# How Time Constraints in a Creativity Support Tool Affect the Creative Writing Experience

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## ABSTRACT

Being able to write 'on cue' is critical in text-based, creative domains, since time is often a limited resource. Although numerous digital-interactive Creativity Support Tools (CSTs) are available, writing applications with features to support creative writing as a time-constrained activity have scarcely evolved since the 1960s. This is striking, since studies show that time constraints may benefit creativity. We present an exploratory survey-based, qualitative user experience study of how a writing application prototype designed to accelerate text production by imposing time constraints affects a creative writing task among high school students ($n$=45). Using thematic analysis, we report how implicit and explicit time constraints built into the GUI (graphical user interface) influence how users experience time pressure and the quantity vs. quality, initiation, and revision of their creative writing process. We discuss how writing applications may develop to incorporate time constraints to support creative writing, as well as the need for increased tool literacy.

## CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in interaction design**.

## KEYWORDS

Creativity, Creative Writing, Time Constraints, Creativity Support Tool (CST), User Experience

## 1 INTRODUCTION

One of the most widely embraced Creativity Support Tools (CSTs) is the writing application known as the *text editor*, which is the digital 'go-to tool' in most text-based creative professions. Over the years, text editors have attained a near-canonical status in the Human-Computer Interaction (HCI) community. This can be traced back to Douglas Engelbart's landmark demonstration of a complete computer hardware and software system, the oN-Line System (NLS), at the ACM/IEEE joint computer conference in San Francisco, California. In 1968, Engelbart presented the 'mother of all demos'–an exposition of most basic components of a modern computer, from windows, graphics, and hypertext to input devices (the computer mouse) and word processing. Although this 90-minute demo inspired numerous new ideas and inventions in HCI, it is remarkable how little the screen-based text editors have changed since. While text editors such as Microsoft's Word (released in 1983 as Multi-Tool Word) remain among the dominant applications for desktop computing, HCI research has generally treated this type of applications exactly as they have been marketed–as tools for text processing, especially editing. Hence, the appellation *text editor* or *word processor*. Although these feature-rich

CSTs afford the (often single) user many functions pertaining to text editing, the question is how well these tools serve the arguably more *creative* part of the writing process–the actual writing of text. This has received less attention in HCI. While general patterns of how people edit text are less complicated to observe and design for, how they write is much more individualized [34]. This makes it more difficult to design appropriate CSTs. Another challenge for creativity-oriented HCI research is the fact that only a minority of CSTs designed by HCI researchers are thoroughly informed by leading creativity research as a requisite for defining the focus and delimitation of the CST, including the aspect of creativity that the CST attempts to support [16, 17].

A creativity theme that has gained some attention in HCI research is the role of constraints, particularly *time constraints*, in creative processes. Still, exactly *how* time constraints affect creative writing has not been studied in any great depth. This lacuna is surprising, as creative writing in art, science, business, and education rarely matches the long-lived idea from Romanticism, which suggests that creation entails a divine element and happens *ex nihilo* while writers "passively rely on inspiration to hit them whilst they ponder a blank page" [8, p. 329]. Conversely, most people working with creative writing today must deliver chunks of text within a (very) limited time frame. This can owe to professional domain expectations, e.g., a journalist who must complete a 200-word feature piece before deadline, or personal circumstances, e.g., a parent who due to a demanding work and family life can only write in small pockets of time. In any case, the notion of pure, boundless "'freedom to create' is [...] an illusion" because "constraints are at the heart of the creative process. They govern the generation of ideas, and they provide criteria for the evaluation of ideas. Without constraints, there is no creativity" [21, p. 532]. This insight makes it relevant to study how time constraints affect a creative writing process where the participants must not just write 'on cue,' but literally face time constraints vis-à-vis the writing application they use to accomplish the creative writing task.

We pose the research question: *How do participants engaged in a creative writing task experience different implementations of time constraints in a writing application prototype?* As an *exploratory, survey-based, qualitative user experience study,* our work builds upon dissimilar visual implementations of time constraints in the GUI (graphical user interface) of a writing application prototype developed at our interaction design research lab. The first variant of the prototype, *Ryng*, features an *explicit* representation of time constraints in the form of a countdown timer surrounded by a colored ring that disappears in a clockwise direction with every passing second until it is complete. The other variant, *Phade*, conveys *implicit* time constraints by making the written text fade as time progresses. To study how time constraints in this writing application prototype affect the experience of writing 'on cue,' we conducted a survey among high school students (n=45), who were individually asked to undertake a creative writing task using prompts. This is a standard study design in creativity research [25]. The creative writing task was supplemented by a qualitative, online survey with pre- and post-task questions. The World Economic Forum stresses creativity as an essential skill for the 21st century's workforce[1]. This importance is mirrored in education [37] where creative writing has proven a relevant venue for enhancing creative competences in general [1, 4] and among students in particular [13, 29]. In order to get rich qualitative data, we contacted an academy for gifted high school students, since we knew, based on a previous research collaboration, that they would be interested in taking part in such a study. We analyzed the data using thematic analysis and report here on the most important user experience insights into how explicit and implicit time constraints built into GUI affect how users experience time pressure and the quantity vs. quality, initiation, and revision of their creative writing process. We consider these insights the paper's *main contribution*, which we discuss and reflect upon in terms of implications for future design of writing applications as an important type of CST.

## 2 BACKGROUND

### Creativity Support Tools (CSTs)

The interest in creativity in HCI has increased significantly over the past decades [16, 17], and developing tools to support human creativity, so-called 'Creativity Support Tools' (CSTs), has been proposed as "a grand challenge for HCI researchers" [36, p. 1]. In the late 1990s, *creativity* became a key theme in HCI with Fischer [15] arguing that "Computers have the potential to be creativity enhancing tools" [p. 235]. More critically, Fischer added that "most of the current systems have not lived up to these expectations–they have restricted rather than enhanced creativity" (ibid.). The variety of CSTs in HCI is now very wide. As discussed by [16], CSTs are designed to augment various aspects of creative activities, e.g., by lowering the threshold of domain or technical skills necessary to accomplish a creative task, or by offering inspiring materials and stimuli to a creative process in order to help reach a more creative outcome. In such processes, time limits are usually a critical factor. Although time constraints may often be seen as detrimental to creativity, this understanding is inadequate, since research has shown that time constraints can indeed evoke creativity.

## Time constraints in creative processes

Creativity research has established that constraints serve a dual role in a creative process in the sense that "constraints on thinking do not merely constrain, but also make certain thoughts–certain mental structures–possible" [6, p.58]. So far, time constraints specifically have received most scholarly attention. In ideation, [30] found that "the controlled application of [...] time constraints can increase productivity and creativity within design idea generation" [p. 1]. In a prototyping experiment, [14] concluded that when working under time constraints, "rapid iteration yields more valuable design insights than allocating that time to a single iteration" [30, p.172]. Similarly, [23] observed a positive relationship between industrial design creativity and short-term time pressure. Although these and other studies point to the benefit of imposing time constraints, other studies have shown that time constraints, as might be expected, can also impede creativity.

In a study on information search [11], participants working under severe time constraints "experienced higher task difficulty, less satisfaction with their performance, increased importance of working fast and engaged in more metacognitive monitoring" [p. 141]. Also, [35] saw that time constraints led to fewer design solutions, so "if one is looking for creativity and an unusual design, then [...] it is necessary to keep the cost and task inherent constraints to a minimum" [p. 233]. In a study on how task constraints affect inspiration search strategies, [5] proposed the idea of a 'sweet spot' of constraint pressure–neither too little, nor too much–as an inverted U-shape, which would seem applicable to time constraints as well. This would be in accordance with [9], who argued for a curvilinear relationship between stressors and creativity, and also with [3], who emphasized the need for moderation of time constraints if they are to be conducive to creativity. In a study on analytical vs. synthetic problem solving (the latter refers to creative thinking), [26] noted that time constraints affect analytical problem solving negatively while synthetic thinking may benefit from moderate time constraints. As an attempt to sum up the complexity of time constraints as both enablers and restrainers of creativity, [2] proposed a creativity/time pressure matrix with four categories to exemplify the experience, i.e., being a) on an expedition, b) on a mission, c) on autopilot, and d) on a treadmill. Here, the authors found that the two former correlate with an increased likelihood of creative thinking under time pressure. Despite this body of interdisciplinary research, exposing exactly how time constraints affect creative writing while using one of the most familiar CSTs, a writing application, has received less attention, which thus calls for a closer examination.

## Writing applications as CSTs in HCI research

Recent years have seen the emergence of many off-the-shelf CSTs that cater to a large, heterogeneous user group in need of digital-interactive tools for text production. Examples of such commercial CSTs include Ulysses, Scrivener, Bear, iA Writer, Byword, OmmWriter, Paragraphs, Liquid | Author, Write or Die, FocusWriter, and many more. Conventional and advanced text editors such as Microsoft's Word or Apple's Pages have only scarcely been studied as dedicated CSTs, i.e., as digital tools to support writing specifically conceived as a *creative* practice. Despite the growing number of writing applications, most have been designed to support the creative writing process through simplification of the GUI, usually by decimating the in-app tools available (e.g., fonts, styles, menus, and toolbars) to reduce distractions. Although relevant, this design feature commonality points to a potential for HCI research to develop new CST prototypes to explore more delimited aspects of creative writing and in greater depth, as well as how to design new CSTs firmly based on current creativity research.

So far, most HCI research contributions have centered on specialized applications and particular use cases. Notable examples include studies of the use of Google Docs for general creativity support [10, 24] and the practice of collaborative writing [33, 38]. Interestingly, how best to support creative writing through CSTs has recently been investigated at the ECCE conference series with studies on user interface design [18], subliminal and supraliminal priming to overcome fixation [20], and mild Virtual Reality immersion to stimulate creativity [19]. Very few studies, however, have examined how constraints affect creative writing. Work by [22] on how semantic constraints (a limited number of nouns) influence creative writing showed that "Mere practice with constraints can stimulate creativity" [p.10] as exemplified by Dr. Seuss's bestseller *Green Eggs and Ham* (1960), which uses only fifty words. Another recent example is a study by [32] on the writing application *MakeWrite*, which was co-designed with people with aphasia in order to enable them to better express themselves and "create meaningful, elegant and sometimes humorous creative writing" (n.p.). To add to this limited body of literature, we present the following study on how users experience their creative writing process based on explicit and implicit time constraints built into the GUI of the writing application itself.

## 3 METHOD

We devised our work as an *exploratory, survey-based, qualitative user experience study* [28]. We used the Web environment *Webstrates* [27] to design a simple writing application prototype with two unique representations of a time constraint embedded. We then applied *thematic analysis* [7] to the data.

**Research design**

Participants were randomly assigned one out of three separate conditions representing a time constraint. As the task was considered easily learned, we opted for a between-subjects study. *Condition 1* was the control group, who were aware of the existence of a time constraint, but had no visual representation of time remaining. In *Condition 2*, participants completed the task using the Phade (implicit time pressure) prototype in which the time constraint was indicated with the gradual fading of written text. Participants in *Condition 3* were given the Ryng (explicit time pressure) prototype with a depleting ring in the upper left corner serving as a timer to show time remaining (see Figure 1). The creative writing task was encapsulated in a survey exploring the participants' experience and impressions of the time constraint within the creative writing task, the extent to which creative writing was part of their everyday practice, and whether or not time constraints were regularly used in their creative writing.

*Participants.* Participants were high school students enrolled in a publicly funded, not-for-profit after-school academy for academically gifted students. They were recruited via email invitation from the program coordinator. In total, 45 complete responses to our study were recorded (30F, 15M) with 12 participants in the control group, 17 in the implicit time constraint group (Phade), and 15 in the explicit time constraint group (Ryng). Out of the 45 participants, 13 students were in the first year of their high school education, 20 were in the second year, and 12 were in the third year (age: $M$=17.5, $SD$=.87). Twenty students indicated a natural science focus, nine the social sciences, eight the humanities, and nine students were undecided. Twenty-eight students stated that their school assignments involved creative writing, whereas 16 did not. Seven students reported using time constraints in their creative writing.

*Procedure.* The participant recruitment email contained a link to the creative writing task and a five-part survey, which ran online and took approximately 30 minutes to complete. Upon clicking on the link, all participants were presented with a written description of the goal of the study. Part 1 of the survey collected demographic information. Part 2 of the survey was the creative writing task itself. The participants were given a short description of the creative writing task, which used *Rory's Story Cubes*, an exercise for quickly writing stories using a set of nine cubes with pictographs. A short, prerecorded video of the cubes being rolled onto a table was then shown. The participants were asked to click on a link, which lead them to one of the three conditions. A photo of the resulting cube roll was displayed to the left of the text input box in the writing application, along with a limited set of options to modify text size, bold, and italic (see

Figure 1). All three conditions were given a five-minute (300 seconds) time limit to complete their story. Participants then proceeded to Part 3 of the survey, which examined the perceived experience of a time constraint (or lack thereof) when doing the creative writing task. In Part 4, the participants were asked about the experience of the writing application prototype. Finally, in Part 5, the participants were asked about the role of creative writing in their everyday lives, and they were offered to enter a draw to win a set of *Rory's Story Cubes*.

*Measure.* In sum, the online survey's five parts served as this user experience study's main empirical basis. More specifically, Part 1 contained four questions related to *demography* (age, gender, nationality, and preferred academic field). After the writing task itself in Part 2, five questions in the survey's Part 3 addressed the participants' *experience of time pressure*. If the participants answered in the affirmative to "Did you experience time pressure during the creative writing session?", they were asked follow-up questions such as "When was the time pressure most obvious to you?" and "What precisely made you feel this time pressure?". Six questions in the survey's Part 4 explored the participants' *experience of the prototype* based on the assigned condition, e.g., "How would you describe the writing app you just used for this creative writing exercise?" and "Why did the design of the writing app affect your creating process? Or why didn't it? Please explain." In the survey's Part 5, the participants were asked eight open-ended questions pertaining to their *individual writing practices*, including, "Do you ever write for fun in your spare time?" and "What tools, either digital or non-digital, do you use for creative writing?" We additionally collected the responses to the writing task based on the story cubes. To elicit themes and gain further insights, five researchers individually conducted a thematic analysis before comparing and refining the findings in a group discussion [7]. Finally, we collected quantitative data on total time spent completing the survey (in seconds) and amount of text produced (in words). Since this was an exploratory, survey-based, qualitative user experience study, and not a creativity research study proper, we did not measure or assess the level of creativity (e.g., as novelty, originality, quality, or valuableness) of the text produced in the writing task in the survey's Part 2.

## 4   RESULTS

### Experience of time constraint and amount of text produced

When asked the binary question whether they did or did not feel any time pressure during the writing task in the survey's Part 2, most participants regardless of condition answered that they did experience time pressure. This was

**Figure 1: Screenshots of the writing application prototype (L-R): Control group, Phade, and Ryng.**

demonstrated by both the qualitative responses and the basic quantitative measures. We did, however, see no statistical difference between the affirmative experience of time pressure between the conditions of *control* (eight out 12 participants, 66.67%), *implicit* (11 out of 17 participants, 64.71%), and *explicit* (14 out of 16 participants, 87.50%) $c^2(2, n = 45) = 2.56, p = .28$). As for the amount of text (number of words) produced during the writing task, participants in the *control* condition produced the lowest amount of text ($M$=109.41, $SD$=45.84, 95% $CIs$=[80.29, 138.54]. Participants using Phade with the *implicit* time pressure had the second-lowest amount ($M$=110.58, $SD$=43.98, 95% $CIs$=[87.97, 133.20]), while participants working under the *explicit* time constraint of Ryng yielded the highest amount ($M$=133.87, $SD$=36.04, 95% $CIs$= [114.67, 153.08]). Despite this clear variation, the difference is statistically insignificant based on a one-way ANOVA $F(2,45) = 2.12$, p=.20. In the following, we report on four themes that emerged from the qualitative, thematic analysis.

### Quantity versus quality of text produced

The first theme to emerge was the impression that time pressure can encourage *greater quantity of writing rather than quality* (measured in number of words) when a visual indicator of time passing is present, whether implicit (Phade) or explicit (Ryng). Eleven participants across these two conditions explained that time pressure directly affected their experience of completing the writing task. They focused on incorporating all nine pictographs into their story in the time given, rather than on the quality of their writing (P18,20,23,33,34,35,39,41). Three reported quickly writing something down rather than structuring their story (P20,34,39) or worrying about cohesiveness or coherence (P32,41). P43 explained that "because there was a time-limit, my text is neither coherent or particularly exciting, mostly weird." Two participants reflected on whether the impact of quantity over quality of writing was detrimental or beneficial to their creative writing experience. Using Ryng, P35 indicated that the shift of focus to quantity had negative consequences, "I often think deeper and choose my words more carefully to make sure they express exactly what I want them

to," but the time pressure "stressed me to get done quickly, which made me less satisfied with the process and with the result." Generating more text under time pressure, however, was seen as beneficial to P23, using Phade, who stated that the time constraint effect "was a great way to silence the inner critic and perfectionist."

### Varying awareness of time constraints

The fading of the text over time in Phade was pointed out by five participants (P17,20,23,30,31) as a palpable cause for *their awareness of the time constraint.* P20 stated that she noticed the time constraint when the font began to fade, leading to a sense of panic, "It made me realize that time was up in a bit, and I panicked because I wasn't done." Conversely, P30 expressed a less dramatic experience of the fading, as it reminded him of "writing in the sand on the beach and letting the waves erase your work." Since the fading effect does not begin until 120 seconds into the process, P23 reported only feeling the time constraint when the fading effect 'caught up' with the current line she was working on. A greater number of participants using the Ryng prototype mentioned the GUI's time constraint feature as the cause of their experience of time pressure. Six participants (P34,35,37, 38,39,42) emphasized how the changing hues on the ring triggered their awareness of a time constraint, either when shifting from blue to orange or from orange to red. Two participants (P43,44) expressed that they were more aware of the time constraint toward the end due to the presence of the timer. P45 was reminded of the time constraint when shifting the focus to the image of the cubes, which was located below the timer (see Figure 1). Two participants said that explicitness of the time remaining caused them to shift their writing strategy to focus on quickly completing their story (P34,37). Interestingly, P11 from the control group highlighted how "it would have been pressing if I'd been able to see the timer."

### Illusion of permanence

Participants using Phade in the implicit condition made several mentions of how the fading effect impacted their writing experience. Beyond the perceived effect the time constraint

had on their storytelling, the thematic analysis revealed a theme suggesting that the fading text also created an *illusion of permanence* of the written content (P17,18,20,23,27,30). For example, P17 noted that "the fading made me less likely to go back and change a past sentences [sic], so I instead just moved forward. Not good for something that needs constant changing, but good for pushing to write more." None of the three conditions restricted editing in any capacity—participants were free at any time to go back and edit text, even if it had faded out almost entirely and was barely legible at only 10% opacity. The participants' prioritization of writing over editing was entirely based on the felt time pressure, which, as mentioned, lead to quantity over quality. However, most participants did not feel this as a detriment, such as P23 who felt that "it was a great way to silence the inner critic and perfectionist" and "I wasn't constantly rating my former words." Comparing the effect in Phade to writing in sand and "letting the waves erase your work," P30 noticed how the feature would work particularly well "if you had to put your emotions into words, but didn't necessarily want to look at them ever again." Several participants in multiple conditions (e.g., P22,27,35,36,43) brought up the fact that the creative writing tool they used did not correct spelling mistakes by underlining text in red. This contributed to the perception that the written story was permanent. Some participants, however, noted that an autocorrect of basic spelling mistakes for catching typos such as swapped letters would be desirable to further support the feature and make it less desirable to go back and edit text and thus rather focus on furthering the story.

### Time-constrained writing as a warm-up exercise

A final theme from the analysis of the qualitative responses was the prospect of employing the renditions of time constraints in the prototype's GUI as part of a fun and liberating *warm-up writing exercise* before an arguably more serious and demanding writing task such as writing an English high-school essay. As shown by [19], priming may benefit creativity when writing, however, we did not design the GUI of the prototype with this in mind. Nevertheless, four participants (P23,33,41,46) specifically mentioned the use of Phade as "a good warm-up" (P23) and a "great way to start up" (P33). Furthermore, P23 stated how using Phade to write under the implicit time constraint of the fading text "improved my ideas" so that she "felt it quickened the creative process." If a future, more advanced writing application were to incorporate time constraints as an expedient warm-up feature before a more demanding writing task, it seems that the implicit Phade rendition would be preferable. The main reason is that the participants experienced this way of engaging with time-constrained writing as less intrusive during the creative writing process itself compared to the experience

of the participants using the Ryng prototype. As mentioned, the latter group (explicit condition) was more focused on wrapping up their story, e.g., "I felt like I had to hurry on to the next part so that I would be able to finish" (P50).

## 5   DISCUSSION

### Productivity or creativity?

Many participants stressed how they felt that the time pressure made them produce more text, but not necessarily *more creative* text. This increase in productivity is arguably related to divergent thinking tests, mostly through the ability of fluency (generating large amounts of ideas) which has, to a large extent, been a measure for creativity in the body of research on time constraints and creativity [9]. This begs the question of whether time constraints in creative writing influence productivity, creativity, and/or both. As mentioned, studies [3, 5, 9] have indicated a curvilinear relationship between constraints and creativity. This relationship is not directly supported by our data. We did find a variation in the amount of text produced in the writing task with the group using the Ryng explicit time constraint prototype producing the most words on average. Even so, there was no statistically significant correlation between the conditions and the amount of text written. We therefore cannot generalize if explicit time constraint such as in the Ryng prototype's GUI really does lead to a greater quantity of text overall in creative writing among high school students. Given the number of participants in this study, the findings lack the statistical power to pursue this in greater depth.

Since the study was devised as an exploratory, survey-based, qualitative user experience study, and not as a creativity research study focusing on creative outcome assessment, we can only speculate about a potential correlation between the utilization of time constraints in the GUI of a writing application and the creative quality or appropriateness of the creative text produced. As P34 using Ryng stated, she became "ambitious in regard to wanting to complete the task." Similarly, P37 reported that "you have to get it done within the time frame." This makes us wonder if awareness of *time remaining*, rather than a more general awareness of time pressure *per se*, can lead to the experience of a *desire for task completion* as opposed to stopping midway. Indeed, we contemplate if this desire to 'push on' can also lead to a higher quality of the creative outcome. Although this is a research question for future work, we wish to underline that, based on the available data, time constraint *per se* was generally *experienced* as conducive for producing (more) text in this particular case, i.e., an intense, five-minute online writing session based on pictographs as prompts for ideation.

**Increased tool literacy**

Our qualitative user experience study has indicated that modifying a simple writing application's GUI by incorporating a visible time constraint feature can affect the user's experience of both the creative writing process itself and the creative outcome in the form of the creative text produced. Although the study and thus the generalizability of the findings are limited in scope, the results still point to the importance of having a reflective stance toward the digital-interactive CSTs we use in our everyday creative practices. Indeed, we see this as a need for an *increased tool literacy*. As shown by [31], there is a tendency in the HCI community to think of certain tools as being "solved problems." This means software that has reached a stable state, which prompts the widespread understanding that no more major improvements are required. However, as [31] has further stressed, this situation can also lead us to uncritically accept and use CSTs and software in general without reflecting upon how it influences our creative practices, for better or worse. Given the findings of our study, we must underline that we should not think of writing applications such as text editors as a solved problem. Rather, considering how many people rely upon this type of CST in their daily workflows, we must pay even more attention to how these digital tools influence the writing process itself. Insights from such studies will enable us to further develop and tailor these digital tools to better fit with the wide variety of use purposes that they serve in practice.

One perspective could be to make such CSTs more malleable so that end-users may appropriate and customize them to different types of writing tasks both within and beyond creative domains. Moreover, as explored in [12], mastering a digital tool such as a text editor in a given work practice is not just a question of developing the skills to use the tool to reach a desired outcome. It also involves "understanding its role, potentials, and limitations in a given project" (n.p.). Future research on CSTs for creative writing should thus prioritize a) understanding writing practices, b) developing software to better support these practices, and c) informing the users of such CSTs about how these digital tools necessarily affect their daily work practices, for better or worse, with the aim of d) inviting the users to take an active part in shaping the CSTs that they already use on a regular basis. A relevant research question for future work to explore would be to what extent it is possible, not to mention desirable or beneficial, to cram numerous features into a single application for the entire creative writing process–from rapid text production to advanced editing–without compromising the user experience, which we believe lies at the heart of any CST-based, creative writing practice. It is our hope that an increased tool literacy might enable users to better select specific CSTs for specific creative tasks so that, as a case in point, the creative writing process itself can become even more enjoyable and productive.

## 6 CONCLUSION

Through a survey-based, qualitative research design, this study has explored how users, exemplified by high school students (*n*=45), experienced implicit and explicit time constraints embedded in the GUI of a writing application prototype. Using thematic analysis, our study has revealed four patterns of how users of these time constraint-fitted CSTs experience *time pressure* and the *quantity vs. quality*, *initiation*, and *revision* of their creative writing process. In sum, we consider these insights the paper's *main contribution*. Designing CSTs to facilitate productivity and/or creativity is highly complex, and so our study further points to the need for an increased tool literacy; not just in the HCI research community, but also among users. With this paper, we hope to encourage more studies to investigate in even greater depth how writing applications such as text editors can be further improved through user experience-oriented interaction design research to support human creativity across creative domains.

## ACKNOWLEDGMENTS

## REFERENCES

[1] Teresa M Amabile. 1985. Motivation and Creativity: Effects of Motivational Orientation on Creative Writers. *Journal of Personality and Social Psychology* 48, 2 (1985), 393–399.

[2] Teresa M Amabile, Constance N Hadley, and Steven J Kramer. 2002. Creativity Under the Gun. *Harvard Business Review* 80 (2002), 52–63.

[3] Markus Baer and Greg R Oldham. 2006. The curvilinear relation between experienced creative time pressure and creativity: Moderating effects of openness to experience and support for creativity. *Journal of Applied Psychology* 91, 4 (2006), 963–970.

[4] Baptiste Barbot, Mei Tan, Judi Randi, Gabrielle Santa-Donato, and Elena L. Grigorenko. 2012. Essential skills for creative writing: Integrating multiple domain-specific perspectives. *Thinking Skills and Creativity* 7, 3 (2012), 209–223.

[5] Michael Mose Biskjaer, Bo T Christensen, Morten Friis-Olivarius, Sille JJ Abildgaard, Caroline Lundqvist, and Kim Halskov. 2019. How task constraints affect inspiration search strategies. *International Journal of Technology and Design Education* (2019), 1–25.

[6] Margaret A Boden. 2004. *The Creative Mind: Myths and Mechanisms.* Routledge, London; New York.

[7] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 2 (2006), 77–101.

[8] Dean Bruton. 2011. Learning creativity and design for innovation. *International Journal of Technology and Design Education* 21, 3 (2011), 321–333.

[9] Kristin Byron, Shalini Khazanchi, and Deborah Nazarian. 2010. The relationship between stressors and creativity: a meta-analysis examining competing theoretical models. *Journal of Applied Psychology* 95, 1

(2010), 201–212.

[10] Erin Cherry and Celine Latulipe. 2014. Quantifying the Creativity Support of Digital Tools through the Creativity Support Index. *TOCHI* 21, 4 (2014), 1–25.

[11] Anita Crescenzi, Diane Kelly, and Leif Azzopardi. 2016. Impacts of time constraints and system delays on user experience. In *Proceedings of the 2016 ACM on Conference on Human Information Interaction and Retrieval*. ACM, 141–150.

[12] Peter Dalsgaard. 2017. Instruments of inquiry: Understanding the nature and role of tools in design. *International Journal of Design* 11, 1 (2017).

[13] Paul Dawson. 2004. *Creative writing and the new humanities*. Routledge, New York.

[14] Steven P Dow, Kate Heddleston, and Scott R Klemmer. 2009. The efficacy of prototyping under time constraints. In *Proceedings of the seventh ACM conference on Creativity and cognition*. ACM, 165–174.

[15] Gerhard Fischer. 1992. Creativity Enhancing Design Environments. In *Modeling Creativity and Knowledge-based Creative Design*, John S. Gero and Mary Lou Maher (Eds.). Lawrence Earlbaum Associates, Hillsdale, NJ, USA, 235–258.

[16] Jonas Frich, Lindsay MacDonald Vermeulen, Christian Remy, Michael Mose Biskjaer, and Peter Dalsgaard. 2019. Mapping the Landscape of Creativity Support Tools in HCI. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM.

[17] Jonas Frich, Michael Mose Biskjaer, and Peter Dalsgaard. 2018. Twenty Years of Creativity Research in Human-Computer Interaction: Current State and Future Directions. In *Proceedings of the 2018 Designing Interactive Systems Conference*. ACM, 1235–1257.

[18] Frederica Gonçalves and Pedro Campos. 2017. Understanding and evaluating the user interface design for creative writing. In *Proceedings of the European Conference on Cognitive Ergonomics 2017*. ACM, 85–92.

[19] Frederica Gonçalves and Pedro Campos. 2018. Mild place illusion: a virtual reality factor to spark creativity in writing. In *Proceedings of the 36th European Conference on Cognitive Ergonomics*. ACM, 1–8.

[20] Frederica Gonçalves, Ana Caraban, Evangelos Karapanos, and Pedro Campos. 2017. What Shall I Write Next?: Subliminal and Supraliminal Priming as Triggers for Creative Writing. In *Proceedings of the European Conference on Cognitive Ergonomics 2017*. ACM, 77–84.

[21] Catrinel Haught and Philip N Johnson-Laird. 2003. Creativity and constraints: The production of novel sentences. 25, 25 (2003), 528–532.

[22] Catrinel Haught-Tromp. 2017. The Green Eggs and Ham hypothesis: How constraints facilitate creativity. *Psychology of Aesthetics, Creativity, and the Arts* 11, 1, 10–17.

[23] Shih-Wen Hsiao, Ming-Feng Wang, and Chien-Wie Chen. 2017. Time pressure and creativity in industrial design. *International Journal of Technology and Design Education* 27, 2 (2017), 271–289.

[24] Young-Wook Jung, Youn-kyung Lim, and Myung-suk Kim. 2017. Possibilities and limitations of online document tools for design collaboration: The case of Google Docs. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*. ACM, 1096–1108.

[25] James C Kaufman, John Baer, Jason C Cole, and Janel D Sexton. 2008. A comparison of expert and nonexpert raters using the consensual assessment technique. *Creativity Research Journal* 20, 2 (2008), 171–178.

[26] Oliver W Klaproth. 2014. Strategic planning in dynamic urban operations: Problem solving under time constraints. In *Proceedings of the 2014 European Conference on Cognitive Ergonomics*. ACM, 1–4.

[27] Clemens N Klokmose, James R Eagan, Siemen Baader, Wendy Mackay, and Michel Beaudouin-Lafon. 2015. Webstrates: shareable dynamic media. In *Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology*. ACM, 280–290.

[28] Mike Kuniavsky. 2003. *Observing the user experience: a practitioner's guide to user research*. Morgan Kaufman.

[29] Gregory Light. 2002. From the personal to the public: Conceptions of creative writing in higher education. *Higher Education* 43, 2 (2002), 257–276.

[30] Lassi A Liikkanen, Tua A Björklund, Matti M Hämäläinen, Mikko P Koskinen, et al. 2009. Time constraints in design idea generation. In *DS 58-9: Proceedings of ICED 09, the 17th International Conference on Engineering Design, Vol. 9, Human Behavior in Design, Palo Alto, CA, USA, 24.-27.08. 2009.* 81–90.

[31] Nolwenn Maudet. 2017. *Designing Design Tools*. Ph.D. Dissertation. Université Paris-Saclay, Paris, France.

[32] Timothy Neate, Abi Roper, Stephanie Wilson, and Jane Marshall. 2019. Empowering Expression for Users with Aphasia through Constrained Creativity. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM.

[33] Judith S. Olson, Dakuo Wang, Gary M. Olson, and Jingwen Zhang. 2017. How People Write Together Now. *ACM Transactions on Computer-Human Interaction* 24, 1 (2017), 1–40.

[34] Mary Beth Rosson. 1983. Patterns of Experience in Text Editing. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 171–175.

[35] Justin CD Savage, Carolynne J Moore, John C Miles, and Christopher Miles. 1998. The interaction of time and cost constraints on the design process. *Design Studies* 19, 2 (1998), 217–233.

[36] Ben Shneiderman. 2009. Creativity support tools: A grand challenge for HCI researchers. In *Engineering the User Interface - From Research to Practice*, Miguel Redondo, Crescenscio Bravo, and Manuel Ortega (Eds.). Springer, London, 1–9.

[37] Bernie Trilling and Charles Fadel. 2009. *21st Century Skills: Learning for Life in Our Times*. Wiley/Jossey-Bass, San Francisco, CA, USA.

[38] Dakuo Wang, Judith S. Olson, Jingwen Zhang, Trung Nguyen, and Gary M. Olson. 2019. DocuViz. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, 1865–1874.