freeze a section that people are forced to look at. (Lotus diagram notes from G2.2)

Others noted how live edits made by co-writers to one's work could be immensely distracting or frustrating. As can be seen from this exchange, some likewise found it difficult to catch onto or respect such boundaries:

P6: I hate when somebody is editing the sentence that I'm writing, in the moment.

P7: Oh, I do that!

P6: (laughing) That's super annoying!

P7: But if you see a typo . . .

P6: Yeah, exactly, but I'm like: “I saw that as well!”

Another contrasting desire that participants discussed was the ability to focus in an undisturbed space (resembling other recent findings [146]), which was seen as an advantage to not writing simultaneously in the same editor. This also related to distractions that do not stem from direct interaction between co-writers: P6 described how she would lose track of her position in a shared live document when the text she was writing got “pushed down the page” due to co-writers pasting in text further up in the document.

Another advantage of not writing simultaneously in the same editor that some participants mentioned was being able to control when text is shared. Participants often referred to text as being “ready” or not. For some, it was a question of not wanting to review someone else's writing until it was coherent, as mentioned by P3 in subsection 6.4.3. Others named motivations having to do with presentation of self [100] and not wanting to share writings until they were no longer “bad text” (P8). Some also used phrases like: “someone looking over your shoulder” (P2) or “Big Brother” (P9) to describe live co-editing, explaining a desire to work on text without others being able to “watch” them. These sentiments echo other findings in recent research on collaborative writing [145,252].
Participants came up with several ideas for managing boundaries in the writing: “Locking” sections or otherwise controlling collaborators’ (level of) access to text (e.g. G2.4) exemplify ideas that rely on enforcement by the software. Other ideas relied on the etiquette and discretion of co-writers by adding means for writers to express how they would currently like others to treat their text, for example, by putting the text in certain visually apparent states, as described in subsection 6.4.3.

An issue that was not tied to a particular mode of collaborative editing was ownership and control of text. G2.4’s idea centered around managing co-writers’ access to particular sections, with the explicit aim of preventing co-writers from “trash-[ing]” each other’s work. This included an idea that writers would be notified if others “visit/review/edit” their sections. G2.3 presented an alternative in which co-writers would vote on changes. Modifications to this idea included being forced to suggest alternative text before being allowed to delete any. Both of these groups’ ideas were construed as ways to avoid edit wars — to align on the text.

6.4.6 It Looks Like They Don’t Agree

In the sections above we have described alignment of the writing, and the role that planning and maintaining an overview play in this, as well as the roles of communication and the significance of being able to communicate intentions. We have also described participants’ ideas for supporting different activities and for reconciling different preferences. Finally, we have described the balancing of writing together and managing boundaries. In this section, we discuss contrasting observations of what is needed in design for collaborative writing. Many of the participants’ reflections and ideas had clear roots in tools they knew of, and many of them proposed things that have previously been addressed in the field of CSCW, such as the ability to locate collaborators. What we want to highlight are the contrasts that are present in some of those reflections and ideas. These are contrasts between the needs and preferences of different co-writers, as well as between individual writers’ personal needs and preferences.

Calling Attention and Controlling Disruptions: On the one hand, participants wanted as much information as possible. They particularly wanted to be able to share information, and to some extent also to receive it. In participants’ discussions of notifications we noticed two contrasting perspectives: notifications as a service for the sender, and as a service for the recipient. In the first case, notifications were envisioned as a means for requesting someone’s presence or feedback. In the second, they were seen as a way to be made aware, e.g. that a piece of text is now coherent enough for feedback, or that a co-writer is making modifications to one’s writing. See, for instance, the discussion among P3 and P12 on page 112. For P12, notifications would be a way to keep up to speed with what is going on in a document, while P3 found this to be unnecessarily distracting and saw notifications from co-writers as a means to know when going over the text would actually be useful.
6.4. FINDINGS

This contrast, among other things, speaks to the granularity of information: Making minute changes apparent can serve to give an overall picture of activity in the document, but such a detailed overview can make it hard to trace the development of overall arguments [129]. In a discussion on calling attention to sections based on how much they have been edited, Olson et al. [188] caution that notifications should be subscribed to at the discretion of writers. However, it is not addressed how to balance the communication needs of one co-writer with those on another.

**Information Availability and Tidiness:** While participants discussed ways of enhancing the writing environment with embedded information, such as visual indications of the state of a piece of text, they were also concerned about clutter. For example, using annotations or formatting to support boundary management around specific paragraphs [145] contrasts with the need for a clean reading space for going over the text. Allowing co-writers to enter such a clean state would make the embedded communication unavailable to them, and its value for enabling boundary management (without enforcing it) would be lost — unless, of course, co-writers are instead notified about text they should leave alone, or manually check for this, both of which would interfere with the reading experience in other ways and would hinder easy switching from reading to commenting or editing. Similarly, having different views, e.g., a drafting and a reviewing mode as suggested by participants, could impede communication if, for instance, a commenting feature is only available in one mode. Posner and Baecker [197] include easy switching between activities as a requirement, but do not address potential problems in considering individual activities as separate. Olson et al. [188] disagree with Posner and Baecker’s view, but do not offer clarification beyond recommending that the tool be “unstructured.”

**Privacy and Availability:** On the one hand, participants described how having a sense of what co-writers are doing in a particular moment can be helpful [156] [252], but they also wanted to be able to withdraw [145] in order to focus or to have a sense of privacy. Support for private writing has been suggested before [75] [252], but the dilemma it poses alongside reactive writing has yet to be addressed. Wang et al. [252] propose augmenting private windows by displaying that a person is active, to avert assumptions that the person is not working. This, however, would not improve the possibility for reactive writing [156]. Posner and Baecker [197] argue that it should be possible to segment a document while maintaining connections with the entire document, but do not go into further detail about how to accomplish this.

Furthermore, this previous work only addresses privacy in the moment of editing. But we also noted diverging needs with respect to privacy over time: Participants saw a benefit to being able to trace from whom different ideas in the text originated, among other things in order to be able to align their arguments or
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seek explanation from each other. Being able to trace who wrote what clashes with the desire for privacy: Either the revision history of text written in private is kept unavailable, or part of the privacy of writing in a separate space is lost. G2.3, in fact, questioned the need to know who wrote what and suggested instead to focus on the state of the text. Several works mention the ability to distinguish who wrote what [65, 188, 252], but none of them address the place of privacy as regards what has happened. Although Wang et al. discuss balancing privacy and awareness they neglect privacy in their discussion of authorship indications.

Sharing and Boundaries: The notion of having the division of work manifest in the tool, for example by enabling writers to “lock” passages of text they are working on to keep others from interfering, contrasts with the aim to produce a text that “reads as one”; a contrast that was also voiced by a participant in response to the idea of locking text. Previous work has addressed support for differentiated levels of access to a document [93, 197], but although they also describe features supporting alignment (e.g., planning [197], status tracking [93]) they do not address the interplay between these sets of features, such as how differentiated access may negatively impact alignment.

Automation and Manual Control: Many of participants’ ideas involved automation to varying degrees. On the one hand, they envisioned how software could help them align their writing style or manage boundaries, as discussed above. On the other hand, they also described needing to be able to fluently adjust in particular situations. For example, participants discussed having a “minimum threshold” for the text locking described above, where everyone is always allowed to make minor edits. It did not become clear, however, exactly when something counts as a minor edit. We find that such a definition is, in fact, not possible in any useful way, as it would likely change depending on the circumstances. Allowing co-writers to declare this for each project, similar to G2.4’s idea for enforcement of writing style, may introduce a kind of flexibility but would take away the moment-to-moment flexibility that the solution was supposed to introduce. Olson et al. [188] are critical of explicit declaration on the part of co-writers. They argue instead for a simple tool that can be used flexibly but do not go into further detail about what such a tool would look like.

Many existing guidelines are well-founded in empirical work and provide useful advice on how to design certain aspects of collaborative writing tools. However, by proposing standalone guidelines, the authors gloss over complexities that must be dealt with. Individual guidelines stand alone by pointing to particular recognizable elements, leaving out the connections to other elements. Hence, they provide a reduced perspective that leaves out the contrasts between elements, resulting in a loss of nuances. As such, they remain at a descriptive level, failing to serve an epistemic [183] function in which they could help researchers or designers address
6.4. FINDINGS

particular cases. We propose that an epistemically generative layer may be added
by framing the problem of designing for collaborative writing in terms of contrasts,
like the ones we have outlined above. Contrasts can be seen as a resource for
questioning assumptions [83] in order to press on from immediate possibilities
for solutions that are anchored in what is recognizable. Considering how to make
space for a particular contrast may result in a design that reconfigures the practice,
in turn providing a new anchor for future solutions. With this paper, we intend to
push for the elaboration of this framing. We expect that it will be helpful not only
when studying and designing for collaborative writing, but also with other kinds of
collaborative work, not least if coupled with an iterative process directly involving
co-writers.

Trade-Off Protocol

As an aid in addressing contrasts, we propose the following protocol for framing
conversations about challenges in terms of contrasts. The protocol can be used
both for ideation and for evaluating systems:

1. Select an aspect to work with (such as one of the five challenging aspects
identified in the previous sections).

2. Identify (current or potential) mechanisms supporting that aspect.

3. For each mechanism, identify relevant contrasts and apply the following
steps:
   a) Note where the mechanism is on the spectrum.
   b) Consider (an) alternative design(s) that are more towards the opposite
      end of the spectrum.
   c) Consider what is lost and gained in the alternative design(s).

As an example, one might consider planning and overview and discuss G3.1’s
metatext mechanism with bullet points hovering next to the text (see Figure 6.6b). One of the relevant contrasts to be discussed is information availability and tidiness. This mechanism is closer to information availability so the task would be to think of a design focusing on tidiness. This could for example be a version where the bullet points are shown only when the section heading is moused over. With this design, writers lose the chance of serendipitously noticing information they were not expecting. But they gain the ability to control when they are viewing metatext.

The protocol is meant to help designers and researchers draw creatively on contrasts. It is intended as a guide for reflection on trade-offs and does not prescribe one side of a contrast as favorable. In some cases, it may be desirable to strike a balance between contrasts by favoring one side in some mechanisms and another in others; while sometimes this may not be the most suitable approach. The
protocol should be seen as a supplement to existing guidelines that may be used to nuance their application.

The hardest problem to address is that of co-writers’ different preferences and intentions. Involving co-writers in co-design can help draw out contrasts, but co-design participants should not only be part of identifying the contrasts: Participants should also preferably take part in applying the procedure using those contrasts. This way they will be made to articulate their practice, as well as discuss and question it. Thereby the procedure can help co-design participants negotiate and (re-) configure their practice.

6.5 Discussion

In arguing that contrasts must be explicitly addressed, we are not saying that we should design our way out of compromises in collaboration. With the benefit of involving multiple people in a piece of work comes naturally a necessity to compromise. However, these compromises should be among people, not between people and computers. And software should not force unnecessary compromises between people.

Some of the dilemmas faced by participants in part come down to figuring out a joint practice and making it work — after all, some things are “solved outside the software” (P3) [197]. But as our participants — as well as our own collaboration on this paper — have taught us, shaping a joint practice is not an easy task. Designers should consider how to support this difficult task, and how to not inadvertently obstruct it.

Tammaro et al. [230] suggest that personalizable, or similarly flexible, groupware may be the only way to meet the needs of diverse groups. Advances in malleable software [47, 135, 201] make this worth exploring further. Malleable tools could enable different views, different representations of text, and adaptability over time — all things that were discussed by the participants. But while malleability can provide more flexible control over a tool on the technical side, this control is not necessarily aligned with the feeling of being in control on the user’s end. Some users do not feel in control when they can mold every aspect of a tool to their exact needs, they rather feel in control when there is no need to mold the interface at all [157]. Another way to provide writers with flexibility and control is to design for multiplicity [31, 32]. Rather than adaptations within tools, focus should then be on the potential to shape the artifact ecology [32, 127] by integrating new devices and software [33]. Such an approach would be in line with what Larsen-Ledet et al. [146] suggest. The open-ended nature of our proposed trade-off protocol is helpful in either approach.

6.5.1 Reflections on Co-Design

Exploring participants’ practices through ideation and design exercises served to bring out nuances to the experiences and preferences they described to us. The
6.5. DISCUSSION

Group discussions allowed participants to challenge each other’s preferences and opinions, which in particular contributed to the perspective on contrasts.

We chose to let all the artifacts created by the participants during the workshops be available to all participants throughout the three stages. Encouraging participants to build on each other’s ideas served to open alternative avenues for discussion and speculation and integrate more people’s perspectives in the ideas developed. Although many of our participants’ ideas are recognizable in terms of existing work on collaborative writing, our participants have surely contributed novel ideas and angles that have helped us understand their perspectives as academic co-writers.

We see the three-stage co-design process presented in this paper as a viable approach to examining contrasts within communities of practice. Drawing on our experiences, we would recommend that if conducting a workshop similar to our third stage, with a pre-made prototype, participants be given more time to familiarize themselves with the prototype; if possible, by extending the workshop to a full day. We also recommend being careful to ensure that all participants find their practice reflected in such a prototype (see below).

6.5.2 Limitations and Future Work

The prototype design leaned towards a WYSIWYG style which naturally influenced what participants focused on in the third stage, and some participants may not have seen their practices reflected in the prototype as much as others. An approach to amend this in future work could be to augment the prototype in close cooperation with individual participants and deploy it with them for a longer duration. This would enable long-term development and let participants reflect on their use of the prototype for actual writing tasks over a longer period, generating further insight into the needs that arise for them in their collaborative writing practice. We are weighing this against potential difficulties of this approach, some of which are evident in our own findings: Participants need advanced tools that they are familiar with in order to do their work, as do their collaborators.

Another point to be made is that all participants of our study had at some point worked or studied at the same university and, further, in mostly similar fields. While involving them broadened our horizon beyond our own individual perspectives, the findings presented still reflect a culturally narrow group. For this study, however, that has served to demonstrate that even within such a narrow group there were idiosyncrasies and contrasts in and among the practices represented. The aim of this paper has been to raise awareness about these contrasts and the importance of designing for different practices, even when focusing on a particular community of practice, in this case academic writers with a background in design or technology.
6.6 Conclusion

Research on collaborative writing often aims to provide guidelines and solutions that address a particular subset of co-writers’ needs and practices. However, research also continues to unearth difficulties or unmet needs similar to those described two, and even three, decades ago. Based on our three-stage co-design study we have presented five themes of challenges that reveal a number of contrasts within collaborative academic writing practices and show that, indeed, co-writers do not always agree in their collaborative writing needs and desires. Individual co-writers, even within the same or similar communities of practice, have idiosyncratic and diverse practices and preferences. With their descriptive nature, guidelines fail to capture such contrasting needs and desires. We propose supplementing guidelines with an epistemologically generative framing by focusing on how co-writers’ different needs relate to and influence each other. We have presented a protocol to examine and draw on contrasts when addressing the challenges experienced by co-writers. This trade-off protocol leaves room for others to identify a different set of challenges and contrasts and may prove useful in different collaborative settings; Being characterized by contrasting needs and preferences is likely not unique to collaborative writing but a feature of many collaborative practices. We have started with collaborative writing and encourage researchers and designers to explore this and other collaborative practices through contrasts by involving users in reflecting on individual preferences and trade-offs.

We are grateful to the people who took the time to participate and share their thoughts and ideas with us — this work would not have been possible without you. We thank Susanne Bodker for the suggestion to do this study and for her feedback and guidance. We would also like to thank Anke van Oosterhout for her advice and feedback regarding facilitation of the ideation processes in the workshops and for feedback on the paper, and Henrik Korsgaard for an enriching discussion about the contribution. Thank you also to Mirzel Avdic for feedback on the paper. This project has received funding from the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation programme (grant agreement No 740548).
Part III

Analyses and Discussion
Chapter 7

Text Functions and Mediation in Multiplicity

The preceding chapters examine collaborative academic writing from each their angle. Chapter 4 primarily tries to understand the practice as it is influenced by social psychological drivers. Chapter 5 broadens up to examine work as it is dispersed throughout artifact ecologies, cataloging the transitions that writers perform and providing a lens for understanding how the dispersed work is kept together through the text. Finally, chapter 6 highlights trade-offs faced when approaching design for collaborative academic writing. My co-author, Marcel Borowski, and I suggest that those trade-offs imply choices that cannot be made in advance of the concrete design situation. Rather, the right questions must be asked when planning and developing a design, with an outset in particular practices and communities. This chapter analyzes the interplay between the text functions identified in chapter 5 and the surrounding web of technologies, activities, and practices. This analysis reveals some less obvious avenues for questioning by, among other things, addressing details of the representations at play in collaborative writing. The next chapter suggests an approach to critically examining the conceptualizations shaping the technologies in use in collaborative writing.

The CIO project has operated with a set of principles about common objects that address the ways in which people organize themselves together around shared objects and artifacts [18, 46]. I use those principles to structure the analysis, by addressing text function along three axes: Mediation, development over time, and multiplicity [18]. For each of these axes I discuss the most relevant text functions. In the case of collaborative writing, mediation (roughly speaking) refers to co-writers acting on a text and interacting with each other through computer applications that scaffold the work in combination with the co-writers’ practice [29, 31] (see also chapter 1). I separate the analysis of mediation into two parts: Material mediation (section 7.1) and communicative mediation (section 7.2). When addressing communicative mediation I focus on the text’s role in mediating communication and coordination between co-writers. The section on material mediation focuses on
representations of the text as the object of work and how these representations can be manipulated. The distinction between material mediation and communicative mediation is an artificial one (as is the nature of such analytical distinctions), as they are dialectically related and in some cases inseparable. For instance there are material characteristics intimately pertaining to communication, as is the case with the demarcation described in chapter 4. Separating communication and materiality analytically, however, reveals that they each hold implications for a different set of text functions.

When discussing development over time [18, 32], in section 7.3, I focus on the way collaborative writing develops over different time scales and how this is tied to the ecology’s development [33]. Developments may come in the form of changes in the configuration of the ecology, or to particular artifacts in the ecology. The group of people may also change, with people joining or leaving. Finally, developments may be about progress in the writing and the changing goals that come with this.

Last in this analysis, I zoom in on the connection between multiplicity [32] and text functions in section 7.4. This is the discussion that follows most directly from chapter 5. I have chosen to present it last to be able to draw on the preceding axes in order to move beyond what has already been discussed in chapter 5.

7.1 Material Mediation

Material This discussion naturally takes its outset in the text function material. While the text as such is a conceptual entity, capable of existing as one or multiple ideas, written or otherwise verbally expressed, among co-writers and in multiple versions while still being the text, this conceptual entity is accessed in the form of digital files or printed on paper (at least primarily, when talking computer-mediated writing). When working on the text, the material is thus at once the sentences making up the text and, indirectly, the underlying representation connecting the text, in the end, to electrical charges in the computer’s memory and hard-drive.

The encoding of a file strongly influences what applications, or mediators, can be used to access the file, and hence what work can be done on the text and how the text can be molded. For instance, a project report written in Microsoft Word cannot be opened in Adobe InDesign to achieve more fine-grained control of font spacing and kerning. File formats thus allow and restrict particular transitions across the multiple ecologies of collaborative writing. The essential linguistic content of the text can be transferred (although this often requires copy-pasting precisely because of lack of cross-compatibility between tools), but material aspects often can not: Formatting and structure, such as links and references within a document, are lost [230]; things that can be essential in conveying meaning either to the writers themselves (such as coloring text red to mean that one is unsure about it) or to the audience (such as using italics for emphasis). Such properties must be manually re-done, if the new “host” mediator even allows them to be expressed. By restricting transitions through the ecology file encoding enforces an (unnecessary)
streamlining of tool choice among collaborators. The initial application used comes to
determine the file format, which in turn defines which tools can be used now and later on. The characteristics of the given tools in use impact the writing in many ways, as I shall discuss on the following pages, and as such the file format has an impact on several of the text functions identified in chapter 5.

Interim Outcome  Aside from determining how the text can be acted upon, the tool also determines how the text appears. This impacts a number of the functions served by the text. Interpreting the text as an interim outcome of work, for instance, can rely on the text’s appearance as was the case of a group that misjudged the length of a paper they were writing (see quote 6 on page 95 with only days left to shorten it to the required length. That case is a good example of how the text is not equivalent to the particular file but yet cannot be detached from it either. It can, however, take on multiple such material forms at once. Two co-writers may both be looking, on each their screen, at the project report they are working on but be seeing different instances: Different versions (saved at different moments in time and/or being of different file types) or the same version accessed in different material forms, such as plain text, syntax-highlighted markup, or a compiled and rendered PDF file. Even just using different versions of the “same” application can provide different visual impressions (see for instance the example with Adobe InDesign in the discussion of reactivity in section 7.3). As a consequence, writers may not share the same interpretation of the state of things. Of course, this is not per se problematic; Being able to view the text in different ways can help productivity by providing a different experience, and thus motivates aesthetic and user experience transitions (see chapter 5, p. 92). Abstracting away from the structure, for instance, can reveal things otherwise obscured by typography or markup.

Reflexivity  The appearance of the text can also hold great significance for the reflexive text function. We see this, for instance, with writers who describe the benefit they experience from occasionally writing in a plain text editor rather than a tool that renders formatting. Although I am not, based on my research so far, able to provide an explanation for why aesthetics and materiality matter to this degree, it stands as an experience described by numerous people, from the academics I have interviewed and worked with (examples are included in chapters 5 and 6) to famous authors of fiction [131, Introduction], and one which I recognize from my own experiences.

Reflexivity involves a “reading as”: The text may be reflected on with an eye to what the writers want with it, what they want it to be (-come). It may also be read from the perspective of an audience, to be assessed for form and clarity, and whether it gets across what the writers want (it to be). Both of these ways of reflecting are related to the text as pointing ahead, but the nuance is between reading as the writer and reading as an audience; a difference noted by a writer participating in the co-design study (see chapter 6, page 114). Such “reading as”
may be supported or hindered by the available appearances. Finally, reflecting also involves acting on the text: Similar to how skilled Tetris players rotate the pieces to assess how to best position them [132], modifying the text is part of considering and discussing alternatives, e.g., in choice of words.

**Outline** The outline text function is also tightly connected with material mediation, in one sense because it captures the text’s function as describing its own material form, but also because the available means of material expression influence which parts of the structure may be captured and in what ways. While structuring into sections and subsections is visually salient in a WYSIWYG (“What You See Is What You Get”) editor, it is not (always) as easily gleaned from markup. On the other hand, markup — while not always understood by the tool — is not lost in copy-pasting. The question of transferring structure thus comes down to both encoded representation and the visual presentation provided by a given tool.

**Division of Work** The division of work comprises past, present, and future: The future in the form of plans and the assignment of tasks. The present in terms of current activities and locations of these activities. And the past as traces of work that has happened. Material mediation of the division of work is in some ways difficult to separate from communicative mediation, as it is often a case of co-writers actively communicating the division of work through forms of demarcation (see [Chapter 4](#)). An example was provided by some interviewees who worked in Google Docs: They described first creating headings for the planned sections, with bullet points describing the content to be covered and color-coded according to who would write what. While the headings, at the project’s end, would be for the audience, they were at first a tool for the co-writers to capture coordinative agreements. Similarly, another group described using the table of contents to get an overview of what work was left to do and decide what to work on next. However, purely material mediation is also possible, such as when unformatted references in a paragraph let me know that said paragraph was recently edited by a particular co-author.

The interface can also provide material cues about division of work, such as through telepointers [102, 110, 242] or color-coded revisions [187, 249]. The latter example is a material quality of the text (although potentially only rendered visible in certain editing environments) while the prior is a transient property of the user interface. Because of the close coupling between file type and application, although logically unrelated to the text such properties come to be directly relevant and connected to the text by virtue of its representation as a file.

### 7.2 Communicative Mediation

**Plan** While material mediation is a central driver for the outline function, the plan function is connected more with communicative mediation. The text is both
a manifestation of the plan and, by virtue of that, a means for further planning and alignment: The ability of writers to “read” the plan from the text depends on the preceding communication about the plan supports later communication and coordination.

Planning and alignment happen at various granularities, from vocabulary to the overall line of argument or timing of work. Common to most granularities is that they become easier to address once palpable in the text, as also mentioned above. Material mediation thus ties into the communicative role of the text in connection with planning and alignment. Similarly, communication about what the text and the work point ahead to can be supported by material work on the text, as when a group of researchers wrote a number of abstracts to define their common vision (see chapter 5 page 97).

Outline  Sensing the structure of the text supports communication about, and assessment and adaption of, the form of the developing text. It is both a manifestation and a scaffolding of planning, as exemplified by the previously described use of the table of contents in this regard.

Reflexivity and Reactivity  Both reflexivity and reactivity depend on the ability to couple communication to the text. Explicit communication about the text most often takes place in a medium separate from the writing application, although communication within the text itself does occur (see chapter 5 and 188). Communication within the text itself comes with issues such as disruption and lack of persistence of what has been communicated (note that both may sometimes be the desired effect), but also has as its major advantage a close coupling between text and communication. Coupling of communication and text is desired both in the moment and later on, when looking back at decisions about the writing and the text 58 238. Currently, the most commonly used tools have poor support, if any, for anchoring communication in text or leaving a breadcrumb trail of the reasoning behind the writing.

Communicative and Material Mediation

I have already noted that the distinction between material and communicative mediation is artificial. As the analysis above shows, communicative mediation rests on material aspects of both the text and the tools, and it may even arise out of material qualities not intended to serve communicative a purpose, such as when a co-writer is recognized due to their (lack of) reference formatting. The text itself also serves a communicative purpose, for the writers but also for a prospective audience, and driving it to serve this purpose is a continuous dialog with the text as material. This dual role of the text results in development, from the text (although pointing ahead to something else) serving a mostly communicative role to facilitate the collaboration, e.g. where the most significant role of the table of contents is to
support a division of work more so than being an outline of the content, to the text eventually (sometimes) being completed and shared with an audience.

7.3 Development Over Time

As is the case for any practice, collaborative writing evolves at different scales. As the writing of a text progresses, co-writers’ needs with respect to that text change. The many activities involved in writing require different forms of control and overview as writers engage materially and reflexively with the text. Extending capabilities for the work is often accomplished by including more tools into the artifact ecology, be it one’s personal artifact ecology or the aligned one. Changes in the ecology, and thereby in capabilities, may also happen as people join or leave a collaboration, bringing experience and different technologies and other artifacts into the mix, or leaving space for a new technology to be adopted.

Collaborative writing may also develop at the scale of practice: Increased familiarity with certain tools shape tool choice and hence how the text is worked on. As a community of practice adopts or alters standards, writers respond by finding ways to fit those standards into their writing ecologies. For instance, the 2014 CHI conference introduced a set of guidelines for producing more accessible publications that required the use of Microsoft Word on Windows or, for those using Word on a Mac operating system or using LaTeX, the incorporation of Adobe Acrobat into authors’ workflows and hence their artifact ecologies.

The ability to extend or reshape the writing ecologies and to transition across them is central to development. How malleable the ecology can be to some extent depends on the restrictions imposed by file types, as discussed above. It also depends on the ease with which files can be shared, either by transfer or in real time (see the segment below on reactivity as well as section 7.4). File type restrictions and forms of sharing add up to interconnectivity: How easy is it to work across different applications in the ecology?

Reactivity Different constellations of tools provide different means for interconnectivity and thus present co-writers with different opportunities for responding to each other’s work. For instance, in the group who moved their layouting work to InDesign (see quote in chapter 5), the writer who was doing the layout could not reactively adapt to input from the rest of the group because she would receive it in batches and in a form separate from the file she was working on, making it a hassle to incorporate input and address changes that conflicted with the work she had already done. That hassle was caused by multiple things: First, only one person at a time could work on the file as there was no support for handling conflicting versions or working in real-time (in a previous collaboration they had even been restricted to use a particular laptop for the work, as incompatibilities between program versions

would alter the appearance of the text. Second, the group lamented the lack of a
good spellchecker in InDesign (see also [230]), meaning they had to run a check
of the text elsewhere before incorporating it into the InDesign file. Finally, the
writer who was proofreading preferred doing it somewhere other than InDesign.
The group had been aware of the potential hassle from the start and had therefore
planned for the layouting pass in InDesign to be the final work on their master's
thesis, with only minor corrections coming in from the proofreading. Ultimately,
however, unforeseen changes came up that starkly underscored the difficulty of
adapting their work and reshaping the ecology as the writing developed.

Interim Outcome  If we look at the interim outcome text function, we get a dif-
ferent perspective on development. Although writing is continuous, the interim
outcome of work is attended to at discrete points in time. Sometimes these are
frozen in time as permanently archived versions [129], either purposefully by co-
writers and/or their tools, or as a side effect of sharing or reviewing practices, such
as turn-taking via email exchanges of a file whereby file instances come to be saved
in the e-mail thread. These frozen interim outcomes become traces of how the text
has developed. However, I gather from my interviews with academic writers that
they rarely return to previous versions of texts. Keeping old versions, old text, seems
to be just as much about a process of letting go of text that someone is not quite
ready to delete. Interim versions can also play a part in communication relating to
division of work and reactivity: They can act as milestones for co-writers to clarify
intentions by communicating to each other how the text has developed and why.

Regardless of their function, saved interim stages of the developing text have
their place in collaborative writing. Commonly used applications and platforms
provide vastly different capabilities for serving this function. The tools that are
most advanced in terms of versioning and labeling of versions are, not surprisingly,
dedicated version control systems like Git [2] and Apache Subversion [3] (both used
by participants in the interview study), created with software development in mind.
However, because of their origin in software development, they present writers
with other challenges: As one writer pointed out, splitting text line by line to not
upset a diff-ing mechanism is “not how writing works” (G-R08/G08 in the interview
study; see tables 4.1 and 5.2).

Past-Future Dialectics

Progress in writing the text rests on the dialectic relationship between traces of
past work and the future work to be done: Co-writers rely on the text as interim
outcome to make sense of developments. This interplay between development
and communicative mediation supports reflexivity that may foster new ideas about
what the text is pointing ahead to, and in turn reactivity that may effect changes to
the plan, the outline, or the division of work. Section 7.1 described how reflexivity
is impacted by the text’s appearance and the possibilities for modifying the text
material. Co-writers’ ability to reflect on interim outcomes and trace the text’s
development is therefore also influenced by how changes are represented, as well as the text as a whole. Since this is often dictated, to greater or lesser extent, by material qualities of the tools in use, development cannot be discussed without addressing material mediation and the text’s tight relationship with the tools that mediate it.

7.4 Multiplicity

I have already discussed how the text as the material of work is impacted by being handled through a multiplicity of tools. Furthermore, the collaborative writing of a paper is impacted by a multiplicity of actors: In addition to the writers, others may for example provide feedback or otherwise consult on the work [197]. Additionally, writers may have different motivations for participating; for instance, their ambitions or the amount of time they each have available may differ. A step further away we find more influences, typically of an institutional nature: A university imposing restrictions on student reports such as deadlines or page limits; a funding body requiring particular measures of acknowledgment or types of publication venues (e.g. open access) for scientific papers; or a publication venue enforcing the use of a particular template. All these formal requirements impact the text as material, by directly influencing its shape or content, and sometimes by indirectly determining that particular tools must be used. For example, the ACM’s enforcement of Word and LaTeX templates [205] rules out InDesign as a paper writing tool.

Interim Outcome As described earlier, the interim outcome of work sometimes manifests in separate versions of the text. This is in part due to transitions through the ecology, in which the text changes hands or format, such as being uploaded as a .docx file to Google Drive or pasted from plain text into a different editing environment. The implications of this have been described in section 7.1.

Division of Work Transitions are also part of the division of work: As a consequence of having divided the work among several individuals, co-writers need to communicate. Chapter 5 describes communication transitions as commonly occurring because of a need for communication features that are not available in the primary tool, or because co-writers need to track down each other. Locating collaborators and the work they are doing in an ecology, or across multiple ecologies, is a consequence of the multiplicity of computer-mediated collaborative writing.

Division of the work is also a contributing factor in the proliferation of versions throughout a writing project, as described in section 7.3. Conversely, the multiplicity of individuals acting on one text, be it in multiple versions and locations or not, must also be addressed. This multiplicity introduces discrepancies such as overlaps, misalignment, and miscommunication. Overlaps are one of the more studied aspects among the technological contributions to collaborative work and in particular collaborative writing [123][178][227]. The technological foundations
are in place. The next step is to think them into ecologies: Presently, there are no generally available cross-application version management systems for those not wishing to write in markup, as far as I have been able to gauge.

**Reflexivity** Unlike the more practical concerns with respect to division of work, the qualities related to reflexivity are more experiential: Working in an ecology of multiple artifacts enables writers to change their perspective by performing aesthetic and user experience transitions. This multiplicity may, however, be stunted in a number of ways, such as by the limitations on material mediation discussed in section 7.1.

**Reactivity** Reactivity is impacted by the multiplicity of writing ecologies in a manner similar to division of work. In particular communication transitions are relevant to reactivity, with the need to communicate about changes to the text. As described in chapter 5, these transitions involve locating co-writers in or outside the common information space and making clear what part of the text one is referring to.

The need to locate co-writers arises out of multiplicity: It is necessary because co-writers may be working in any one of a multitude of applications even when working on the same object of work. The need for coupling communication and content, on the other hand, induces multiplicity when the tool(s) in use do(es) not provide sufficient capabilities for such coupling and writers seek out other means.

Reactivity is also impacted by co-writers’ access to each other’s work: With work and the interim outcomes of that work scattered across applications, online platforms, and local drives it is not a given that co-writers are on the same page, literally or figuratively. Real-time shared editing environments seem like ideal places for reactivity because co-writers can instantly and simultaneously access any part of the text and get the very latest version (keeping in mind that co-writers may have temporarily transitioned their work elsewhere). How other forms of sharing invite and support reactivity is less apparent. Being co-located and physically sharing screens is one way. But was does reactivity look like in distributed asynchronous or turn-based collaborative writing? This is an open question I am presently left with.

**Whole-Part Dialectics**

As Bødker and Klokmose describe, the meaning of individual tools is shaped by a dialectical relationship with other tools in the artifact ecology, like when InDesign is designated as a layouting tool while another one comes to be the proofreading tool. The negotiation and forming of artifact ecologies exemplifies the interplay between multiplicity and the changing needs that are foregrounded when talking about development. But the negotiation is not completely open: The interoperability of artifacts is limited by material characteristics of files and programs. Some choices about what to include or exclude from the artifact ecology may force additional choices, such as when deciding to use LaTeX means that
Adobe Acrobat must be used in order to produce an accessible publication. This points back to how multiplicity need not only refer to the multiplicity of tools or writers, but may also refer to the multiple sources of impact on a writing project, such as a publishing venue with particular requirements. The shaping of co-writers’ artifact ecologies is situated in this field of tension.

7.5 Summary

Operationalizing text function in this analysis has helped elaborate the text’s functions in collaborative writing and how they influence and are influenced by collaborative writing’s characteristics as a common, mediated, and multiple process. The principles about common objects have served to theoretically frame those characteristics. They have, furthermore, emphasized the additional aspect of development which, as mentioned, is relevant to collaborative writing at multiple scales — e.g., both in terms of the development of a particular text and in terms of the development of the practice as a whole, etc. I see potential in revisiting the CIO principles with a focus on scale or granularity, as exemplified by the discussions on different scales of development (section 7.3) as well as the different granularities of planning and alignment (section 7.2).

In addition to the text’s functions in relation to the writing process, the characteristics of collaborative writing themselves exhibit a dialectic interplay with each other which, through an analysis like the one above, elucidates the complexity encountered when working to design solutions for collaborative writing (see chapter 6 and, e.g., [230]). In the web of all that goes into collaborative writing it is difficult to pin down where change is needed, and the dialectic nature of it all means that when one thing is changed, effects propagate through the web and we must look at everything again. If we, for instance, nudge communicative capabilities by adding a feature to tag co-writers next to updated text it might prompt co-writers to invent strategies for materially distinguishing whether the tag means “please proofread” or “your turn to write”; and this change in material mediation practices would in turn reveal a communicative need (the hypothetical tagging feature is inspired by the newly released demo of Microsoft’s new collaboration system Fluid [166]). As this example shows, what is changed may be both technology and practice. Furthermore, change can be directed at immediate needs or at the conditions in which needs are embedded. For example, section 7.4 described a dialectical tension between multiplicity at once causing co-writers’ need to locate each other and being induced by their need to extend capabilities for communication. In both cases, multiplicity is a condition of collaborative writing, but it may be productive to ask where and how multiplicity could (desirably) be reduced, and where it is necessary or even favorable to work with the multiplicity. Is there, for example, a benefit to the multiplicity that is induced by communication needs among a particular group of writers, or is it desirable to effect change by providing different, improved means for communication?
Some of this complexity can be reduced — or at least tempered — by applying text function as an analytical lens, through which different characteristics and principles are foregrounded by different text functions. Such foregrounding supports learning about characteristics of the different text functions in the given context and narrows the scope of what is relevant to consider in design. It can help us discover and express breakdowns in terms of text function and in terms of the interplay between particular text functions and characteristics of collaborative writing. The next chapter contains the outline for an approach to address those breakdowns.
Chapter 8

Questioning Conceptualizations

The most treacherous metaphors are the ones that seem to work for a time, because they can keep more powerful insights from bubbling up. As a result progress is slow — but there is progress.

– Alan Kay [128, p. 54]

The reflections in chapter 7 flesh out the role of the text and its relationship to tools and artifact ecologies. They highlight challenges in supporting collaborative writing in and across artifact ecologies, and the analysis revealed how breakdowns are related to representations and transformations in the digital environment, and to available means for access and version management. This chapter narrows in on breakdowns in relation to file representations.

Breakdowns with technology occur when attention switched from the task at hand to the technology [29], such as when writers become focused on recovering lost formatting rather than continuing to write their text after transitioning from one application to another. Madsen [158] frames this notion of breakdowns in terms of conceptual distinctions becoming salient and relevant. This chapter presents an attempt at examining such conceptual distinctions through an analysis scaffolded by the theory of conceptual blending [90]. Conceptual blending (explained in section 8.1 below) has previously been suggested as an explanatory framework for human interpretation and adoption of digital artifacts [34] and as an approach to utilize “real-world” concepts in design of interactive systems [126]. The inspiration to apply conceptual blending to analyze breakdowns in relation to file representations comes from my previous work with cognitive semiotics. The work is tentative and the analysis presented below is a first draft. It is my intention to develop the analysis further by applying a greater range of principles from conceptual blending than what is included here.

Chapter 7 returned to the limitations imposed by file encoding a number of times. The analyses therefore focuses on the part played by file encoding, as one example of how the metaphors we apply in our language about computing shape
the solutions we are able to imagine. The discussion centers around the example of conceptualizing digital text using the metaphor of computer files. I apply the theory of conceptual blending to point out problematic premises in our current conceptual grounds for imagining and show how an alternative conceptualization can support different inferences.

8.1 Conceptual Blending

Conceptual blending, also known as conceptual integration, describes a cognitive process of meaning making. It describes how new meaning emerges in the forming of connections between different mental spaces in conceptual integration networks. A mental space is a structured assembly of information that draws on local context and pre-existing knowledge. A blended space, or simply blend, exhibits selective projection in that it inherits some (but not all) structure and relations from the input spaces it draws on. The new conceptualizations formed this way in turn enable inferences to be projected back onto the input spaces. I keep this description concise, but the meanings should become clear as needed when reading the following analysis.

A simple example of conceptual blending is found in Conceptual Metaphor Theory. According to this theory, language and linguistic structures include expressions of a human tendency to understand complex and abstract target domains in terms of familiar and simpler source domain, such as when we understand time in terms of motion, with expressions like “those days are behind us” or “as time goes by”. These are expressions of metaphorical mappings of characteristics from the source domain (in this case motion) to the target domain (in this case time). These mappings play a subtle but significant part in the way we understand and experience the world. For example, the two expressions about time are ingrained in the way we, whose language(s) speak of time in this manner, understand time: The past is behind us and the future is in front of us, among other implications. It is central to conceptual metaphor theory that metaphorical mappings reach beyond language and into how we perceive and reason about the world. Metaphors like those are abundant in computing, too. Not just in computer interfaces but throughout the layers of abstraction that make up computers.

The selective projection that occurs in conceptual blending is part of what allows mappings between disparate mental spaces, or domains, to be formed. But this selective projection also means that not all blends work equally well. Fauconnier and Turner’s book on the subject of conceptual blending includes a range of examples of how blends may break down, along with a list of principles used to explain different kinds of such breakdowns. Like Fauconnier and Turner, Anderson notes how metaphors used in design for human-computer interaction can break down and thereby create confusion. Discussing the use of metaphorical thinking in design, Andersen stresses the need to examine the ways in which metaphors being considered for design might break down. As noted above,
the theory of conceptual blending provides a framework to address metaphor and conceptualization in HCI both analytically and generatively \[34, 126\].

8.2 Text as Clay — Conceptual Blending

As presented in section 7.1, the use of multiple file encodings has problematic implications for how applications interact with files and, ultimately, for co-writers’ ability to transition through artifact ecologies. The place of encoding in this in part stems from the way we use metaphor to abstract away (some but not all of) the underlying technology. This analysis critically examines the conceptualization of computer files. Given my focus on collaborative writing, I will frame this argument in terms of text documents, although the problem is really with computer files in general. More precisely, the analysis will examine a conceptual metaphor \[144\] I have chosen to call TEXT AS FILE. The analysis is illustrated in Figure 8.1 and will be explained shortly.

![Conceptual integration network for the TEXT AS FILE metaphor. The shaded circle is the blend.](image)

**Analyzing the Blend** The diagram in Figure 8.1 depicts the conceptual integration network behind the TEXT AS FILE conceptual metaphor. The network shows how TEXT AS FILE inherits properties from computer files and their interplay with computer applications. For clarity, I have included the input spaces for the
CHAPTER 8. QUESTIONING CONCEPTUALIZATIONS

*COMPUTER FILE* mental space, which is in fact a blend of its own. The diagram is vastly simplified, to only include the elements and relations consequential for what I will discuss here.

Some might find that I am abusing this terminology; I am not sure there would be unanimous agreement about referring to *TEXT AS FILE* as a metaphor in itself, although *COMPUTER FILE* most certainly is one. Regardless, conceptual blending is the process shaping the way *TEXT AS FILE* is comprehended.

What I would like the reader to notice in Figure 8.1 is how *TEXT* as concept has the property of only being constrained by the limits of (written) language, but this is not imported into the blend. Rather, a stronger constraint, namely file encoding, is imported all the way from the *COMPUTER STORAGE* input space. While one may philosophically discuss language as an encoding of meaning, the difference here lies in that language limits what a person can express while encoding becomes a property of the material used to carry those expressions. Encoding in and of itself is not the problem, but combined with the fact that applications are only designed to interpret and work with particular encodings, file encodings mean that the flexibility available in the *TEXT* space is hampered in the *TEXT AS FILE* space. It is this same limitation I discussed in section 7.1 along with its impact on co-writers’ ability to transfer content across their writing ecologies.

Encoding could have been abstracted away and not imported to *TEXT AS FILE* or even to the *COMPUTER FILE* blend. Note that abstracting away the encoding is not to say that we remove encoding from the implementation of files; this would indeed not be possible. But it is possible to abstract it away from how the writer conceptualizes, or rather is forced to conceptualize, the text — similar to how “emptying” the trash/recycling folder in many operating systems abstracts away the fact that the data making up the file is not actually deleted, its location in storage is simply marked as available for use; the person emptying the folder need not be aware of this nor that the storage is divided into separate parts that may be marked separately. The transparency of the system is lost in the *TEXT AS FILE* blend because letting the encodings be relevant to co-writers’ handling of files forces co-writers to be aware that they are working on computer files rather than documents that may (almost) as well be made of paper.

Re-Imagining Digital Text Documents  It is one thing to be able to analytically tease out the elements and relations underlying these issues by examining the design metaphor through a blend. But conceptual blending is not only analytic, it can also be used generatively. We can use it to conjure up a blend in which encoding is abstracted away from the text that the writer encounters.

We could re-imagine the *TEXT AS FILE* blend by changing which elements and relations are included, and potentially add new relations between elements in the blended space. We can also, alternatively, conjure up a different metaphor and backtrack from that. In section 7.1 I previously used the term mold about

Footnote 1: Transparency in the sense of not being the object of focus or actions from the writers.
working on the text. If aiming to create a conceptualization that emphasizes the text’s capacity for being molded, a TEXT AS CLAY blend could be a suggestion. Although a mention of Alan Kay’s [128] analogy between computing and clay is appropriate here, I am speaking of conceptualizing the object of work, not the computer itself, as clay. A TEXT AS CLAY blend may look as in Figure 8.2.

![Figure 8.2: A TEXT AS CLAY conceptual integration network. The shaded circle is the blend.](image)

This blend preserves the inner relation between the text being made up of written language and it being constrained (only) by this. The latter is achieved by not propagating encoding into the blend. Attempting to construct a new blend has forced a number of additional things to be considered, the seeds for which are already present in the blend. Starting from clay, with the desired quality being that it can be acted on by, in principle, any tool, led me to consider how this quality could come to make sense in the blend. One way is to imbue computer applications with the relevant qualities of tools, in a coarse-grained version of instrumental interaction [17] [136]. Instrumental interaction is in itself a blend (COMPUTER APPLICATIONS ARE TOOLS), although the literature on instrumental interaction is focused on individual features more than full applications and does not describe it in terms of conceptual blending.

My re-conceptualization of applications as tools led to a removal of the relation between applications and files that is present in the TEXT AS FILE blend: There is no analogy for the file that makes sense in terms of clay. Rather, the file becomes a particular property of the text as “digital clay”: Digital data must be stored in some
way, in bundles that make sense to the user so they may, e.g., conceptualize the text as a document. Hence, the text as (digital) clay is contained in files, but the role played by files has no impact on the role played by applications, and vice-versa.

**Realizing the new Blend**  Backtracking from the TEXT AS CLAY blend, we are led to consider what qualities are needed of the input spaces, and the rest of the conceptual integration network, for a writer to experience the text in this way. From an implementation perspective we cannot avoid encoding at some level. The question is how to abstract this away from the blend that the design conveys to writers. It may require applications to be file-type agnostic, or the solution may be abolition of file types in favor of a unified encoding. Analyzing and creating blends like this one can frame the formulation of concrete questions to guide the design. In this case, we are made to consider the implications of abstracting away encoding at the level of writers’ interactions with files. Such implications could also have been raised by modifying the TEXT AS FILE blend to exclude the import of encoding.

The significance of encoding, for both file types and applications, comes from the fundamental nature of computers as machines of representation. Encodings are necessary to transform from electrical signals, through digital, to something human-readable. But the many layers of abstraction in computing leave multiple options for where to perform such transformation. Considering that all encodings are, in the end, translated to the same basic electrical signals, the encoding does not have to hold significance at the level of files.

It would be empowering for writers to allow them to work on their text “without appeal to abstract intermediaries” [128, p. 54] as expressed by Alan Kay. In his comparison of clay and computer memories, Kay asserts their equal power of representation [128]. But unlike the case of pottery, we actually have access to the foundational building blocks, or “atoms”, of computing: We could construct a system that leaves the need for encoding and translation properly transparent to writers by handling them at lower layers of abstraction. There are a number of reasons that encoding does, nonetheless, impact computing at the level of files:

**Convenience:** Having different standards for different types of content and purposes allows programmers, during implementation, to abstract from things that are irrelevant to the particular type of content or application being implemented.

**Optimization:** Related to convenience, using a particular file encoding allows exclusion of irrelevant data, allowing for more efficient use of storage, bandwidth, etc.

**Economic motivations:** There is also an economic interest in locking people to particular (artificially enforced) technological ecosystems (see for instance [4]).

**The proliferation of standards:** Finally, we are far beyond the point where the number of file format standards in existence makes it nearly infeasible (and in

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1At the time of writing, the file extension compendium FILExt has catalogued 51,537 file types [91].
terms of technological politics highly unlikely \[175\] to switch to using a unified standard.

All this suggests that the status quo is not likely to change. In an argument for viewing computing as a material process, Blanchette \[25\] laments related issues of backward compatibility hindering fundamental changes to the material basis of computing. In line with my claims above, Blanchette notes the infrastructure’s significant role in determining the conditions under which users and others are able to conduct their activities. He remarks, akin to the convenience caveat described above, that the computational infrastructure is there to relieve users and programmers from the specifics of the material resources of computation. However, the analysis in this chapter suggests that users are, at least in some cases, currently shouldering more of that burden than I find to be reasonable.

### 8.3 Next Steps

I have presented this analysis to sketch out an approach that seems useful for addressing the conceptualizations at play in design and understanding of technologies used by co-writers and other people who collaborate. By taking outset in text function, the analysis has demonstrated how starting from the object of work, the functions it serves, and the ways it is conceptualized may help us ask critical questions about the tools that mediate work on and around that object. I plan to develop the approach further in my future work.

The observations from chapter 7 analyzed in this chapter are evidence that HCI cannot be reduced to surface-level concerns. While I do not think it right or timely to give up on improving and developing solutions that are feasible with current infrastructures, I do believe the computing community should work together on fundamentally improving the basis on which we support computer-mediated activity. It may seem a longshot to suggest changing such low-level infrastructures, but that does not mean that the benefits of doing so should remain unaddressed.
Chapter 9

Discussion and Conclusion

This thesis has presented an understanding of computer-supported collaborative academic writing as mediated by a multiplicity of artifacts. The empirical work has enabled a characterization of co-writers’ motivations for performing transitions between tools, showing how there is a complex interplay between practical and social concerns that is further influenced by characteristics of the tools in use. The presented research has furthermore outlined the complexity of balancing the needs and preferences of multiple co-writers when designing for collaborative writing.

In addition to detailing the way collaborative writing takes place in artifact ecologies rather than singular tools, thereby extending observations that have previously been mentioned in passing [39, 65, 184], this thesis has also contributed a new framing of collaborative writing by emphasizing the role of the text that co-writers’ efforts are centered around: Through its material, coordinative, and epistemic functions, the common text itself serves as a mediator for the work. These text functions have been operationalized in an analysis of the way they are affected by qualities of the tools and the possibility for working and communicating across co-writers’ artifact ecologies.

The analyses of co-writers’ motivations has contributed a thorough explanation for the emergence of multiplicity in collaborative academic writing, and by accounting for co-writers’ transitions through their ecologies, the presented research has shown that multiplicity is not by definition problematic: Rather, multiplicity is a demonstration of co-writers’ resourcefulness in utilizing available means to scaffold a collaboration, and problems arise when this resourcefulness is hampered by technological limitations.

Designing for Collaboration and Writing

Not all of the observations in the previous chapters pertain to collaborative writing in particular. They are nonetheless significant to the way collaborative writing is carried out. The findings presented have contained multiple examples of co-writers being faced with a trade-off between advanced document processing capabilities and features to support collaboration. Several lamented the need to transition
between applications because the collaborative writing platforms they use do not provide necessary or satisfactory features.

According to Bødker [29], what users want must be understood in a dialectical tension with what they can get. Transitions may be seen as a manifestation of this dialectical tension. But while Baecker et al. [11] recommended providing basic word-processing and enable smooth transitions to single-user software, 27 years of technological development has progressed us to a stage where co-writers can ask for more. Already around the time of Baecker et al.’s recommendation, others argued against prioritizing collaboration over other qualities of tools designed with collaboration in mind [60, 73, 231]. This thesis suggests that we should primarily consider collaborative writing as work directed at the aim of producing a text. The important thing is not how well a platform or tool lets co-writers feel as if they are co-located with other co-writers, or how well it lets them construct a plan for the writing. What is important is to leave space for co-writers to achieve and maintain a context around the common text.

Looking beyond the singular artifact in use enables us to cease viewing collaborative writing as defined by how it is “made” collaborative by technology. It is collaborative because it is an orchestrated effort of multiple people. Because of this, what we may call the context of the work is not always well-defined or stable. What ties the work together is the common text. Text function as a concept captures the ways in which the text as the common object of work is able to mediate that work.

This Is Not a Boundary Object

The title of this section is a, slightly humorous, reference to Star’s reflective paper [225] on the reception of the boundary object concept that she and Griesemer introduced in 1989 [226]. I take the opportunity to briefly address this concept, and its relationship to the notion of text function. This is prompted by two remarks I have gotten regarding the publication presented in chapter 5: One was wondering if what my co-authors and I refer to as a common object is really the same as a boundary object. Another praised the work for applying a boundary objects perspective on the text.

The notion of text function is meant to describe functions or “roles” the text can serve as an object of work. Similar to boundary objects, it captures the point that an artifact can present different perspectives and push for different discussions depending on the vantage point [225, 226]. But rather than the focus on bridging between individuals or communities of practice with disparate views (or different social worlds as Star and Griesemer refer to them [226]), text functions can help to address the relationships to the involved technologies. Boundary objects is as such closely related to the notion of communities of practice, while text function is more related to artifact ecologies as it can help us understand how different parts of such

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1While I am using the occasion to contend that viewpoint, I was deeply honored and delighted to receive an e-mail from the individual in question that praised the publication, which I want them to know should they ever read this.
an ecology, or of multiple ecologies, impact the object of work — more so than how that object impacts or serves understanding between collaborators. The latter can be part of some of the text functions that may then be said to be describing a boundary object-like function, if one finds use in characterizing it as such.

9.1 Limitations

Looking Beyond Academic Writing

The empirical work in this thesis only supports answers to the research questions as regards academic writing. How well the findings apply to other kinds of collaborative writing remains to be studied. Wang et al. [252], for instance, observe a difference between perceptions of close co-editing among writers in academia and industry. On the other hand, Mitchell et al. [169] note a high degree of similarity between observations made of middleschool children's collaborative writing and observations from studies of adult writers. There are likely also disciplinary differences within academic writing.

In my own work I have noticed differences between, e.g., students and researchers, such as the students placing a strong emphasis on equal contribution (perhaps influenced by university policy) or the difference between students’ one-chance deadlines and the researchers’ world of rejections and “re-submits”, which likely has impact on the way work is prioritized. In the future, I would like to explore the extent to which the findings from this thesis apply in other contexts, in particular in other forms of collaborative writing where authors are given named credit on the text.

Constructive Outcomes

The work described in chapter 6 strived to build a constructive layer on top of the findings presented in the chapters preceding it. The extent to which this was successful can be discussed in terms of two aspects: First, the activities carried out in the workshops were guided by the previous findings, for example by drawing on concepts identified as relevant in chapter 4. But the analysis does not draw on those findings in the same way. Analyzing the co-design data with a closer eye to, e.g., transitions might provide useful insights, for example by helping identify at which junctions in the design transitions need to be addressed.

Second, the chapter presents constructive advice on how to approach a multiplicity of perspectives through trade-offs. But this is not directly constructive for all the people who participated in creating that result. To truly benefit from the involvement of (other) domain experts, a longitudinal study rather than a total of a mere six hours with the participants in the co-design study would have been desirable. The choice for a small-scale co-design study was primarily driven by the limited time remaining of my Ph.D. studies.
9.2 Conclusion

Although the findings from the empirical work do not necessarily apply beyond collaborative academic writing, the analyses in chapters 7 and 8 carry implications beyond collaborative writing. The CIO project’s aims towards control, malleability, and shareability relate to the limitations revealed, in particular, by findings presented in chapter 5 and analyzed in more depth in chapter 7. Supporting co-writers as resourceful people by allowing them to adapt and develop their tools and artifact ecologies requires an attention to the limits imposed by current infrastructural implementations. Whether the aim is to change those implementations or work around and with them, the CIO project must critically examine their influence on collaborative work. The possibility for people to better understand the technologies they use may be explored by using the approach outlined in chapter 8, to ask how technology can come to make sense in terms of people’s practices.

This points to some obvious directions for future work. First, contributing further to the CIO project with a critical examination of infrastructures and their role as part of the technological basis for malleability, control, and shareability. Second, applying conceptual integration theory in a more in-depth analysis of problem areas, such as those identified in this thesis, to explore the possibility for formulating a framework for critical analysis of how both infrastructures and higher-level designs are conceptualized.

In conclusion, collaborative academic writing, and likely other kinds of collaborative writing and work, is a demonstration of a human resourcefulness that it is our task as researchers and designers of technology to scaffold. This is not a challenge that can be solved solely through user interface design or implementation of new infrastructure. It will require a concerted effort, and probably some amount of resourcefulness.
Part IV

Appendix
Appendix A

Interview Protocol: Master’s Students

Project

1. What can you, briefly, tell me about the work you are doing together?

2. What is your relationship to each other and to the project? How much have you worked together previously?

Tools and writing process

1. What tool do you use when you are writing together?

2. Do you sit in the same place when you are working? Do you work at the same time?
   a) How do you coordinate the work?
   b) Do you use other functionalities than the text editing itself, such as chat or the change log?

3. Do you ever make drafts when working on something, before entering it into the shared document?
   a) Do you use drafts in a different way if it is not a collaborative setting?
   b) How do you feel about co-writers reading or commenting on work that you are not done with?
   c) Does this depend on what type of work you are doing, e.g. what type of text it is?
SCENARIO 1

1. What are your thoughts on what Laura is doing here?
2. How would you respond if you were in Simon’s place?
3. Do you recognize yourself in the situation? Can you tell me about similar experiences?
4. How would this situation have played out among you guys?

Collaboration

1. Do you sometimes watch each other in the document?
2. Do you think more about what you are doing, or how you are doing it, if you are not “alone” in the document?
3. Do you think about when you work in the shared document?

SCENARIO 2

1. What are your thoughts on Simon doing this?
2. How would you feel about it if you were Laura?
3. Do you recognize yourself in this situation? Can you tell me about similar experiences?
Appendix B

Interview Protocol: Researchers

Project
1. You have been writing with _______________________________. Are you currently writing something together?
2. In what context do you write together? What is your work relation (e.g. post-doc and professor)?
3. How long have you been colleagues? Have you worked together often?
4. Can you tell me a little about what you are/have been writing together?

Tools and writing process
1. What tool do you use when you are writing together?
2. Do you sit in the same place when you are working? Do you work at the same time?
   a) How do you coordinate the work?
   b) Do you use other functionalities than the text editing itself (such as chat or the change log)?

Anecdote?
**Drafts**

1. Do you ever make drafts when working on something, before entering it into the shared document?
   
   a) Do you use drafts in a different way if it is not a collaborative setting?
   
   b) How do you feel about co-writers reading or commenting on work that you are not done with?
   
   c) Does this depend on what type of work you are doing, e.g. what type of text it is?

**Collaboration**

1. Do you sometimes watch each other in the document?

2. Do you think more about what you are doing, or how you are doing it, if you are not “alone” in the document?

3. Do you think about when you work in the shared document?

**ASK: Access to project?**

**SCENARIO 1 (editing)**

1. What are your thoughts on what Laura is doing here?

2. How would you respond if you were in Simon’s place?

3. Do you recognize yourself in the situation? Can you tell me about similar experiences?

4. How would this situation have played out among you guys?

**SCENARIO 2 (checking)**

1. What are your thoughts on Simon doing this?

2. How would you feel about it if you were Laura?

3. Do you recognize yourself in this situation? Can you tell me about similar experiences?
Appendix C

Interview Scenarios

Figure C.1: Scenario characters.
Simon is working on the conclusion. Laura is done with her section and scrolls down to see how far Simon is. Laura skims through what he has written. She thinks it sounds a little too bold and decides to change it.

Figure C.2: Scenario 1: Ownership.

Simon is wondering if Laura is making sure to work on the section that they are supposed to discuss tomorrow when they meet up. He logs into the document and checks that she is online.

Figure C.3: Scenario 2: Privacy.
Appendix D

Co-Design Scenarios

A

• Students
• Writing their joint master’s thesis
• Co-located
• Supervisor sometimes reviews and gives comments

Figure D.1: Scenario “Master’s Thesis.” (Photo by Dato (WMAM), CC 4.0, photo was cropped, https://commons.wikimedia.org/wiki/File:Collaboration_with_Yerevan_State_University_of_Languages_and_Social_Sciences_after_V._Brusov_01.jpg; icons made by Freepik from www.flaticon.com).
APPENDIX D. CO-DESIGN SCENARIOS

Figure D.2: Scenario “Book.” (Photo by University of Michigan School for Environment and Sustainability, CC 2.0, https://www.flickr.com/photos/snre/6721656127; icons made by Pixel perfect and Freepik from www.flaticon.com).
C

- PhD student and supervisor
- Jointly writing a scientific paper
- Co-located

Appendix E

Co-Design Disruptions

A

• Students
• Writing their joint master’s thesis
• Co-located
• Supervisor sometimes reviews and gives comments

DISRUPTION:

The ministry of education imposes a new set of rules:

• The supervisor must grade students separately, by monitoring individual student contributions to the thesis.

Figure E.1: Disruption “Master’s Thesis.”
APPENDIX E. CO-DESIGN DISRUPTIONS

B

- Researchers
- Mixed seniority
- Writing a book
- A mix of co-located and distributed

DISRUPTION:

The print deadline for the book is approaching. The researchers get together for a two-week sprint to finish the book.

- They are now working intensely and in close physical proximity of each other.

Figure E.2: Disruption “Book.”
C

- PhD student and supervisor
- Jointly writing a scientific paper
- Co-located

DISRUPTION:

The paper gets rejected. Meanwhile, the supervisor has gotten a job abroad.

- The PhD student and the supervisor must now work together remotely.
- They want to resubmit the paper in time for the student's thesis deadline.

Figure E.3: Disruption “Scientific Paper.”
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