Multitasking with Play Write, a Mobile Microproductivity Writing Tool

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ABSTRACT
Mobile devices offer people the opportunity to get useful tasks done during time previously thought to be unusable. Because mobile devices have small screens and are often used in divided attention scenarios, people are limited to using them for short, simple tasks; complex tasks like editing a document present significant challenges in this environment. In this paper we demonstrate how a complex task requiring focused attention can be adapted to the fragmented way people work while mobile by decomposing the task into smaller, simpler microtasks. We introduce Play Write, a microproductivity tool that allows people to edit Word documents from their phones via such microtasks. When participants used Play Write while simultaneously watching a video, we found that they strongly preferred its microtask-based editing approach to the traditional editing experience offered by Mobile Word. Play Write made participants feel more productive and less stressed, and they completed more edits with it. Our findings suggest microproductivity tools like Play Write can help people be productive in divided attention scenarios.

Author Keywords
Interruptions, microtasking, multitasking, microproductivity.

INTRODUCTION
With the rapid improvement in the computing power of mobile devices and the ubiquity of their use in a variety of scenarios, users today have the opportunity to make use of fragmented time previously considered unproductive. However, while the devices have advanced capabilities, the productivity tasks users can complete on them remain limited. Part of the challenge is that the devices have limited I/O, which makes it difficult to attempt complex tasks that require a lot of context. Additionally, the devices are usually used in divided attention environments, where the user either attends to another task simultaneously or is only able to attend to their device in short time intervals.

Rapid task switching is standard practice on mobile devices as tasks routinely get interrupted [17, 23, 31]; it is difficult to allocate the required amount of focus that complex tasks require. Research shows it takes 25 minutes to reach full productivity after an interruption [26], and in environments where tasks get continuously interrupted, attempts to complete multiple tasks simultaneously often results in less than desirable outcomes [7, 8, 11].

The most common way researchers have explored to help people complete complex tasks while mobile is to support better mobile interruption management practices [28, 42]. But there is another approach: to change the nature of the tasks themselves to make them resilient to challenges coming from attention being divided across multiple points of interest [37]. Prior work has demonstrated how to algorithmically support task decomposition, breaking tasks into much smaller pieces than previously imaginable [1, 22] while maintaining the necessary context [33]. Based on this, we explore the concept of *microproductivity*, where a large productivity task is decomposed into a series of smaller microtasks. These microtasks can designed to be independent of each other and require limited time and context to complete, making it possible for them to fit well into the mobile form factor and usage scenario.

Prior work shows that doing a task via microtasks allows people to produce higher quality work with less effort than doing the task as a whole [4]. Additionally, while interruptions interfere with a person's ability to complete a large task, they have far less impact on that person's ability to do the same task via a series of microtasks [4]. This is because interruptions are less disruptive when they occur at task boundaries; microtasks are, by definition, short, which means that task boundaries are common. Moreover, with microtasks the context needed to resume the larger task is contained entirely within the next microtask [13, 39].

The flexibility and portability of microtasks makes them ideal for surfacing on mobile devices; they can then be performed anywhere, at any time, and even interleaved with other tasks (e.g., while waiting for another task to complete [2], or during a continuous attention task such as driving [15]). Thus microtasks can help recoup productive time from the many micromoments of downtime that occur during a day.

In this paper we present *Play Write*, a mobile application for performing document editing microtasks, as a proof of concept implementation that enables us to explore mobile microproductivity in divided attention contexts. Editing documents from a phone via a traditional editing tool is

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challenging due to the limited display size, limited input affordances, and fragmented attention. Play Write surfaces microtasks that are designed to address these constraints. However, because the microtasks are simple and limited in scope, they should be viewed as complementing – rather than replacing desktop editing tools designed for in-depth focused work. Play Write merely creates additional opportunities to edit during moments that are typically considered unsuitable for complex tasks. While existing microwriting tools have focused on leveraging the crowd to perform microtasks, Play Write allows the individual to selfsource microtasks that can be deferred and interleaved with other tasks, taking advantage of micromoments that happen throughout the day.

The design of Play Write was motivated by prior literature and supported by a survey of 106 information workers. We studied how well people were able to use Play Write to edit a document in a divided attention scenario via a within-subject laboratory study with 16 participants. Our results show that participants had a better multitasking experience and made more edits with Play Write than they did with Mobile Word. This suggests that one way for complex tasks to be reliably completed from a mobile device while multitasking is to decompose them into smaller pieces.

RELATED WORK

Play Write builds on existing literature on productivity and distraction to use microtasking as a way to help people make use of small moments. While there are systems that have decomposed writing into a series of microtasks for completion by crowd workers [1, 19, 20, 25, 29] or a loosely-coupled set of collaborators [36], Play Write allows exploration of how microtasking impacts an individual's experience with mobile multitasking.

Multitasking

Prior work has studied how interruptions affect productivity [8, 9, 11, 34]. Multitasking is common due to external and internal interruptions [11]. Once interrupted, it can take upwards of 25 minutes to return to full productivity [26]. Switching tasks often starts chains of distraction, where people cycle through multiple stages of disruption [14]. Challenges with remaining focused are also compounded by the fragmented availability of work time. Gonzales and Mark showed that activities shift every three minutes on average [26], and a more recent study showed that desktop users only stay focused on a single window for 47 seconds [27]. Switching attention between different tasks results in 50% longer time to finish those tasks as compared to focusing on one task through to completion without switching tasks [10].

Task resumption is easier when a person is interrupted at a breakpoint [13] and when the interrupted task has a clearly achievable short-term outcome [39]. Researchers have tried to use these insights to decrease the cost associated with interruptions by strategically scheduling interruptions to occur at breakpoints [13], helping users set goals upon interruption [39], and reminding users of their goals upon return [1]. An emerging approach to address a person's fragmented time and attention is to fragment the tasks into microtasks to be completed between interruptions [4, 36].

Microtasking

Microtasking is prevalent in crowdsourcing, as tasks are mostly context-free and allow crowd workers to schedule flexibility [30]. A variety of large and complex tasks (i.e., taxonomy creation [5], copyediting [1], and even research training [42]) can be decomposed into smaller microtasks that can be completed in short bursts of time. While microtasking is traditionally associated with crowd work, the microtask structure can be beneficial to individuals [35], enabling people to complete parts of large tasks in many brief moments when they want to be productive but do not have a long stretch of uninterrupted time [2, 4, 41]. Leveraging micromoments for microtasks allows people to discover extra time in their day by taking advantage of time that was previously deemed unusable. For example, Kang et al. demonstrated how micromoments can be used to create audio books for children [16]. Microtasks can allow multitasking in continuous attention scenarios. Prior work has shown how a task of giving directions while driving can be decomposed into shorter microtasks which can then be safely interleaved with the primary task of driving [15].

Research shows that microtasking has certain advantages. Breaking certain large macro-tasks down into a series of small, context-free microtasks leads to higher quality work, reduces task complexity, and makes the task more resilient to interruptions [4]. Thoughtful ordering of the microtasks can improve performance even further [3, 30].

CURRENT MICROWRITING PRACTICES

We chose to explore microtasking within the context of the writing domain because it requires fundamental but varied skills, including reading, analysis, reasoning, and communication. Writing tools provide a valuable lens through which to understand and explore a range of problems related to information work [12]. Further, decomposing writing into microtasks based on rhetorical category (i.e., mechanics, organization, semantics) has been shown to aid the writing process, especially for weak writers who spend the majority of their time and effort attending to surface-level, mechanical details rather than more complex processes of meaning-making [32].

Considering the document's developmental stage (e.g., pre-writing, writing, and re-writing) in categorization of microwriting tasks is valuable because it scaffolds the work, prompts engagement with tasks people might normally skip, and eases cognitive load [16]. People can also use small writing tasks to ease into larger writing tasks [3]. For example, authors skim existing text and make small changes, which has a positive side effect of re-familiarizing an author with the content.

Existing MicroWriting Systems

Most existing microwriting systems do so in the context of crowd work, breaking a task down to allow multiple people

Statement	Neg	Neut	Pos
I like to have a solid block of time for writing	9	11	85
I get distracted when I write	21	30	55
I currently write or edit documents from my phone	86	9	9
I find writing hard	56	27	22
I find it hard to start writing a new document	47	26	33
I find it hard to start editing an existing document	85	8	12
It would be easy to edit it from a mobile phone	89	7	10
It would be hard to start working on it right now	50	28	25
It is stressful to think about editing it	59	25	22
I know what needs to be done next with it	6	9	91

Table 1. The number of survey participants with negative, neutral, or positive agreement. The top set of statements refers to writing in general; the bottom refers to a specific document.

to contribute to a single piece of writing. For example, CrowdForge [21] creates written content by asking workers to complete tasks like preparing an outline, gathering facts, and writing simple prose. Soylent [1] divides editing projects into stages and uses crowd workers to suggest content, shorten text, and proofread. Ensemble [19] uses a team leader to direct writing projects. By using the complementary writing skills of different crowd members, the authors find that writers can produce better content in less time. Similarly, WearWrite [29] uses microtasks and the crowd to make it possible to write a paper through interactions from a watch. Little et al. [25] find that workers who perform writing tasks serially produce better content than workers who perform the tasks in parallel. Mechanical Novel [20] demonstrates how the crowd produces better quality stories by decomposing a high level goal identified during the reflection phase into smaller sub-goals during the stages of revision, compared to a traditional iteration pass.

While prior work supported microwriting by the crowd, this work support microwriting by individuals. Additionally, crowd work tends to be done in a session, while Play Write tasks are designed to be interleaved with other tasks. Play Write microtasks are generally completed by the document author, who has background knowledge of the underlying content and owns the outcome. Play Write also differs from previous systems in that it looks at microwriting in a mobile context. The only other system that we are aware of that does so is the MicroWriter [36], which decomposes writing to distribute the component tasks to collaborators across mobile and desktop form factors. This distribution enables users to create new content while mobile. In contrast, Play Write tasks are limited to editing because the system is designed to be used only by a single mobile user. Play Write extends existing microwriting work by looking at a different paradigm for task creation (automated extraction) and task completion on a different form factor (phone).

Microwriting Practices

To inform the design of Play Write, we also interviewed and surveyed writers about their current writing practices. An informal interview session with professional writers revealed that they rarely used mobile devices for writing

Stage	Description	#	%
Outlining	Generating ideas, creating a draft structure	7	6.6%
Creating	Expanding on the initial ideas and structure	21	19.8%
Revising	Revisiting content, reorganizing, restructuring	37	34.9%
Finalizing	Copy-editing, rewording, fixing mistakes	24	22.6%
Finishing	Putting the final touches in place	17	16.0%

Table 2. The stage of the document participants last edited.

but would benefit from a micro-editing tool to copy-edit text from their phones after a few rounds of initial drafts. We then conducted a survey to understand how people currently write and to learn what editing tasks would be useful to implement in a mobile micro-editing tool.

A randomly selected sample of 106 regular Microsoft Word users (M=75, F=31, Age=35-74) from a large technology company participated in the survey. The survey questions focused on their current practices of document editing and insights on how they allocate their time around different editing stages of a document lifecycle (see Table 1).

Consistent with what we found when interviewing writers, the survey revealed that very few of our participants (9/105) wrote or edited documents while mobile using the mobile version of Microsoft Word despite having easy access to the documents on their mobile phones. Documents at the respondents' company are typically stored in the cloud, so the full document is usually readily available in the mobile editor. Only 10 people felt that it would be easy to edit a document from their mobile devices; the mobile editing tools currently available are not be well suited for the small screen and limited attention contexts.

We also asked respondents to consider the last document that they edited in Microsoft Word. For that document, we asked them what stage the document was in (see Table 2). Most documents were in the *Revising or Finalizing* stage. When asked to describe the next edit they expected to make to their document, 37 (35%) of participants said they did not know. These participants may benefit from a system that helps them identify what to do next.

Of the remaining 69 participants, most (34) were in the *Creating* content ("expand the outline with more detail") or *Revising* it ("improve key bullets") stage. Relatively few (5) dealt with structural aspects (e.g., "reorganizing the structure of the document"). More (19) dealt with relatively contained tasks that are probably easy to start with [3], such as spelling, grammar, formatting, and simple updates to headings and titles. Twelve of the replies from participants mentioned explicitly dealing with comments, feedback, or tracked changes. Most of next steps people mentioned reflected an interest in incorporating other people's feedback, including making changes based on feedback and "triaging," "reviewing," and "responding" to the comments other people had left in the document. However, some participants mentioned "revising" and "adding" comments, and in one case someone mentioned that she planned to deal with the comments she had previously left herself

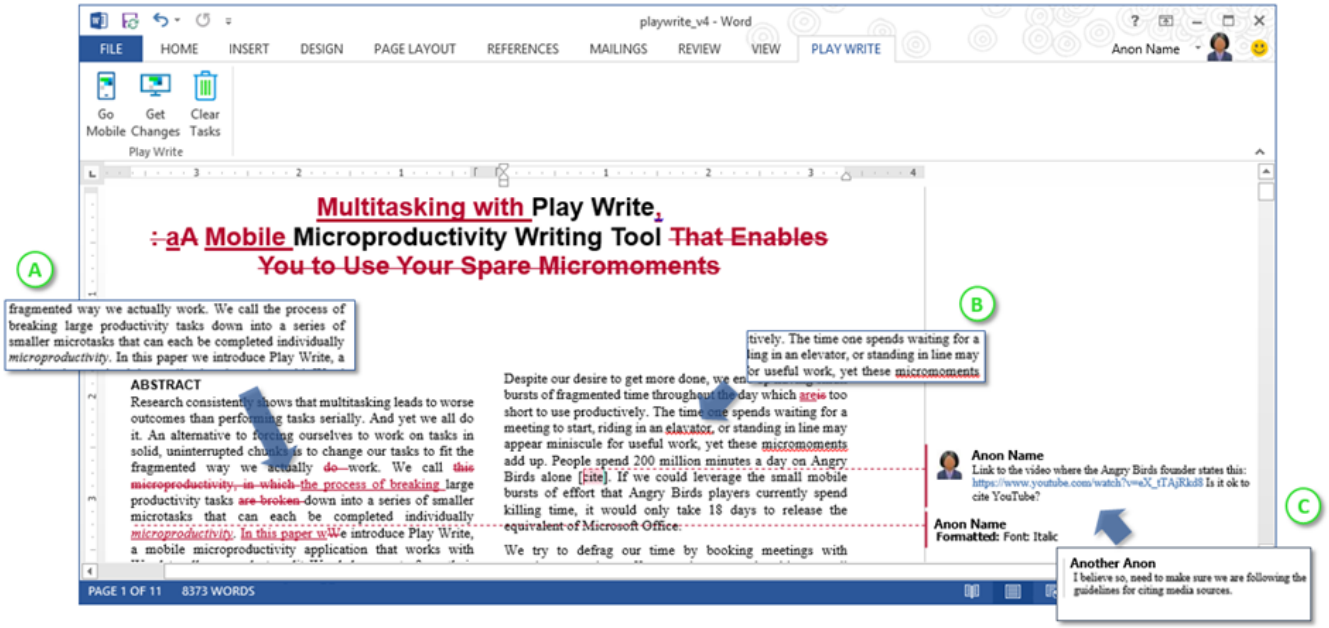

Figure 1. The Play Write Word plugin displays buttons that allow users to extract tasks from the document and send them to the server (*Go Mobile*), and then pick up the changes that are made from the Play Write mobile app (*Get Changes*). For example, the user may pick up an accepted change (A), a spelling correction (B), and a reply to a comment. This example is drawn from real edits we made to this document using Play Write while attending a research talk.

("Address comments I left in the document to remind myself what I need to follow up on with additional detail").

Taken together, responses from the survey suggest that a mobile system that supports simple editing tasks that are often ignored in a larger document could be a useful complement to existing editing practices. Based on the replies we chose to enable tasks like spelling and local grammar correction, sentence revision, comment triage, and the acceptance or rejection of changes as our initial set of writing microtasks. These microtasks mostly belong to the 'Finalizing' and 'Finishing' stages shown in Table 2 which are better suited for the mobile environment than the earlier stages of 'Outlining,' 'Creating' or 'Revising.' While there are many other editing tasks from the 'Finalizing' stage that we could have included (e.g., adding a citation or fact checking) we felt this initial set was sufficient to provide some initial insight into mobile microwriting behavior.

THE PLAY WRITE SYSTEM

The Play Write experience works as follows: First, users create Play Write microtasks from an existing Microsoft Word document on their desktop by clicking a *Go Mobile* button that is surfaced in Word via a plugin (see Figure 1). The button click causes the plugin to parse the document, extracts actionable text from the document, and stores that text in the cloud. A workflow engine then extracts and sequences microtasks from the actionable text, with the text sometimes producing multi-step or conditional series of microtasks. After this happens on the server, the user gets a push notification on their phone indicating new Play Write tasks are available. Users complete these tasks through the Play Write mobile app (see Figures 2 and 3), which returns the output of their actions to the workflow engine through a REST API and stores them on the server. When the user later opens the source Word document from their desktop, they can chose to integrate the work they did while mobile back into the document by clicking the *Get Changes* button provided by the Word plugin.

Based on the feedback from the survey, Play Write exposes the following microtasks on the mobile app: fixing spelling errors, identifying wordy sentences, simplifying text by deleting words, accepting or rejecting changes, and addressing comments. We describe each in detail after first describing each of the Play components: the Word plugin, the workflow engine, and the mobile application.

Play Write Word Plugin

To interact with a user's document, the Play Write system uses a Word plugin that extracts editing tasks from the document and integrates the results of mobile edits into the document. Word provides an API for navigating and manipulating the document structure. Text, spelling errors, tracked changes, and comments are provided as objects through the API. The plugin adds three buttons to the toolbar – that enable the user to *Go Mobile*, *Get Changes*, and *Clear Tasks* – but no additional UI otherwise.

When the user clicks the *Go Mobile* button, the plugin interrogates the API to discover actionable text. Some content, like spelling errors, maps directly to microtasks that the end-user sees. Content requiring additional analysis is processed by the workflow engine. Integration of changes to content resulting from microtasks completed in the

mobile app is initiated via the *Get Changes* button. Figure 1 illustrates the Play Write Word experience.

There are many challenges with processing text in Word documents. For one, text that appears in the Word UI as a contiguous block of text often consist of multiple distinct runs with formatting properties, inline images, tracked changes, and more. Word does not include built-in methods for uniquely identifying a block of content, so we implemented logic to infer this.

Another challenge is that after a user has "gone mobile," they or a coauthor may modify the document text even though actionable text has been extracted for mobile editing. To address this the plugin wraps a region of actionable text that has "gone mobile" with an invisible bookmark; these bookmarks can bracket regions of text that cross run, sentence, and even paragraph boundaries. When incorporating user changes, the plugin verifies that the current content in the bookmarked region matches the original content on which the user acted. If they do not match the system lets the content in the document stand, rather than going forward with a potentially onerous merge process. For example, suppose the system discovers a block of text inserted with change tracking on. The user takes action in the mobile app to accept the change. However, in the time between going mobile and acting in the app, this block of content changed again. It is not clear whether a user action (accept) on the original change still applies. On the other hand, if a spelling error moves globally in the text because words were inserted in the beginning of the document, the erroneous text still exists – in this case the spell correction task in Play Write would remain valid.

Workflow Engine

The actionable text extracted by the Word plugin is stored and processed in the cloud using cloud storage and computation. Each item stored on the server consists of the original document text, the bookmarked location of the text, additional text surrounding the source that can be used for context, and tracking information about the state of the text. A REST API exposes these data to the app and the Word plugin. We use an OAuth provider to authenticate users and we encrypt content in the cloud store.

The server component is implemented as an event driven workflow engine that extracts and manages microtasks from the actionable text, similar to the workflow engine used by Calendar.help [6]. Since the actions a user needs to take on a piece of text may consist of multiple subtasks, the workflow engine builds a dependency graph and ensures that the subtasks are executed in the right order. The subgraphs pause when input is needed from the user or an asynchronous process, and resume when the dependencies are satisfied. Depending on user action or algorithm output, the downstream task graph may change or terminate early.

Some microtask workflows use only the originally discovered content plus user action to create modified content. Other, more complex workflows use machine learning models to suggest text improvements, which are then decided by the user.

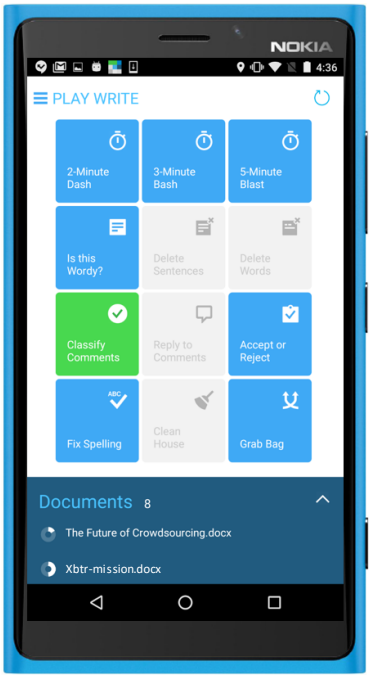

Figure 2. The Play Write home screen. Tiles correspond to time-bound or category-bound sets of tasks. The intensity and hue of each tile varies to indicate completion progress.

Play Write Mobile Application

The Play Write Android app is the core of the microtasking user experience. When the task graph reaches a state requiring user input, microtasks become available in the mobile app. The server pushes notifications to the app to alert the user to task availability. In the reverse process, user actions are pushed to the server via the REST API, feeding the task graph and eventually becoming available for incorporation into the original document.

Play Write Editing Home Screen

Microtasks are grouped and displayed to the user as a set of action tiles (Figure 2). Each tile on the home screen represents a set of microtasks. To complete tasks, the user selects a tile. Each tile is either time-bound or category-bound. For time-bound tasks, the user races against a clock to complete as many tasks of in all categories as quickly possible in the time allotted. For category-bound tasks, only tasks of the selected category are shown. By making the use of time explicit through the interactions, users are made aware of how they are able to use their micromoments. Additionally, the home screen provides ambient awareness of category completion by varying the color and intensity of the tiles. The darker the tile, the more tasks of that category are available; a green color indicates recent completion of a set of tasks in a category.

Finally, a pop-up drawer (shown in the bottom part of the home screen) shows the different documents that the user is working on and the progress the user has made through

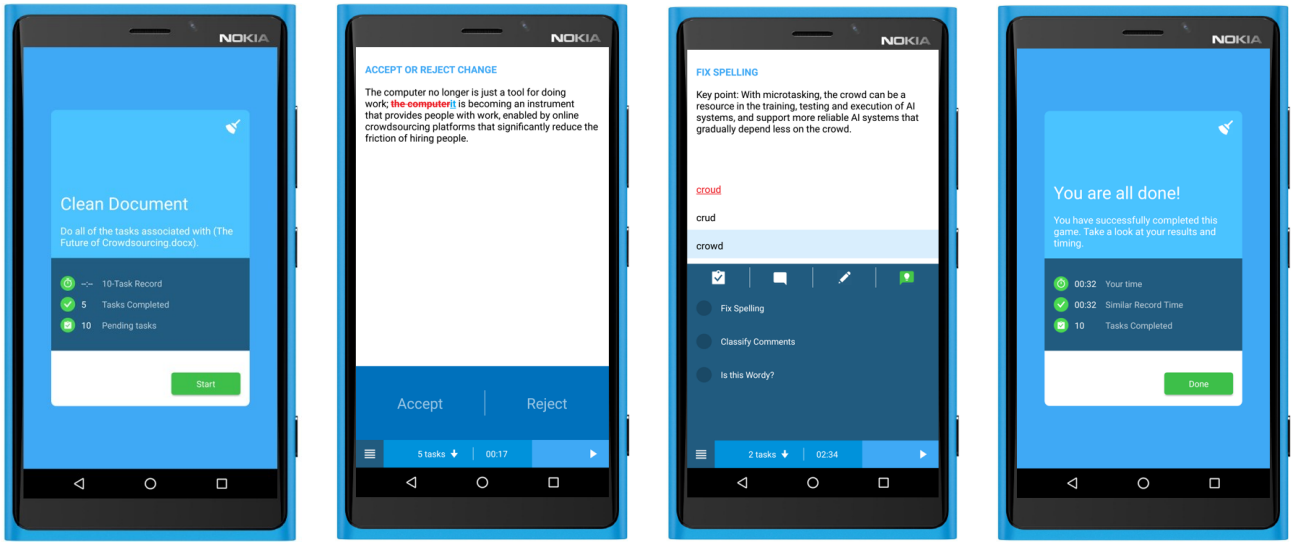

Figure 3. A Play Write game with some example tasks.

each document. Figure 2 shows a sample home screen with multiple active documents and sets of tasks.

Play Write Editing Tasks

Once a user clicks on a tile they are shown instructions and a series of microtasks, as shown in Figure 3.

Fix spelling: Spelling errors in the document are extracted and presented with alternative suggestions. Individuals may also enter a custom spelling if none of the presented alternatives were correct or retain the existing spelling.

Identify wordy sentences: Sentences over a fixed length are marked as possibly too verbose. A task is created asking a user to evaluate the verbosity of the sentence. If users respond yes, the task spawns a "Delete Words" microtask.

Delete words: A sentence that was marked as being too verbose is then sent to a natural language processing system where parts of the sentence are marked as candidates for deletion (while still preserving the meaning). A user is presented with these altered sentences who decide which alternative sentence, if any, they desire.

Accept or reject a change: This task shows pending changes created using change tracking for a document. Changes are shown on a sentence by sentence basis, and a user may choose to either keep or reject the change.

Classify comments: Comments are shown as individual tasks. A user can either acknowledge the comments as an FYI, delete the comment, or indicate that it requires a response; the final option spawns a new microtask.

Reply to a comment: If a user selects the reply option in the classify comments task, a new task is created in which they could write the reply. This task appears immediately after the classify comments task, and the user may skip the task if they did not want to write the reply at that moment.

User use the buttons at the bottom of the screen to navigate through the tasks. The right arrow brings up the next microtask. The hamburger icon on the left offers a list of related microtasks should user not want to follow the application's default navigation. This contextual menu (accessed through the row of icons in the third screenshot in Figure 3) allows users to do additional related tasks as described below.

Edit text: Directly edit the text.

Add a comment: Add a comment to any text.

Mark as to-do: Users can also turn a comment into a custom to-do task. Rather than having the comment produce a triage task, any comment that begins with the string #todo would be extracted into a custom task. The text in the comment would become the instruction for the to-do. In the task, the user may edit the text of the section directly, reply to the to-do for later processing, or delete the to-do.

Provide feedback: Provide feedback about the tool.

EVALUATION

We conducted a lab study to compare the experience of using Play Write to microedit a document with the more traditional mobile editing experience of using Mobile Word for Android. Mobile Word replicates the features one can access on the desktop version and is adapted to fit in the mobile form factor. Its user interface is shown in Figure 4.

Most mobile phone use occurs in divided attention contexts, where other tasks simultaneous compete for the user's attention. To simulate this in the lab, we asked participants to edit a document from their mobile phone while watching a video on their laptop, with the video serving a proxy for a continuous attention task. Both the document and video were fixed. By conducting a controlled study where all users watch the same video and edit the same document, we were able to reduce confounds and make a direct comparison of the two editing experiences. This allowed us to observe how participants engaged with editing tasks on their mobile device while engaged in another task, and

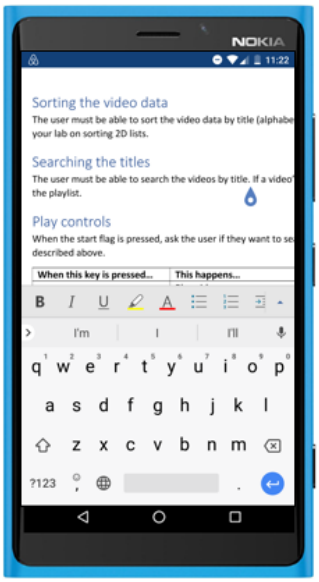

Figure 4. The Mobile Word editing interface on Android.

build a picture of the contexts in which microediting might be useful as compared to traditional editing.

The study used a within-subjects design with the editing app (Play Write, Mobile Word) as the factor. To make the conditions comparable and because we were primarily interested in quick edits in a mobile usage scenario, we only compared the Play Write Mobile app interactions to Mobile Word interaction (i.e., we did not compare the Play Write edits to edits one does in a traditional desktop setting). The same set of editing tasks were prepopulated for both conditions – as microtasks in the Play Write app, and as tracked changes, typos, and comments in Mobile Word.

Participants

Sixteen people participated in the study (M=11, F=5). Participants worked for a large technology company and were experienced with editing documents on Microsoft Word. They had little to no experience editing documents on their phones, with only one reporting that he/she used a mobile phone for editing documents. In a pre-study questionnaire asking the same 'general editing' questions reported in the motivation section, we found no significant difference in the replies given by the lab study participants as compared with those by survey participants.

Experimental Task

In each trial participants were asked to watch a video on their laptop while editing a Word document on their phone. They were instructed to attend to both tasks, and told their performance would be evaluated by how well they edited the document and how well they answered comprehension questions from the video. In one trial users used Play Write for editing and in the other they used Mobile Word. The order was counter balanced across users.

Video Watching Task

For the video watching task, we identified two light-hearted videos from the "Annoying Orange HFA" series. Each video was 11 minutes and 22 seconds long. While the videos have millions of views on YouTube, we confirmed that none of our participants had seen them before. We identified three transition points in each video to create four segments of roughly equal length. We then inserted three 30 second advertisements at each transition point. This was done to provide participants with several clear instances where they could ignore the video watching task if desired.

To ensure participants attended to the videos while editing, we created comprehension questions that we asked at the end of each trial. Questions were multiple-choice, with one correct answer and four incorrect answers. For example, one question asked, "For what crime does the Annoying Orange make Apple walk the plank?" The answers included: "Eating a blueberry," "Talking too much," "Not laughing at Orange's jokes," and "Being mean to Marshmallow," and the correct answer, "Being an apple."

The questions were selected iteratively: we first generated 12 per video, three for each segment so that the questions drew from the beginning, middle, and end of the videos. To ensure that the questions could be answered by someone who had watched the video but not guessed, we asked between 8 and 22 people to answer each set of questions after having either seen or not seen the video, collecting answers from total of 62 randomly selected people drawn from the same population as the study participants. We then removed the question for each video segment that was easiest to guess without watching the video. For segments where none of the questions were easily guessed by people who had not seen the video, we removed the answer that people who had seen the video got wrong the most. This resulted in a set of 8 comprehension questions for each video. People who had watched the video got these questions correct an average of 89% of the time (min: 73%), and people who had not watched the video got them right an average of 25% of the time (max: 38%). At the end of both trials we also asked participants to provide a free text list of the advertisements they remembered as being shown during the videos.

Document Editing Task

For the documents, we selected two articles on Wikipedia from the 'Wikipedia articles needing copy edit' category. The topics of the articles were similar – one focusing on 'Public Speaking' and the other on the topic of 'Rhetoric.' We preselected the documents to maintain consistency across users and so that we could ensure that the documents were of similar quality across the two conditions. To ensure that the articles had enough editing requirements, we manually inserted spelling and grammatical errors, comments, and edits that showed up as tracked changes resulting in around 190 potential edits for each document. This ensured that the participants would have enough editing tasks for the 13 minute time span of the video.

Protocol

Upon arrival participants filled out a pre-study questionnaire about their general editing practices, similar

	Play Write	Mobile Word	Same
Which method did you prefer for editing in this particular setting?	13	3	0
Which method made it easier to resume the editing task when you came back to it?	11	0	5

Table 3. The number of participants who preferred Play Write, preferred Mobile Word, or thought them to be the same.

	Play Write		Mobile Word		
	Mean	S.D.	Mean	S.D.	Sig
It was easy for me to edit the document on my phone	3.00	1.15	1.125	0.34	**
It was stressful for me to edit the document	3.31	1.14	4.44	0.73	**
At the end of the video, I felt more productive than I would have just watching the video	2.88	1.31	2.00	1.10	*
I felt that the editing task was negatively impacted because of the video	3.75	1.29	4.38	0.81	*
I felt that the editing task detracted from watching the video	4.25	0.93	4.50	0.89	
I could easily switch back and forth between editing and watching the video	2.75	1.24	1.81	1.05	**

Table 4. The post-trial responses given to statements on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). Significant differences are marked with a * (p<.05) and strongly significant differences (p<.01) with a **.

	Play Write		Mobile Word		
	Mean	S.D.	Mean	S.D.	Sig
Number of correct answers to questions about the video task	5.63	2.28	5.06	1.88	

Table 5. The mean number of correct answers to the questions we asked about the video watching task. The difference is not significant.

to the one used in our survey (see Table 1, top section). They were then given an overview of the study. To familiarize them with Play Write and Mobile Word they were given 3 to 5 minutes to interact with both applications with a practice document. This was followed by two experimental trials, one for each editing tool. Each trial was followed by a questionnaire that asked about the video they had just watched (as described in the previous section) and how they felt about their editing experience (see Table 4). Finally, at the end of the study, they filled out a questionnaire about which system they preferred and were asked to provide general feedback on both editing tools.

RESULTS

Overall Play Write was overwhelmingly preferred to Mobile Word for the divided attention scenario we studied, with 13/16 participants preferred Play Write to Mobile Word (Table 3). We now look in detail at the document and video editing experiences for each tool, as well as our participants' experience switching between the two tasks.

Document Editing Performance

Consistent with prior work [8, 11], participants found it hard to edit a document while watching a video. However, they preferred Play Write over Mobile Word in terms all of the metrics we measured. Table 4 shows the replies participants gave to the post-trial questionnaire where they were asked how they felt about their editing experience for that trial. Responses are based on a Likert scale from 1 (strongly disagree) to 5 (strongly agree).

Fifteen participants found the Play Write tasks useful given the time constraints that they had for the study. Nonetheless, while using Play Write they were neutral (M=3.00, S.D.=1.15) about how easy it was to edit the document from their phone, and inclined to agree that it was stressful (M=3.31, S.D.=1.14). They also slightly disagreed that they felt more productive by editing the document while watching the video (M=2.88, S.D.=1.31), and most agreed that watching the video negatively impacted the editing task (M=3.75, S.D.=1.29).

In all of these cases participants reported a significantly worse experience with Mobile Word. With Mobile Word they strongly disagreed (M=1.125, S.D.=0.341) that editing was easy ($t(15)=6.23$, $p<0.0001$) and strongly agreed (M=4.44, S.D.=0.73) that the experience was stressful ($t(15)=5.084$, $p<0.0001$). They also felt significantly ($t(15)=2.2$, $p<0.05$) less productive (M=2.00, S.D.=1.10), and were more likely to think ($t(15)=2.076$, $p<0.03$) watching the video negatively impacted their ability to edit (M=4.38, S.D.=0.81).

Participants edited more of the document using Play Write. They completed an average of 55 Play Write tasks while watching each video, as compared to an average of 28 edits with Mobile Word. (One participant's Word document failed to save, and was excluded from the above analysis.)

Compared to Mobile Word, participants reported finding the Play Write tasks better suited to a small screen and the divided attention environment in which it was studied, as the tasks could be completed quickly with limited context. However, they noted that the limited context made it difficult to complete edits that required more focused attention, and Mobile Word appeared more suitable in these cases. One participant, for example, said, "The context I got through Mobile Word by seeing more of the document helped me move faster when not focused on the vid[eo]."

Video Watching Performance

Participants reported that the editing task detracted from watching the video for both editing via Mobile Word (M=4.50, S.D.=0.9) and Play Write (M=4.25, S.D.=0.9),

and the difference is not significant. However, despite the reported difficulties, participants were still able to attend to the video. This was demonstrated in their performance in answering the video comprehension questions. On average 5.06 (out of 8) questions were answered correctly for Mobile Word (S.D.=1.88) and 5.63 questions were answered correctly on average for Play Write (S.D.=2.28). The differences across the two tools was not significant. For comparison, people who watched the videos while not editing got an average of 7.12 questions correct, and those who answered the questions without watching the video got only 2.00 correct.

Multitasking Performance

In addition to looking at participants' performance with each task individually, we also looked at their ability to switch between the two tasks. As reported in Table 4, participants generally disagreed that they were able to switch easily between the video and the editing task, though they were significantly more favorable ($t(15)=3.03$, $p<0.01$) towards Play Write (M=2.75, S.D.=1.24) as compared to Mobile Word (M=1.81, S.D.=1.05). Additionally, 11 out of the 16 participants felt it was easier to resume editing with Play Write when switching back from the video, with the remaining five finding the resumption experience similar across the two tools (see Table 3).

The limited context needed for the Play Write tasks seems to have facilitated resumption of edits when users switched away from the video. One participant, commented that Play Write "[a]llowed faster switching - e.g. didn't have to find my place in the document and reorient myself." Another participant summarized the experience by saying, "While still sub-optimal, if I had to do both at once, PlayWrite at least helped me focus on one or two editing tasks at a time, and I didn't have to worry about losing context and searching for where I left off as in the Mobile Word case."

To understand task swiching between editing and video watching, we asked participants to share the strategies that they used. Most (13 out of 16) prioritized editing, switching to the video when something in the audio caught their attention or processed the audio as they focused on the editing task. One participant remarked, "[T]o optimize for editing I focused on easy tasks like spelling corrections and deferred harder tasks like responding to comments. I also waited for dull moments or commercials to focus more on editing and go faster. [W]hen there was interesting plot moments, I slowed down the editing. I don't have a good overall sense of the document while watching a video, so I focused on local low level tasks."

Other participants prioritized the video watching. One of these participants highlighted their use of micromoments to complete quick editing tasks by commenting, "I'd watch some of the scene, then glance over at the phone. When the phone task was easy, I'd do it in a few seconds." Several participants reported using the commercial breaks to complete editing tasks, as they could edit then without having to worry about missing parts of the video.

When Play Write May Be Useful

When reflecting on situations where they might imagine using Play Write, participants mostly agreed about not wanting to do complex editing tasks on a mobile device, saying they wanted to defer edits that required significant cognitive engagement to a large block of time where a larger screen and keyboard would be available. However, participants noted a number of scenarios where they felt Play Write, and more generally, the concept of micro-editing would be suitable. This included while on the go (e.g., "waiting for a bus") or when they had a few seconds to do something without the need for deeper engagement.

Participants felt that light weight tasks such as correcting spelling and simple grammar errors were ideal for Play Write, and some felt that tasks as comment triage and even accepting or rejecting changes required the larger document for both context as well as required time to complete the task. Some participants wanted to flag certain tasks for follow up on the desktop later, indicating that the tool would be suitable for triaging or creating to-dos.

Summary

In summary, we found that participants preferred Play Write over Mobile Word for editing documents while also watching a video. Participants completed more edits using Play Write and felt slightly more productive using Play Write compared to Word. While both experiences were challenging, participants found Play Write comparatively easier to use for editing, and less stressful, and that their ability to edit was less negatively impacted by the video watching task. Although editing detracted from watching the video, participants were still able to answer more questions about the video than randomly guessing. Most found task switching easier with Play Write. Mobile editing while multitasking appears to be valuable for simple tasks that did not require a lot of context to complete.

DISCUSSION

In a world of fragmented attention and rapid task switching, finding large blocks of time to accommodate traditional ways of being productive is challenging. Play Write provides an opportunity to use micromoments to complete microtasks that contribute towards a larger productivity goal without a large time commitment, even when the user is engaged in another task. Our evaluation of the system was geared towards understanding how well it supports the aforementioned goal. However, there were limitations to the study. In order to control for task, we conducted the study in a controlled laboratory setting using documents that did not belong to the participants. This means that they had limited awareness of the overall content; personal documents might have been easier to edit. Additionally, the videos we showed contained simple content that was not necessarily of immediate interest. More complex or compelling video content might have yielded different editing patterns. Nonetheless, there are a number of lessons that can be taken from the evaluation when considering the development of microproductivity applications.

For our particular setup of editing a document while watching a video, we did not find many instances where participants leveraged small breaks. Instead they tended to batch the microtasks while also consuming the video, and only occasionally switched their attention solely to the video. However, as suggested by previous research [4], Play Write microtasks were more resilient to such task switching (e.g. in terms of task resumption) than the more traditional macro-editing tasks done via Mobile Word. For future evaluations, we would like to study Play Write use *in situ* to get a sense for how it is used in true instances of micromoments. In situations where attention is divided, perhaps microtasks are the way of getting small, bite sized tasks done with minimal disruption to other tasks.

We compared two mobile interfaces in a divided attention scenario, but did not compare the quality of edits. While we feel that this is a necessary next step, especially to understand how edits made in short bursts affect the document quality when integrated back, we wanted to focus on the experience itself in this initial evaluation.

While Play Write presents microtasks that could be completed with limited context, in practice we found that apart from spelling and grammatical corrections, microtasks like triaging comments, shortening, and accepting and rejecting changes sometimes required more context than Play Write provided. This is an interesting challenge, as our design goal was to provide the minimal information needed so as to not overwhelm the user. It is certainly possible to embed more context in the microtasks [33]. On the other hand, prior work has shown that the absence of context encourages more creative outcomes [38]. Future work will look at how to identify and incorporate microediting tasks into Play Write that require creativity.

Regardless of the amount of context we provide, Play Write currently seems unlikely to ever fully support the range of editing that people are used to in their desktop editing experiences. For that reason, we see Play Write being best used as a complementary mobile editing experience to what people are used to on their desktop environment. While focused editing is not seen to be suitable in an environment with limited screen space and limited attention, micro editing tasks can provide people with the opportunity to complete a few short edits in quick bursts.

The editing tasks Play Write currently supports was motivated by prior work, and our pre-study survey. While we were unable to validate that the tasks would be actually useful for users to do in real life settings, we can extend the system to generate a larger variety of microtasks. While Play Write is constrained by the depth of engagement and length of time it provides users for each task, future work will look at how we can decompose any editing microtask into a series of microtasks that can be completed in short bursts, or as a small batch. We are currently investigating other relevant editing microtasks such as *adding a note* (which many writers report to be one of the most common tasks they perform while they are mobile) and creating new content. We are also exploring how to allow users to specify their own microtasks while writing or automatically create microtasks from complex editing tasks using a pre-determined vocabulary [18], which could be then resurfaced at a later time. This can allow users to create to-do items for the future, which they can continue on their mobile device in a different environment. Deferring mundane writing tasks until a later moment may also enable users to maintain flow while writing on the desktop.

While Play Write presents microtasks on a mobile device to leverage micromoments, they could be surfaced in other contexts to yield added benefits. For example, microtasks can be used in desktop editing as a way to get people started or build context [3], a task that writers reported to be challenging. Microtasks can also be used to disengage people from work at the end of the day and help them reengage the next day through a few short interactions, eventually positively impacting productivity [40].

We studied microproductivity in the context of individual writing, but it has the potential to change shared work practices as well. Microediting tasks can be shared with collaborators who have context, or even crowd workers with no context, e.g. for tasks such as providing feedback [24]. This can reduce the editing burden on the user and provide expert help for specific editing needs. There is also opportunity to leverage automation for some microtasks, creating a pathway for integrating artificial intelligence into productivity tasks that are currently impossible to automate when considered as complete tasks. Additionally, personalized models can be learned from the data that is collected as people perform them.

Despite its current shortcomings, we believe that Play Write, and, more broadly, the concept of microtasking is potentially disruptive to existing work practices [37]. While our participants do not currently imagine writing while mobile in short bursts of time, applications like Play Write may, over time, encourage them to start thinking differently about how to be productive given limited attention that is stretched in multiple directions. Thirteen out of our 16 participants reported preferring having a solid block of time for editing, yet after using Play Write 15 out of 16 felt that the system presented a useful editing concept.

CONCLUSION

We present Play Write, a mobile microproductivity tool that works with Word to allow people to edit documents from their phone via microtasks. Common document editing tasks are broken down into microtasks and presented to the user in a low-context manner so that documents can be edited in short bursts of time while mobile. We discussed the system and showed from a lab study that users found Play Write easier to use for mobile editing than Mobile Word while attending to another task. Microproductivity tools like Play Write can help people find a significant amount of hidden productive time in their day.

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