

A Nossa
Universidade

Colégio dos Jesuítas
Rua dos Ferreiros - 9000-082, Funchal

Tel: +351 291 209400
Fax: +351 291 209410
Email: gabinetedareitoria@uma.pt

UMa

— New Paradigms for the Design and Evaluation of Creative Writing User Interfaces | Frederica Margarida Camacho Gonçalves

TD

New Paradigms for the Design and Evaluation of Creative Writing User Interfaces

DOCTORAL THESIS

Frederica Margarida Camacho Gonçalves

DOCTORATE IN INFORMATICS ENGINEERING
SPECIALTY: HUMAN - COMPUTER INTERACTION


UNIVERSIDADE da MADEIRA
A Nossa Universidade
www.uma.pt

March | 2017

New Paradigms for the Design and Evaluation of Creative Writing User Interfaces

DOCTORAL THESIS

Frederica Margarida Camacho Gonçalves

DOCTORATE IN INFORMATICS ENGINEERING

SPECIALTY: HUMAN - COMPUTER INTERACTION

SUPERVISOR

Pedro Filipe Pereira Campos



Ph.D. in Computer and Software Engineering, specialty in Human
Computer Interaction

New Paradigms for the Design and Evaluation of Creative Writing User Interfaces

Ph.D. Candidate: Frederica Gonçalves

Supervisor: Prof. Dr. Pedro Campos

Funchal - March 2017

New Paradigms for the Design and Evaluation of Creative Writing User Interfaces

© Frederica Gonçalves March 2017

Photos taken in a Hotel in Glasgow June 2015, by Frederica Gonçalves.

All Rights Reserved.

SUPERVISOR

Professor Doutor Pedro Filipe Pereira Campos

Professor Auxiliar da Faculdade de Ciências Exatas e da Engenharia da Universidade da Madeira

ACKNOWLEDGMENTS

"(...) If you are writing without zest, without gusto, without love, without fun, you are only half writer. (...)"

Who wrote these words was Ray Bradbury, in his book, "The Zen of Writing", and after I read the book, I realized that I would have a long path until I reached the end. This path was made possible with zest, gusto, fun, and with much persistence.

Firstly, I would like to thank my advisor (and friend) Prof. Dr. Pedro Campos for his advice and unconditional support. Despite all the setbacks, and even if at some point on this path we had opposing views on which way the research should continue, you never gave up, and I always tried to see the brightest side of things. Thank you for believing in me! I am honoured to be your Ph.D. student.

I would like to thank two people who let me interview them extensively and who contributed to this work. Dr. Jon Mason and Dr. Dzmitry Aliakseyeu, senior scientists from Philips Lighting Research, who gave me much of their time and insights and also provided detailed feedback on my path. You were very generous with your thoughts, many thanks.

A warm thanks to Prof. Dr. Eduardo Fermé for your precious comments and especially the advice to read the book by Ray Bradbury, which made me find the inspiration to finish this thesis. I thank Prof. Dra. Mónica Cameirão, from the Universidade da Madeira (UMa)/Madeira Interactive Technologies Institute (M-ITI), Prof. Dr. João Carlos Ferreira, from Instituto Universitário de Lisboa (ISCTE), and all my co-authors, for their comments and suggestions along this path.

I would like to thank Wowsystems, especially Miguel Campos, whom I have worked with and who gave me the possibility to contribute in the testbed development. To let me use the tool in my work, which contributed to the enrichment of this thesis.

The users who participated in the studies, as well as all the anonymous users, significantly helped to improve my work. I am grateful for their insights, sharp comments and creative suggestions.

I have many generous friends and colleagues from UMa and M-ITI that I would like to thank for their help and advices along this last years. Without distinguishing any, here is my recognitions to all.

I am fortunate to have a wonderful group of friends, without differentiating any, because they know who they are, many, many thanks! You all, encouraged me to continue, motivating myself, even when I thought it would never end. Some of you have read my work, even without understanding it, others gave me fabulous help and support for my writing. That made me "grow", so thankful I am!

I am especially grateful to my parents, Hélder and Luisa, to my brother Miguel and his family and also to my sister Sara and her family, for their unconditional belief in me.

Last, but certainly not least, I want to thank Paulo, my friend, my love, my partner for life, for supporting me all the way through. I could not have never made it here without your patience and care.

To You,
*my angels, who gave me the
strength to be myself and
encouraged me*

*"Há tempos de usar de coruja, e
tempos de voar como o falcão"*

D. João II



ABSTRACT

This research evaluates different techniques for improving creativity when writing, applying them to different scenarios. We introduce a new concept, called “mild” place illusion, as a new paradigm for designing user interfaces targeted at stimulating creativity. We show that for creative tasks such as creative writing, new product ideation, and brainstorming, a “just-enough” amount of place illusion leads to a greater self-perception of creativity, as opposed to a “full-level” place illusion. Secondly, we evaluate the effectiveness of subliminal cues as a novel creativity support technique. Results showed that participants in the subliminal condition experienced more flow when writing. Thirdly, we explore the effect of auditory and olfactory cues and their combination during a creative writing exercise. Our results provide useful insights suggesting that olfactory cues have an important role in the creative process of users and also when this type of cues are combined with auditory cues. These modalities should gain more relevance on the development of environments for supporting the creative writing process. New tools for creative writers can also be used to support community-based writing projects and encourage people from all backgrounds to find their voice and tell their unique stories. Our work also addresses, for the first time, a minority user group of underserved youths, by evaluating how they write using different user interfaces. We conclude that using our tools they felt more empowered to tell their unique stories and experienced an increase in their mental well-being.

Keywords: Human Computer Interaction; User Studies; User Experience Design; User Interface Design; Creative Writing tools; Creativity Support Tools;

RESUMO

Esta investigação avalia diferentes técnicas para melhorar a criatividade ao escrever, aplicando-as a diferentes cenários. Nesta tese apresentamos um novo conceito, denominado "mild place illusion, "ilusão de lugar", como um novo paradigma para projetar interfaces de utilizadores com o objectivo de estimular a criatividade. É demonstrado que para tarefas criativas como a escrita criativa, ideação de novos produtos e brainstorming, uma "apenas e suficiente" quantidade de espaço de ilusão, leva a uma maior auto-percepção da criatividade, por oposição a um "nível completo" de ilusão de lugar. Em segundo lugar, avaliou-se a eficácia de pistas subliminares como uma técnica de suporte à criatividade. Os resultados mostraram que os participantes na condição subliminar experimentaram mais "flow" (fluxo) durante o processo de escrita. Em terceiro lugar, exploramos o efeito das pistas auditivas e olfativas e a sua combinação durante um exercício de escrita criativas. Os resultados fornecem conhecimentos úteis, sugerindo que pistas olfativas têm um papel importante no processo criativo dos utilizadores, sendo também válido quando este tipo de pistas são combinadas com pistas auditivas. Estas modalidades devem ganhar mais relevância no desenvolvimento de novos ambientes que suportem o processo de escrita criativa. Verificou-se que novas ferramentas para escritores criativos, também podem ser utilizadas para apoiar projectos de escrita baseados em comunidades e podem também incentivar pessoas de todos os contextos culturais e sociais a encontrar a sua voz e contar as suas histórias únicas. Esta tese também aborda, pela primeira vez, um grupo de utilizadores minoritários de jovens carentes e institucionalizados, na medida em que foi avaliado o seu processo de escrita utilizando diferentes interfaces de utilizador. Concluimos que, utilizando as ferramentas apresentadas neste estudo, o grupo de utilizadores em questão, sentiram-se mais capacitados para contar as suas histórias singulares e experimentaram um aumento no seu estado de bem-estar mental.

Palavras-Chave: Interação Humano-computador; Estudos de utilizadores; Design de estudo de utilizadores; Design de Interação de Utilizadores; Ferramentas de Escrita Criativa; Ferramentas de Suporte à Criatividade

CONTENTS

PART I - Introduction & Background

CHAPTER 1	5
INTRODUCTION.....	5
1.1. Motivation.....	6
1.2 Problem Statement	8
1.3. Research Overview.....	9
1.4. Thesis Contribution	10
1.5. Dissertation Roadmap	10
1.6. About this thesis	11
1.7. Publications.....	11
CHAPTER 2	15
BACKGROUND.....	15
2.1 Design Tools.....	15
2.1.1 Creative Writing	15
2.1.2. Creativity Support Tools.....	17
2.1.3 Creative Writing User Interfaces.....	18
2.2. Models for Human Work	20
2.2.1 Activity Theory	20
2.2.2 Cognitive Work Analysis.....	22
2.2.3. Human Work Interaction Design.....	24
2.3. Supporting Creativity.....	28
2.3.1. Creative Behavior Inventory.....	29
2.3.2. Flow Theory dimensions.....	30
2.3.3. External judging.....	31
2.3.4. Creativity Support Index (CSI)	32
2.3.5. Self-assessments and Post-experiment interviews.....	32

2.3.6. Increased output.....	32
2.4. Conclusions	33
PART I I- Understanding and Evaluating Creative Writing UI	
CHAPTER 3	39
UNDERSTANDING CREATIVE WRITING UI.....	39
3.1. Dimensions for Creative Writing UI.....	39
3.1.1. Serendipity.....	41
3.1.2. Evolution.....	41
3.1.3. Shuffle.....	41
3.1.4. Haven.....	42
3.2. Simple interactions for a complex domain.....	42
3.3 Second Look	44
3.4. Conclusions	47
CHAPTER 4	51
EVALUATING CREATIVE WRITING UI.....	51
4.1 Introduction.....	51
4.2 Dimensions for creative writing tools versus Technology Acceptance Model.	52
4.3 User Study - Challenge to write	53
4.4 Results.....	56
4.5 Discussion	61
4.6 Conclusions	63
CHAPTER 5	67
ENHANCING CREATIVITY THROUGH THE USE OF A CROWDSOURCED PLATFORM - CREATIVWALL.....	67
5.1 Introduction.....	67
5.2 Crowdsourcing	68
5.3 Moods, Emotions and Colors.....	68

5.4 CreativeWall Platform.....	70
5.5 CreativeWall MSWord Add-In	74
5.6 User Study - CreativeWALL.....	77
5.7. Results.....	80
5.8. Discussion	84
5.9. Conclusions	84
CHAPTER 6	89
CREATIVE WRITING UIS TO EMPOWER UNDERSERVED YOUTHS.....	89
6.1. Introduction.....	89
6.2. Empowering Minority Groups.....	90
6.3. Creative Writing user interfaces.....	91
6.3.1. Haven: a “Zen” Creative Writing UI	91
6.3.2 Hanx Writer: the Return of the Nostalgic Typewriter	93
6.3.3 Write or Die ... no tagline needed!.....	93
6.4. First study: zen UI VS. BASELINE	95
6.4.1 Results.....	96
6.5. Second study: NOSTALGIC TYPEWRITER VS. ZEN UI.....	100
6.5.1 Results.....	101
6.6 Third study: WRITE OR DIE	102
6.6.1 Results.....	103
6.7. Comparing creative writing user interfaces.....	104
6.8 Discussion	105
6.9 Conclusion.....	106
CHAPTER 7	109
MILD PLACE ILLUSION.....	109
7.1. Introduction.....	109
7.2. The Illusion as a factor to spark creativity.....	110

7.3. User Study.....	111
7.4. Findings.....	115
7.5. Discussion and Conclusions.....	127
CHAPTER 8	133
WHAT SHALL I WRITE NEXT? PRIMING CREATIVITY.....	133
8.1. Introduction.....	133
8.2. Creativity and the Automatic Mind: Explicit vs. Implicit cues.....	135
8.3. User Study – Priming Creativity	136
8.4. Results.....	140
8.5. Discussion	146
8.6. Conclusion.....	148
CHAPTER 9	151
EXPLORING THE EFFECTS OF OLFATORY AND AUDITORY CUES TO SUPPORT CREATIVE WRITING TASKS.....	151
9.1. I SMELL CREATIVITY	151
9.1.1. Introduction.....	151
9.1. 2 Perception of olfactory and auditory cues	153
9.1.3 User Study	153
9.1. 4 Results	158
9.1.5 Discussion	167
9.1.6 Conclusion.....	168
9.2. CREASENSES.....	169
9.2.1 Introduction.....	170
9.2.2 User Study.....	170
9.2.3 Findings.....	173
9.2.4 Discussion	177
9.2.5 Conclusion.....	177

PART I I I- Reflections

CHAPTER 10	183
CONCLUSIONS AND FUTURE WORK.....	183
10. 1. Conclusions.....	183
10.2. Future Work	184
APPENDIX	187
A - Example of the questionnaire for each dimension for creative writing.....	187
B - Example of the questionnaire for TAM dimensions.....	190
C - Example of the Creative Behavior Inventory.....	192
D- Example of the list of adjectives used to assess participants mental well-being.	194
E- Example of the Flow Theory dimensions survey	195
F - Example of the Creativity Support Index survey.....	196
G - Example of the Perceptual Effects survey	198
REFERENCES	199

LIST OF FIGURES

Figure 1 - Writing feather from 19th Century.....	6
Figure 2 - The outputs of Design Research [Source: isworld.org].....	9
Figure 3 - The writing process.....	16
Figure 4 - Model example of human activity by Engeström [7].....	21
Figure 5 - The dimensions of Cognitive Work Analysis.....	23
Figure 6 - Human Work Interaction Design framework.....	25
Figure 7 - A revised version of the general HWID framework a new HCI field.	27
Figure 8 - Dimensions of Flow Theory.....	31
Figure 9 - Final look of the Yarn tool.....	40
Figure 10 - Dimensions for creative writing tools.....	40
Figure 11 - Initial analysis of connections between Human Work analysis and Interaction Design in the case of creative writing.....	43
Figure 12 - A possible scenario for Second Look.	44
Figure 13 - The overall architecture based on the crowdsourcing engine.....	46
Figure 14 - A Second Look user – a creative writer – spots an inspirational spot for her next novel and geotags some photos with Google Glass. At the same time she also uses the mobile app to write a few lines from her “in-the-moment” creativity and geotags them.....	46
Figure 15 - Hypotheses considered in our framework.....	52
Figure 16 - Performing the study in the research laboratory: Participants were seated alone in a quiet room to answer the writing challenges.....	55
Figure 17 - Final prototype of the CreativeWall platform.....	71
Figure 18 - The integration on the word processor tool Microsoft Word.....	71
Figure 19 - Example of a Creative Moment.....	72
Figure 20 - Top bar of the moment showing the three options available.....	72
Figure 21 -Top bar of the moment showing the rating feature.....	73
Figure 22 - Sort feature showing the options available.....	73
Figure 23 - Dialog box showing the possible fields for creating a new moment.....	74
Figure 24 - CreativeWall Add-In ribbon with buttons and inputs available.....	75
Figure 25 - Creative Moment in the Microsoft Word Add-In.....	75
Figure 26 - Software architecture including the platforms implemented.....	76
Figure 27 - Context given to the user on the first challenge.....	78
Figure 28 - Context given to the user on the second challenge.....	79
Figure 29 - Context given to the user on the third challenge.....	79
Figure 30 - Chart relating the tasks with the adjectives used in them.....	81
Figure 31 - Sample distribution.....	82
Figure 32 - Snowy writing theme.....	92
Figure 33: Moonlight writing theme.....	92
Figure 34: An example of a writing prompt.....	92

Figure 35: Hanx Writer.....	93
Figure 36: Write or Die.....	94
Figure 37: The youths in the educational establishment.....	94
Figure 38 - Box Plot.....	97
Figure 39 - Word clouds for the adjectives that participants selected at the end of each daily challenge. Numbers indicate the day.....	98
Figure 40 - Total count for the adjectives chosen by participants.....	99
Figure 41 - Test of normality	101
Figure 42 - Total count for the adjectives selected by the participants when using Write or Die.	104
Figure 43 - Framework and chart for plotting and comparing creative writing tools.	105
Figure 44 - Creative writing conditions in the experiment (from left to right): <i>No PI</i> ; <i>"Mild" PI</i> ; <i>"Full" PI</i>	112
Figure 45 - Participants in the brainstorming stage	112
Figure 46 - Performing the study in the research laboratory. Participants were seated alone in a quiet room to write their ideas in each specific environment (No PI "Mild" PI Full-level PI).	115
Figure 47 - No Illusion Session	117
Figure 48 - Mild Place of Illusion Session	117
Figure 49 - Full-level of Place of Illusion.....	118
Figure 50 - Sample Distribution.....	123
Figure 51 - Number of words written by each participant versus time spent	123
Figure 52 - Some of the participants' ideas during brainstorming, before they started to write.	124
Figure 53 - Participants self-perception of creativity in the No PI condition.....	125
Figure 54 - Participants self- perception of creativity in the "Mild" PI condition.	126
Figure 55 - Participants self-perception of creativity in the "Full" PI condition.....	126
Figure 56 - Example of Supraliminal Priming.....	137
Figure 57 – Magnetic fridge used as a creative writing prompt to initiate the writing for it users.	138
Figure 58 – Experimental setup.....	139
Figure 59 - User performing the study in the research laboratory.	140
Figure 60 – Users perception of creativity after each condition.	142
Figure. 61. Map used to trigger the writing task.....	155
Fig. 62. Students from session 7, performing the study in the moment of the experience. .	157
Figure 63 -Fragment of monitoring during the writing activity: example of the use of image search during the writing task.	162

Figure 64 - Participants performing the study in the research laboratory, in conditions odor:
ambience, and no odor..... 173

Figure 65 - Statistics for Flow Dimensions..... 174

Figure 66 - Statistics for "*How do you rate your creativity in this condition?*" 175

LIST OF TABLES

Table 1 - Results of Cronbach's alpha	56
Table 2 - Correlation between survey items.....	57
Table 3 - Average (SD) for each Creative Writing Dimensions and TAM dimensions in each tool.	58
Table 4 - Average (SD) for amount of words written, amount words length in each tool.....	60
Table 5 - Statistics from expert rating about creativity	60
Table 6 - Moods mapped into colors.....	70
Table 7 - Cronbach's alpha related to each of the dimensions.	80
Table 8 - Statistics from time in minutes spent on each condition	82
Table 9 - Participants Age, Gender and score points in CBI	116
Table 10 - Correlation between survey items	121
Table 11 - Statistics from experts' rating about the texts' creativity.....	127
Table 12 - Average (SD) for Flow Theory dimensions in each environment.....	143
Table 13 - Overall CSI Score in each environment.....	144
Table 14 - CSI Avg. Factor Counts (SD): Sum of Results of Two Questions by Factor.....	144
Table 15 - Avg. Factor Score (SD).....	144
Table 16 - Avg. Weighted (SD).....	144
Table 17 - Number of writer's blocks across the conditions. Participants in the Subliminal condition that noticed the cues are identified with *	146
Table 18 - Comparison between the number of words seen and used in the supraliminal and subliminal conditions.	146
Table 19. Description of the creative writing conditions used.....	158
Table 20. Frequency and percentages " <i>I consider myself a creative person</i> ".....	158
Table 21. Descriptive of self-assessment about creativity in each creative writing conditions.	158
Table 22. Average (SD) from CBI in each creative writing condition.	159
Table 23. Results in percentages for the adjectives chosen by participants in each creative writing condition.....	160
Table 24. Average (SD) for Flow Dimensions in each creative writing condition.	161
Table 25 - Average time in each session on the writing activity using the keyboard.....	162
Table 26 - Average time pauses in each session while writing and average switches between mouse and keyboard.	163
Table 27. Average (SD) for words written in each creative writing condition.	163
Table 28. Overall CSI Score in each condition.	164
Table 29. CSI Avg. Factor Counts (SD): Sum of Results of Two Questions by Factor.....	164
Table 30. Avg. Factor Score (SD).....	164
Table 31. Avg. Weighted (SD).....	165

Table 32 - Overall CSI Means..... 175
Table 33 - Categorization of each odor through self-perceptions..... 176

ACRONYMS

CBI	Creative behavior Inventory
CSI	Creativity Support Index
CST	Creativity Support Tools
CWA	Cognitive Work Analysis
HCI	Human Computer Interaction
HWID	Human Work Interaction Design
ICT	Information and communication technologies
IFIP	International Federation for Information Processing
PI	Place Illusion
TAM	Technology Acceptance Model
TTCT	Torrance Tests of Creative Thinking
UI	User Interface



PART I
INTRODUCTION
&
BACKGROUND

CHAPTER 1

INTRODUCTION



"Creativity is Intelligence having fun"
Albert Einstein

CHAPTER 1

INTRODUCTION

As a contribution to the field of Human Computer Interaction (HCI), especially in the development of user interfaces (UI) for creative writing, this research aims to be a small, but significant step forward.

Writing has been one of the most important developments of human civilization, but people are often unconscious of how long and complicated this path has been. Writing is one of the oldest and most important human activities, dating back as far as the 3200 BCE. In the beginning, writing was used in the form of pictures or convention signs. In today's schools, teachers present writing as something that has always existed. But we never actually know how important this ancient and refined technique of expression and communication is. However, the intensification of digital computing accelerated writing in all its forms, and people in today's society have a much easier access to create new ways of writing such as using characters and abbreviations, reminding us of what some ancient civilizations used to do. However, writers still face the lack of ideas, and therefore the lack of words to write. Writer's block was described as a condition characterized by the inability to come up with original or novel ideas, regardless of the topic being worked on. Almost everyone is familiar with writer's block and most of us have experienced it in some degree.

Creative writing is an essential activity, not just in the education sector, where it is often used as a pedagogical tool to increase literacy, but also in the filmmaking, advertising, video games, broadcasting industries and in much more sectors. Creative writing can be also used to build positive relationships and encourage people from all backgrounds dialogue across diverse communities.

Some of the writing tools that are currently available attempt to initiate the creative process, for example by providing story prompts, while others focus on creating a distraction-free interface where writers can focus on their craft. The problem, however, there are very few studies about what makes a good user interface design for creative writing, as there is no consensual approach on how to evaluate them.

1.1. Motivation

Primitive men, living around 45 000 B.C recorded their thoughts in the form of drawings on stone and on cave walls. The first writing instruments used by men were probably their fingers, which would be superseded with the use of hollow canes and reeds. Progressing to the use of styluses, brushes made from animal fur, and finally feathers – the writing instrument used by civilized society for more than 100 years (see Figure 1).

Originally, stories were passed from generation to generation through oral storytelling traditions. The primary “writing” tool was the storyteller’s memory and voice, even though stories were often augmented by instruments and dances.

The inexpensive mixture of graphite and clay, placed in a wooden casing, supplied with varying degrees of hardness, originated the pencil. Only in the beginning of the 19th Century do we see the prototypes for handmade fountain pens and only at the end of the 1930’s do we see the arrival of the current ballpoint pen that we know today.



Figure 1 - Writing feather from 19th Century¹.

Before the invention of paper, Man engraved on stone, wet clay and wood. He wrote on leaves and tree bark. The emergence of 17th century newspapers led to the invention of paper fabricating machines. Curiously the first typewriter that we know

¹ All rights reserved <https://www.the-saleroom.com/>

to have existed was used in Italy in 1808 by a blind countess, having been invented so that she could write letters without the aid of a secretary. The machine did not reach modern times, its operating principle is unknown. Using ink pads or a roller to apply ink to characters, and the use of carbon paper, visible images of written characters were produced, this was possible in the printing telegraph. The first Typewriter *per se*, arrives on the market in 1874. These machines were widely used, especially by middle class women, in a time when they started to reclaim their freedom from domestic functions exclusivity. In 1902 an electric typewriter was introduced in the market, but only in 1961 does IBM reintroduced an invention which had been tried out in the 19th century, but was later abandoned. This invention is the word processor, which brings together typewriter and computer technology [1].

We know that writing a letter can require a pen and paper, and the resulting activity of writing with one's own hand has certain features that shape the resulting experience. Recent decades brought us technological advances able to improve the writing activity.

Instead of telling and retelling stories orally and making them better over time, written language gave storytellers the ability to tell *themselves* the story over and over again using a drafting process. It gave them a way to record more stories by providing them a physical extension of their memory: ink and paper.

As we saw previously, a hundred years later, computers were invented and another dramatic shift in the writing process was made possible. Instead of typing a story on paper, writers could type it on a screen—no more wasted paper. People in today's society have an easier access to Reading and Writing. There are hundreds of new programs, websites, and apps to help with creative writing.

Creative writing is an essential activity, not just in the education sector, where it is often used as a pedagogical tool to increase literacy, but also in the filmmaking, advertising, video games, broadcasting industries, to describe functionality in the software with the use of user stories and in much more sectors. Creative writing can be also used to build positive relationships and encourage people from all backgrounds dialogue across diverse communities.

Whether we are writing a letter, a novel, or some simple story, we need all the time "to tell our story", conveying the meaning of it in a way that the user understands. For example, the use of stories in user experience design is very important, because when

no prototypes are available yet, stories can capture the characteristics of the design space and allow users to better understand the application and its benefits.

1.2 Problem Statement

How do you decide what creative writing user interface is better to write what you are supposed to write? And then, how do you guarantee that specific tool would help you to overcome the inertia to write? The problem is difficult because each participant has different needs.

Over the years, new technologies transformed how we work, think and relate to each other. People are often easily distracted. We all write, and we find, in some way, our inspiration and creativity in different places, moments and we write in different ways. We also face the deficit of the human kind – distractibility. In those moments we experience what is known as “writer’s block”. We can be highly creative and overcome our inertia with novel environments based on a human-centered view of the design.

This work addresses the general research question of how to design user experiences with creative writing where the creative side of people is sparked by the peculiarities and elements of the user interface.

In this context, there are several research questions that need to be addressed.

- Research Question 1: what is the best process for designing these creative writing environments, and what are the required technical and methodological innovations leading to an increasing adoption of these tools by users?
- Research Question 2: what are the main factors leading to successful writing tools and environments, in terms of creativity?
- Research Question 3: what novel user interface elements can better improve the writers’ creativity?

As mentioned in the previous section, we study the design and evaluation of creative writing user interfaces and their power, to be capable of conducting us towards a user interface design solution that can address users' needs while simultaneously improving their creative levels.

1.3. Research Overview

The research approach followed in this thesis has been based on Design Research. The design process is used as a form of research to contribute to a design activity [2]. Stappers [3] states that working prototypes are created from a clear research question and thus can express a hypothesis. Then, prototypes are put to test in real-life contexts so users can experience them [4]. The design solutions behind the prototypes can be based on research methods or theories. Knowledge is generated by designing the artifact, by the artifact itself, and by the evaluations of use [5]. The knowledge achieved can later be derived as design recommendations, theories or frameworks. March and Smith [6] contrast the approach of design research with natural science research, and proposed four general outputs for design research: constructs, models, methods, and instantiations. Constructs are the conceptual vocabulary of a problem / solution domain. Constructs arise during the conceptualization of the problem and are refined throughout the design cycle (*see Figure 2*). Since a working design (artifact) consists of a large number of entities and their relationships, the construct set for a design research experiment may be larger than the equivalent set for a descriptive (empirical) experiment. A method is a set of steps (an algorithm or guideline) used to perform a task. Implicit in a design research method is the problem and solution statement expressed in the construct vocabulary. In contrast to natural science research, a method may well be the object of the research program in design research. Since the axiology of design research stresses problem solving, a more effective way of accomplishing an end result – even or sometimes especially a familiar or previously achieved end result – is valued [7].

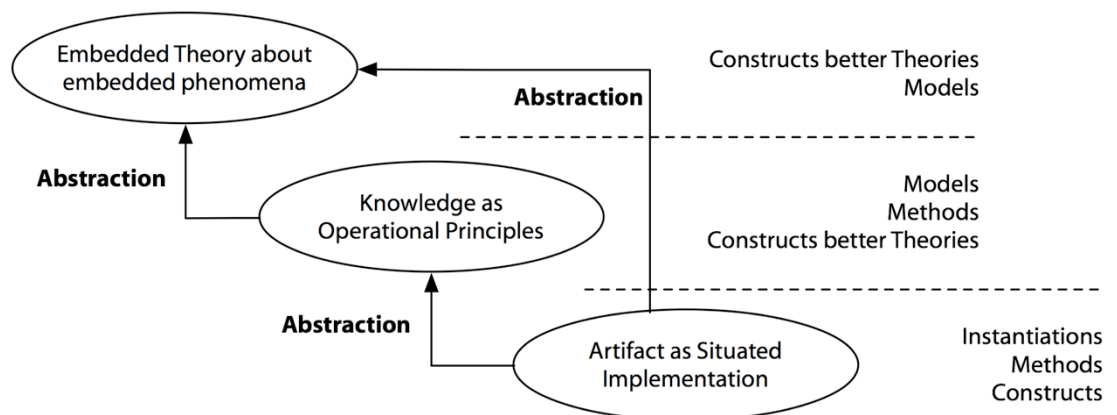


Figure 2 - The outputs of Design Research [Source: isworld.org].

Models differ from natural science theories primarily in intent: natural science has a traditional focus on truth whereas design research focuses more on (situated) utility

[7]. Thus a model is presented in terms of what it does and a theory described in terms of construct relationships. However, a theory can always be extrapolated to what can be done with the implicit knowledge and a set of entities and proposed relationships can always be expressed as a theoretical statement of how or why the output occurs [7].

The act of designing is in itself a confrontation of various forms of knowledge, both formalized and experiential, which brings about new knowledge [5]. This aspect emphasizes the exploratory nature of design research over the traditional scientific culture of evaluating by testing, which must be conducted following very specific directions.

In the context of this engineering-based thesis, the design research we performed was based on studying and modeling UI-related behavior, designing tools using that model and using the revised model for evaluating the tools and improving on them.

1.4. Thesis Contribution

This research work offers contributions in:

- A. Novel tools designed in order to support creative writing, with minimalistic design capable of promoting creativity, focus or collaboration.
- B. New metrics for creativity, by understanding of the creative writing process as well as the design processes and practices that were more effective.
- C. New design guidelines for novel tools, user interfaces or other artefacts.
- D. New data about how people write/create, through the analysis of cognitive, will improve the way people work.

1.5. Dissertation Roadmap

The remaining chapters of this thesis are organized as follows. Chapter 2 describes the background work in which this thesis was built. Following that, in Chapter 3, it is presented insights about the user's writing perspectives on their own writing process and the evaluation of creative writing environments.

In Chapter 4, it is addresses for the first time an approach targeting a minority user group of underserved youths, and evaluating how they write using different user interfaces. Then, in Chapter 5 we present a new experimental method based on virtual

reality for studying place illusion in a writing context, along with the correlation of the degree of creativity.

Chapter 6, discuss the effectiveness of subliminal and supraliminal cues as a novel creativity support technique. We explored the impact of subliminal cues on self-experienced creativity during the creative writing task. Lastly, in Chapter 7 we study the effects of olfactory and auditory cues to support creative writing tasks. Finally, the conclusions and discussion regarding future work are reported in Chapter 8.

1.6. About this thesis

To avoid as much as possible repeating background information at the beginning of each chapter, this thesis is constructed as different chapters that build from one another. This thesis follows a chronological order to give a sense of the process together with the specific activities undertaken.

1.7. Publications

Different aspects of this thesis are included in the following publications:

- Gonçalves, F., Cabral, D., Campos, P. and Schöning, J. (2017). I Smell Creativity: Exploring The Effects Of Olfactory And Auditory Cues To Support Creative Writing Tasks. In Proceedings of INTERACT'17, Mumbai, India. (To appear).
- Gonçalves, F., Fermé, E., Ferreira, J. C., "Emerging Opportunities for Ambient Intelligence in Creativity Support Tools", (ISDA 2016), A.M. Madureira et al. (eds), Intelligent Systems Design and Applications, Springer International Publishing AG, 2017.
- Gonçalves F., Fermé E., Martins A.L., Ferreira J.C. (2017) Towards Activity Theory - Preliminary Report: Ambient Intelligence Applied to Smart Education. In: Madureira A., Abraham A., Gamboa D., Novais P. (eds) Intelligent Systems Design and Applications. ISDA 2016. Advances in Intelligent Systems and Computing, vol 557. Springer, Cham.
- Gonçalves F., Campos P., Clemmensen T. (2015) *Human Work Interaction Design: An Overview*. In: Abdelnour Nocera J., Barricelli B., Lopes A., Campos P., Clemmensen T. (eds) *Human Work Interaction Design. Work Analysis and Interaction Design Methods for Pervasive and Smart Workplaces*. IFIP Advances in Information and Communication Technology, vol 468. Springer, Cham.
- Gonçalves, F., P. Campos, Hanna, J. Ashby, S. (2015). *You're the Voice: Evaluating User Interfaces for Encouraging Underserved Youths to express themselves through Creative Writing*. C&C '15, June 22 - 25, 2015, Glasgow, United Kingdom, 2015 ACM. **Nominated for Best Contribution to Creative Communication.**
- Campos, P., F. Gonçalves, M. Martins, M. Campos, and P. Freitas, (2014). "Second Look: Combining Interactive Surfaces with Wearable Computing to Support Creative Writing", Proceedings of the Ninth ACM International Conference on Interactive Tabletops and Surfaces, Dresden, Germany, ACM, pp. 323–326, 11/2014.
- Campos, P., F. Gonçalves, M. Martins, M. Campos, and P. Freitas (2014). "Second Look: Combining Wearable Computing and Crowdsourcing to Support Creative Writing", Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational, Helsinki, ACM, pp. 959–962, 10/2014.

- Buenafe, S., L. Guzman, N. Kannan, K. Mendoza, N. J. Nunes, V. Nisi, P. Campos, F. Gonçalves, M. Campos, and P. Freitas (2014). "*Yarn: A Product for Unraveling Stories*", Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational, New York, NY, USA, ACM, pp. 1089–1094, 10/2014.
- Fuchsberger, V.; Murer, M.; Tscheligi, M.; Abdelnour-nocera, J.; Campos, P.; Gonçalves, F.; Barricelli, B. (2015). *Human Work Interaction Design (HWID): Design for Challenging Work Environments*, INTERACT 2015.
- Gonçalves, F., Campos, P., Garg, A., (2015). "*Understanding UI Design for Creative Writing: A Pilot Evaluation*". *Human Work Interaction Design (HWID): Design for Challenging Work Environments*, INTERACT 2015, Bamberg, 14-18 Sept., 2015.
- Gonçalves, F., P. Campos, (2014). Towards supporting "in-the-moment" Creativity: combining Crowdsourcing with Interactive Surfaces. Workshop "Collaborative Meets Interactive Surfaces (CMIS): Walls, Tables, Tablets and Phones" in the International Conference on Interactive Tabletops and Surfaces, Dresden, Germany, ACM.
- Gonçalves, F., P. Campos, (2014). Towards Pervasive and Inspiring Workplaces for Creative Writers: Simple Interactions for a Complex Domain. Workshop "Human Work Interaction Design (HWID) for Pervasive and Smart Workplaces in the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational, Helsinki, ACM.
- Gonçalves, F., Campos, P., "*Mild Place Illusion: A Virtual Reality Factor to spark Creativity in Writing*". Submitted to International Journal of Virtual Reality (August 2016).
- Gonçalves, F., Clemmensen, T., Campos, P., Molka-Danielsen, J., "*Drifting towards a new HCI field: A Review of 10 Years of HWID Research*". Submitted.
- Gonçalves, F., Campos, P. (2017) "*Understanding and Evaluating the User Interface Design for Creative Writing*". Submitted.
- Gonçalves, F., Sousa, I., Campos, P. (2017) "*Triggering your creativity and mental well-being while writing: CreativeWall - A novel Crowdsourcing Platform!*". Submitted.
- Gonçalves, F., Caraban, A., Karapanos, E., Campos, P., "*What Shall I Write Next? Subliminal and Supraliminal Priming as triggers for Creative Writing*". Submitted.
- Gonçalves, Cabral, D., Campos, P., "*Olfactory Cues and their Influence on the Self-Perception of Creativity*". Submitted.

CHAPTER 2

BACKGROUND



Through the following publications:

Gonçalves F., Campos P., Clemmensen T. (2015) *Human Work Interaction Design: An Overview*. In: Abdelnour Nocera J., Barricelli B., Lopes A., Campos P., Clemmensen T. (eds) *Human Work Interaction Design. Work Analysis and Interaction Design Methods for Pervasive and Smart Workplaces*. IFIP Advances in Information and Communication Technology, vol 468. Springer, Cham.

Fuchsberger, V.; Murer, M.; Tscheligi, M.; Abdelnour-nocera, J.; Campos, P.; Gonçalves, F.; Barricelli, B. (2015). *Human Work Interaction Design (HWID): Design for Challenging Work Environments*, INTERACT 2015.

Gonçalves, F., Clemmensen, T., Campos, P., Molka-Danielsen, J., "Drifting towards a new HCI field: A Review of 10 Years of HWID Research". Submitted.

CHAPTER 2

BACKGROUND

This chapter presents the background about design, models of human work and measurements to support creativity.

2.1 Design Tools

In this initial section, creative writing is contextualized for the reader to understand how existing methods can inspire and serve creative writing user interfaces for the writing process itself. Afterwards, we describe state of the art regarding creativity support tools.

2.1.1 Creative Writing

As we know, writing is one of the main artistic expressions of humans. In ancient times, images were used as a form of expression, and nowadays we use images as a way of recording a moment that we want to continue or “use” later on. Creative writing often displays imagination or invention. It goes outside the bounds of normal professional or technical forms of literature and can be found in journalism, science fiction, etc. and typically identified through different forms such as prose, poetry and many assorted ways [8]. Writers tend to write using different techniques and they take their creativity from anything. The creative writing process can be divided into six different stages (see Figure 3). : pre-writing, drafting, revising, editing, evaluating and publishing [9]. But in this process, writers often have one or more creative blocks, and they need creativity for finishing their work. Sometimes writing might not be as easy as it seems, as there are millions of subjects a writer can write about, thousands of ways to spread the same idea, hundreds of tools to use to help them write. Deciding what to write about can sometimes be surprisingly tricky. Writers often face a

common problem known in this area as writer's block [10] . Writers refer to writer's block as the inability to write, despite the desire and ability to do so. There are different reasons for this situation to happen. Aspects such as stress, fear or simple problems with organization or prioritization can be the cause for it [11]. There are currently some possible solutions to this issue and each writer seems to have its own way to deal with it. Writers need to look for ways to get creative and finish their work.

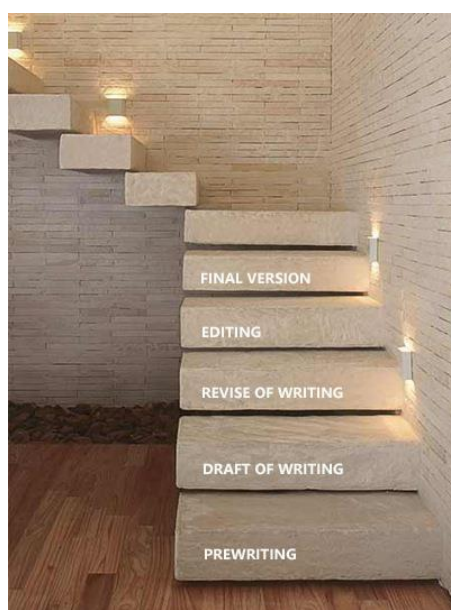


Figure 3 - The writing process.

Successful writers write regularly and develop a routine. Regular writers struggle with this [12]. Most of the work of successful writers (up to 90% of their work) does not make it to the final version [13]. However, regular writing strengthens their voice and their levels of motivation. The rise of digital computing exacerbated writing in all its forms. People in today's society have an even easier access to reading and writing. Some of the currently available writing tools attempt to initiate the process [14], providing story prompts, while others focus on creating a distraction-free user interface where writers can focus solely on their craft. Creative writing is a field that will continue to develop itself, because it is not just related to human creativity and to the significance of words as tools of human communications, but because it celebrates individuals as well as cultures [9]. It has also been reported to be among the most demanding creative tasks [15] [16]. It's an interesting and vibrant field that continues to evolve as complex as creativity itself.

2.1.2. Creativity Support Tools

New technological developments, such as those in the field of virtual reality, facilitate new forms of creative work. It is a two-way process, the interaction with technology provides fresh possibilities to use it in creative ways, while also leading to the evolution and sometimes transformation of technologies. Emerging computer-based tools can develop better and more creative solutions to the problems they face whether it's in decision support systems [17] or in simple software systems.

After decades of creativity research there is still no consensus on how to evaluate how well a Creativity Support Tool (CST) supports the creativity of its users [18]. Hedge et al. [19] considers that success during software development, depends on the creativity of software engineers, despite being a conceptually complex, knowledge-intensive activity. We can praise science and engineering, but there is still a paradox about technology that helps us to be more productive, perform our work more rapidly and effectively. Therefore, there is an effort for developing creativity support tools, which enable us to explore, discover, imagine, innovate, compose and collaborate [20]. Joy et al. [21] suggest that people who generate multiple possible solutions are more likely to produce solutions which are less common. Also, they argue that some people are more capable than others of *breaking free* from the mental set established by their initial ideas, therefore they are more flexible, from a cognitive point of view.

Selker [22] considers that creativity and motivation enhancement can easily be aligned with the design of high-quality human-computer interaction and also that creativity might be viewed as any process which results in a novel and useful product. Shneiderman [23] argues that it is a challenge to construct information technologies that support creativity and the goal of developing new CST can be obtained by building upon an adequate understanding of creative process.

The main goal of CST is to develop improved software and user interfaces that make users become more productive, and more innovative [23]. Search tools based on clustering, self-organizing maps, employing visual maps of semantic relationships are just one example of CSTs. Any user interface or software system that has a focus on improving creativity can be considered a CST: this naturally includes VR-based technology and tools, which show promising potential for effectively addressing the problem of improving creativity levels. Creativity and motivation enhancement can easily be aligned with the design of high-quality human-computer interaction and also creativity might be viewed as any process which results in a novel and useful product,

as stated by [22]. Researchers have also targeted other stimuli to support creativity, such as the visual stimuli, images and text, increase both originality and diversity of ideas during brainstorming [24] [25]. Other such as Gonçalves et al. studied UI Zen-based themes, composed of sound and images, foster inspiration, focus and immersion on creative writing tasks [26].

2.1.3 Creative Writing User Interfaces

Perhaps surprisingly, there is relatively little research performed around creative writing tools, but some researchers, e.g. Magnifico [27], have investigated how to improve the creative writing *process*. Giving students the opportunity to interact with real readers of their work may motivate them not only to write, but also to take on new literacies and to regard themselves as writers in new contexts. Advances in tool support have been mostly made in very specific areas. For example, Yannopoulos [28] proposed a symbolic language intended to express the content of films (motion pictures) much as notes provide a language for the writing of music, therefore bringing a new approach to the creative process of filmmaking.

Subsequently writing is often a collaborative activity and an approach to supporting creativity to encouraging awareness, for cases involving distributed collaboration activities. Farooq et al. [29] analyzed three groups collaborating on a research task in a distributed setting and identified four breakdowns in creativity: (i) Minority ideas were under-considered; (ii) Novel ideas were easily lost; (iii) There was a lack of critical evaluation of perspectives; and (iv) Reflexivity was weak during convergence [29]. More recently, Gramenos [30] notes that (a) There is no reliable way to tell if an idea that seems to be stupid is ground breaking or actually is stupid; (b) Ignorance can be synonymous with bias-free; and (c) Nonsense is far more powerful than sense and can provide solutions to problems that logic may deem unsolvable [30]. Others [31] chose to study the use of tools and resources for computer-supported collaborative writing. They implemented a custom-made, computer-supported environment that enables pairs of high school students to collaborate in writing an argumentative essay. They concluded that the tools analyzed reflected the writing strategies adopted by the students. Other authors focused on computer writing tools used during the production of documents in a professional setting [32]. They report on a focus group conducted with professional writers, in which writers narrated their experiences using computer tools to write documents, describing their practices, pointing out the most important problems they encountered, and analyzing their own needs. Based on this

work, they describe LinguisTech, a reference website for helping language professionals. Keeping in mind that one goal of digital tools for creative writing is to help users produce greater quantities of writing, some researchers note that the productivity expectations placed on writers are, at present, higher than ever before [9]. Therefore, there is a need for tool support that can promote not only writers' creativity but also their productivity levels.

Coughlan and Johnson [33] present three perspectives on creative interaction that have emerged from four years of empirical and design research. They argue that creative interaction can be usefully viewed in terms of *Productive Interaction* – focused engagement on the development of a creative outcome; *Structural Interaction* – the development of the structures in which production occurs; and *Longitudinal Interaction* – the long-term development of resources and relationships that increase creative potential.

Mobile narratives can be one way to reach this goal [34]. This concept allows creative writers to exploit knowledge of the reader's context, by intensifying the user experience and integrating that knowledge into the writing process [34]. Another approach is to use crowdsourcing, as in the case of Soylent, a word processor that integrates crowdsourced human contributions directly into the user interface [35]. Other tools support the more general concept of creativity. Adventure Author is a learning environment that supports the creative design process that occurs during game design [36]. Jones et al., for example, use creative writing as a means to teach introductory programming [37].

Some researchers, such as Steidle and Weirth [38] have investigated how the physical environment can improve the creative writing process. They report that messy, dark, noisy environments can actually stimulate creativity. In fact, dim lighting and darkness can encourage freedom of thought and can lead to a generation of ideas. Others researchers such as Shah et al. [39] have started to investigate creative writing with neuroscientific methods and the act of writing with some elements that characterized the process by a high hierarchical organization, and goal-directed thinking. The elements were task environment, the writer's long-term memory and the writing process. All of them combined with some techniques like brainstorming show that creative writing activated motor and visual brain areas for handwriting and additionally, cognitive and linguistic areas. Christiaans [40] suggest that as long as no absolute criterion of creativity exists, the assessment of creativity remains dependent

on subjective judgment. He refers that design can include more objective aspects that mainly involve the functionality and technical quality of the design. Creativity includes discovery or invention of a significant idea, pattern, method, or device that gains recognition from accepted leaders in a field [41]. Certainly, well-designed creative writing tools can help users in generating multiple levels of satisfaction, efficiency and creativity during the process of writing and tracking their creativity choices.

2.2. Models for Human Work

The limitations and work processes for how people work and interact are suffering changes due to the very fast development technologies. This section is therefore dedicated to covering the range of models that capture and describe the work practices and interaction of users and which were most influential in the present work. These include Activity Theory, Cognitive Work Analysis and Human Work Interaction Design.

2.2.1 Activity Theory

Many boundaries are collapsing in the world of work and in the conceptual frameworks of research on work [42]. The field of Human-Computer Interaction has been dominated by a cognitive perspective - people and computers are analyzed as equal members of an information processing system - in its approach to research [7]. To perform a specific task with the computer (e.g. writing a letter in the word processor) inputs and outputs of information are exchanged between the two as the individual works.

Over the last decades the proliferation of human civilization has significantly shifted from desktop computers to new devices such as tablet computers, large displays, smart mobiles among other ways which are used to exacerbate work in all its forms. The increasing adoption of computerized tools caused people to express themselves more easily and more often in diverse ways. Today, people are surrounded by intelligent and intuitive interfaces embedded in all kinds of objects. It is a true challenge to design applications that support users of technology in complex and emergent organizational and work contexts [43]. Information and communication technologies (ICT) and all artefacts would fade into the background while people are immersed in a digital environment [44].

Early work in HCI concentrated solely on this relationship between the human user and computer, ignoring the larger contextual factors that influence computer use. For example, the user who wants to write a letter using the word processor, is mostly likely not working in an isolated room, moving step-by-step through each of the procedures necessary to write the letter until it is complete. Rather, while working to write a letter, the user is interrupted by co-workers and performs other tasks like answering e-mail in between all of other activities.

Activity theory holds that the human mind is the product of our interaction with people and artefacts in the context of everyday activity [45]. This conceptual framework was originally developed by Leontiev's [46] and Vygotsky [47] and the foundational concept is "activity", which is understood as purposeful, transformative and developing interaction between actors ("subjects" and the world ("Objects") [48]. A new version (see Figure 4) of activity theory was proposed by Engeström [42] and it is today a global multidisciplinary research approach [42]. The theory provides a number of constructs by focusing on activities as the unit of analysis, activities as goal-directed or "focused" interaction of a subject with an object through the use of tools [49]. The "representation" of these tools are forms of mental processes manifested in constructs whether physical or psychological. This theory identifies both internalization and externalization of cognitive processes involved in use of tools, as well the transformation or development that results from the interaction [49].

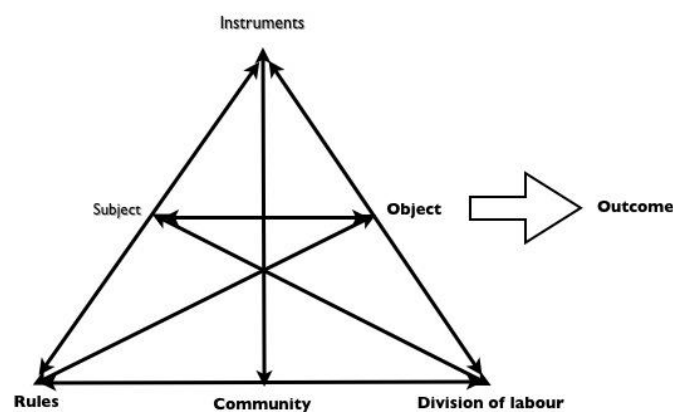


Figure 4 - Model example of human activity by Engeström [7].

As stated by Bazerman [50] as useful and ubiquitous as computers have become in human activity and as innovative as people have been in inventing new uses for computers, it is not easy to think in principled ways about how new computer systems can be made more useful for human proposes. Bardram et al. [43] states that human activity is executed in a hierarchy of three levels: activity-action-operation. They

report that an activity is always directed towards a motive, and can be divided into a series of actions, each of which are directed towards more specific goals. These goals are conscious; humans are aware of the goals they want to achieve. Actions, in turn, are decomposed into lower-level units of execution called operations, which are executed in accordance with, and adjusted to, the specific conditions of the context, in which the operation (and hence the action) takes place. Finally, operations are often automated (internalized) and people are typically not aware of how operations are performed – they become routine [43]. Bannon [51] criticizes the most contextual aspects in traditional HCI models like the human-information processor [52] and the use of the framework of activity theory for new methods, can overcome this limitation [53], [54].

2.2.2 Cognitive Work Analysis

The world is changing every second and we are looking for new ways of working, different creative conditions of work. Creative professionals such as writers often report they feel more creative when they are working at a special place or location or setup that increases their creativity. Understanding their process of work will help us obtain a good user interface that will assist their creative work.

Rasmussen et al. [55] developed a work-centered conceptual framework to analyze cognitive work. The purpose of Cognitive Work Analysis (CWA) is to guide the design of technology for use in the work place. It is unique because of its ability to analyze real-life phenomena while retaining the complexity inherent in them. When applied to information behavior, the approach guides the analysis of human-information interaction in order to inform the design of information systems.

CWA's theoretical roots are in General Systems Thinking, Adaptive Control Systems, and Gibson's Ecological Psychology, and it is the result of the generalization of experiences from field studies which led to the design of support systems for a variety of modern work domains, such as process plants and libraries. In the context of Information Science, the concept "information system" refers to any system, whether intellectual or computerized, that facilitates and supports human-information interaction [7].

Unlike the common approach to the design of information systems—design and development first, evaluation later—CWA evaluates first the system already in place,

and then develops recommendations for design. The evaluation is based on the analysis of information behavior in context. CWA has been successfully applied to the evaluation and design of information systems and collaborators. Cognitive Work Analysis considers people who interact with information “actors” involved in their work-related actions, rather than “users” of systems. Focusing on information behavior on the job, CWA views human-information interaction in the context of human work activities. It assumes that in order to be able to design systems that work harmoniously with humans, one has to understand:

- The work actors do,
- Their information behaviour,
- The context in which they work, and
- The reasons for their actions

Therefore, CWA focuses *simultaneously* on the task actors perform, the environment in which it is carried out, and the perceptual, cognitive, and ergonomic attributes of the people who do the task. A graphic presentation of the framework is given in Figure 5.

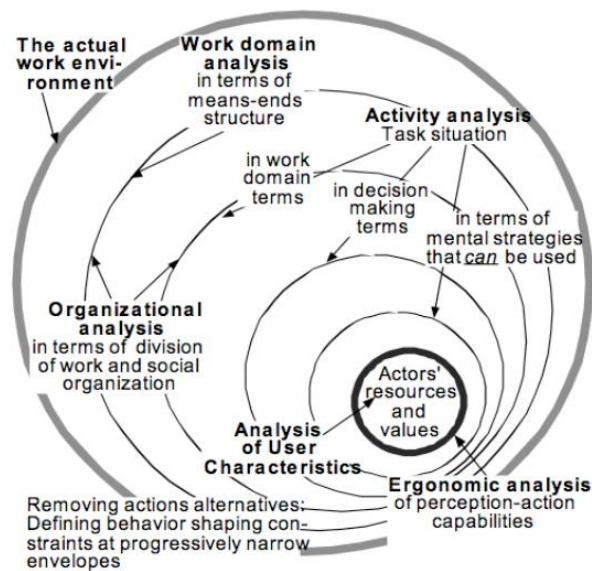


Figure 5 - The dimensions of Cognitive Work Analysis

In this presentation each set of attributes mentioned above is designated with a circle and is considered a dimension for analysis. Thus, each dimension is a host of attributes, factors, or variables— depending on the purpose and method of a study. In addition to the dimensions for analysis, CWA provides several templates to support

both analysis and modelling. These templates are particularly suitable for the analysis of complex and dynamic phenomena.

2.2.3. Human Work Interaction Design

The boundaries and work processes for how people work and interact are suffering changes due to the very fast emergence of new information technologies. To address this comprehensive problem, the Human Work Interaction Design Working Group was established in September 2005 under the auspices of IFIP, the International Federation for Information Processing [56].

HWID is an emergent approach that aims at connecting studies of work and the workplace with interaction design [57]. It builds on the tradition of cognitive work analysis [58]. The aims of the HWID working group were defined as follows [7]:

- To encourage empirical studies and conceptualizations of the interactions among humans, their different social contexts and the technology they use both within and across these contexts;
- Promote the use of knowledge, concepts, methods, and techniques that enable user studies to achieve a better apprehension of the complex interplay between individual, social and organizational contexts, and therefore achieve a better understanding of *how* and *why* people work in the ways they do;
- Promote a better understanding of the relationship between work-domain based empirical studies and iterative design of prototypes and new technologies;
- Establish a network of researchers, practitioners and domain/subject matter experts working within this field.

Thus, on an overall level of working group aims at establishing relationships between extensive empirical work-domain studies and HCI design.

In order to provide an easy understandable version of the framework that is applicable across domains, Clemmensen [57] developed a revised HWID framework (see Figure 6). The characteristics of humans and work domain contents and the interaction during their tasks and decision activities, individually or in collaboration, are the base of this framework.

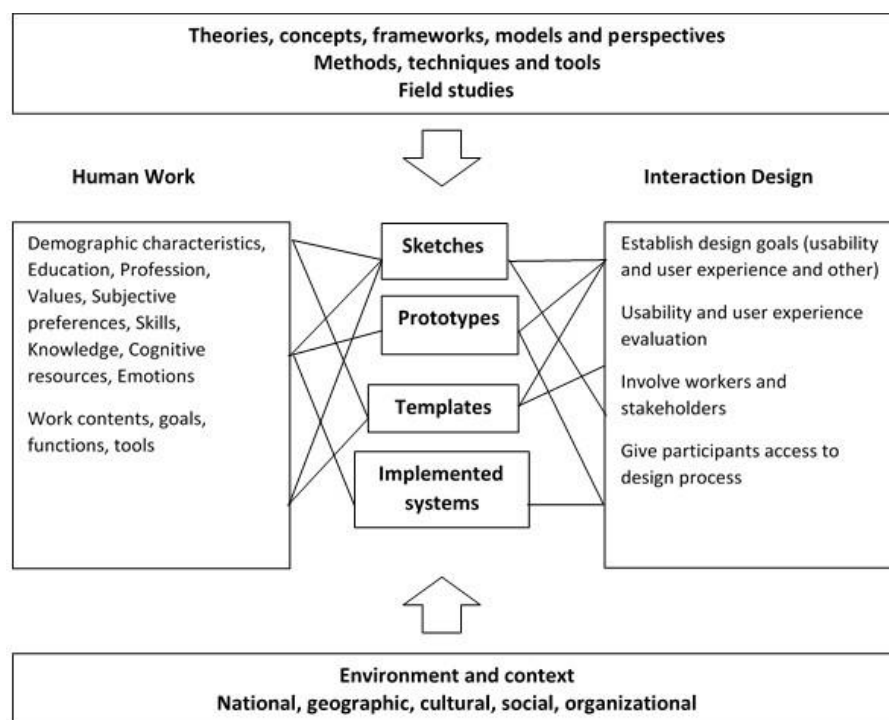


Figure 6 - Human Work Interaction Design framework

The top box illustrates the theories used, the left is the analysis of users' work and life, in the middle column the artefacts, and to the right the design of interactive information technologies. The box at the bottom indicates that environmental contexts, such as national, cultural, social and organizational factors, impact the way in which users interact with computers in their work and life. The lines connecting the left-right boxes illustrate the various relations between empirical work analysis and interaction design activities and products, which are the focus of HWID research.

For the early years of HWID research (2005-2008), Ørngreen et al. [58] reviewed the theory and empirical evidence behind attempts to combine empirical work studies and interaction design. Since then, the research in this area has grown significantly, and an updated review is timely. Gonçalves et al. [59], reviewed and selected 54 research papers about HWID from workshops, conferences and journals from 2009 until 2014. The review reflected diverse topics and problems that the authors of the 54 papers perceived to be the major concerns and challenges. The papers presented in this review illustrates that researchers have developed the understanding of the HWID notion by experiencing and texting the contextualization of the concepts and framework, either empirical or theoretically [59].

The authors decided to deepen the analysis and reviewed the 142 papers about HWID from workshops, conferences, journals and Springer book from 2005 until and

including 2015. HWID research has until now largely been published at workshops and conferences, in line with the format and aim of HWID being an IFIP working group. Furthermore, the 142 studies that are taking up the challenge are still relatively few as compared with other subfields of HCI [9, 10]. Over the last decade, researchers across five continents have studied what empirical relationships in work domain and HCI design also providing a cross-disciplinary cooperation studies, can enhance the HCI curriculum. Using bibliometric techniques, text-mining and co-word analysis, the authors [60] discover patterns and articulate information that drifts towards a new HCI field, formed around research on the relationships between work analysis and interaction design. Their findings reveal two major opportunities for design research in the work domain: a) human-centered design approaches for specific work domains (workplaces, smart workplaces); b) visions of new roles for workplaces that enhance both work practice and interaction design. Drifting towards new HCI fields opens up new possibilities.

Based on results from analysis and almost parallel to it, new research has emerged which will be addressed in the future as a consequence of a new HCI field called HWID. Figure 7 frames the vision of this new field. This vision places artefacts at the core that are outcomes of interactive systems designs, theories, methods, approaches in the context of human work within complex contexts. The vision allows for future design of a flexible yet integrating framework that can take into consideration the ever-blurring boundaries of what is work and the workplace. In addition, it anticipates that HWID systems must be research, designed and developed within complex contexts of multi-organizations, cultures and perspectives of understanding.

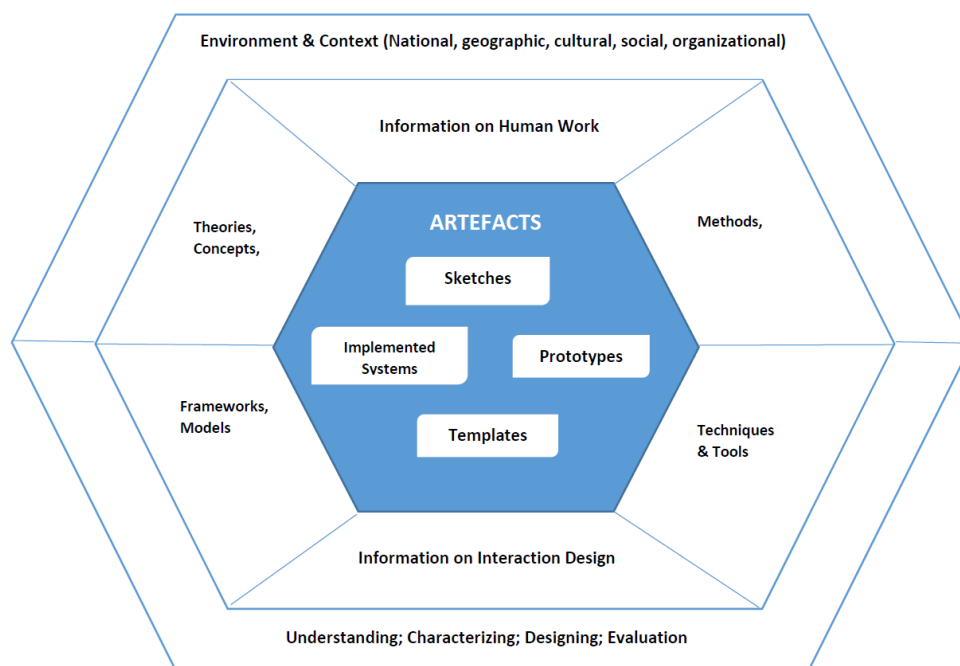


Figure 7 - A revised version of the general HWID framework a new HCI field.

The framework is defined as a hexagon. The inner-core represents "practical" constructs of HWID systems based on higher level "theoretical" constructs that include theories and concepts, frameworks and models, methods, technologies and tools, information on HW and information on ID. There is a need to develop this visionary meta-framework for HWID. Such a meta-framework will help bridge the gap between theoretical constructs and future practical implementations of HWID systems. . These elements form a set of sub aspects of Human Work and Interaction Design that identify what can be considered of great relevance for future search in the field of Human Computer Interaction.

While previous work [59] has outlined a research gap in the HWID framework and the need to better theories, concepts, frameworks models and perspectives in HWID, this work provides a new perspective to better understand the HWID and the way forward for research. Clemmensen [61] suggest that the development of a HWID framework may make it a better tool for mapping the combinations of multiple other theories onto the relations between Human Work and Interaction Design.

2.3. Supporting Creativity

Being creative is not something you can just turn on or turn off. It strikes at different times depending on the environment, your mood, the weather - you can name it. In fact when the upper limb of the sun disappears below the horizon the brilliance of nature becomes apparent, you can be creative. When I was writing this thesis, I went through something like this: "I'm trying to write my thesis, but I'm just not feeling very creative". Meanwhile, I knew that I had to be creative. The atmosphere in the living room was so cozy and cool when I sat at the table to write the thesis. On the table, there were these very beautiful pure blue bowls, simplistic in design, hiding a decadent surprise inside. I was using my best set of dishes. The bowls were hiding something irresistible, an indulgence which was worth every calorie that they knew it contained. When I looked inside I saw on the bottom of the bowl a hot, tender brownie loaded with nuts. I put one brownie on my plate, combined with two firmly packed scoops of ice cream, laying side by side, each one with a different flavor. Finally I completed this indulgence with a shower of chocolate sprinkles and maraschino cherry. My brain was delighted with what my eyes were seeing. It was a contrast of colors, textures and flavors appealing to every part of my senses. I could not wait to eat it. But I knew that something important was about to come. I had little time to finish this thesis and to find this way of describing what can be considered as "creativity". You can take charge of your creativity. Don't think of yourself as having a block, instead simply think of it as a need to overcome inertia.

Creativity is an inspiration many of us have and want more of [62]. Robinson [63], state that creativity involves putting your imagination to work. He also defines creativity as the process of having original ideas that have value. Nevertheless, to investigate creativity is appropriate to adopt a variety of methods and perspectives to make it plausible understanding. Creativity is a complex and multifaceted phenomenon [64]. Even with decades of creativity research, there is no single, agreed upon methodology for evaluating how well a creativity support tools to aid the creativity of its users [18]. There are also different studies to overview and measure the creativity behind ideas [65] but a lack of research work in creative writing user interfaces and tools, a gap this paper attends to address by giving insights to future work.

Despite significant efforts spent on creativity research, there is no consensual methodology for evaluating how much creative support a given tool can provide to its users. This is problematic because a solid evaluation is paramount to the design of new creative support tools as well as the improvement of existing ones [66]. One approach to dealing with this problem is the use of *triangulation methods*, which involve several temporal metrics, self-report ratings, external judgments, and physiological measurements [66]. Silva and Read [67] selected and defined four metrics to evaluate their creativity method: Mass of Ideas generated (MI), which is the number of ideas generated by a group divided by the number of participants; Quality of Ideas generated (QI), the average novelty rating (from three creativity evaluators) multiplied by the average appropriateness rating (from the same three evaluators); Enjoyment of Participants (EP); and Learning of Participants (LP). The five ratings are combined into a single calculable value metric, given by a formula. As the authors mention, HCI is not particularly strong when it comes to the evaluation of methods, especially with regard to creativity and innovation. However, evaluation and comparison are needed not only when one is required to select a specific method to work with, but also when one wants to compare the results of different methods [67].

Christiaans [40] suggest that as long as no absolute criterion of creativity exists, the assessment of creativity remains dependent on subjective judgment. He refers that design can include more objective aspects that mainly involve the functionality and technical quality of the design.

Creativity includes discovery or invention of a significant idea, pattern, method, or device that gains recognition from accepted leaders in a field [41]. Certainly, well-designed creative writing tools can help users in generating multiple levels of satisfaction, efficiency and creativity during the process of writing and tracking their creativity choices.

2.3.1. Creative Behavior Inventory

Among the many problems associated with the identification of creative talent is the problem of selecting appropriate criteria of creativity [68]. We should agree that measuring creativity is hard, because measuring “a thing” that is atypical, novel, innovative or unusual, be they products, ideas or people [69] it is difficult to generalize and to rank. Hocevar [70] developed the Creative Behavior Inventory (CBI) that tests how

divergent thinking and creative attitude measurements can predict future creative behaviors by examining past creative behaviors. Creative Behaviour Inventory (CBI) is a psychometric tool to investigate ones past creative behaviour and activities [71]. The CBI was used as a way to access the different creative levels of the participants. We used a subset of thirty items from the original CBI [71] [72], particularly the specific examples of creative activities such as: literature, miscellaneous, performing arts, science and music [69]. We used thirty items from the original CBI, particularly the specific examples of creative activities from literature, miscellaneous, performing arts, science and music [69]. We used the CBI as a psychometric tool to ask about past creative behavior and activities, and as a way to categorize how creative the participants were. An item score was based on response category: zero points for never, one point for once; two points for twice, three points for 3-4 times, four points to 5-6 times and five points for more than 6 times [68]. We classified subjects that had less than 30 points on the CBI as being *less creative*, and participants that had more than 30 points on the CBI as *highly creative* [18].

2.3.2. Flow Theory dimensions

Today there are many different approaches to measuring creativity: one of the most famous is Flow Theory [73]. Human psychology, our desires, emotions and motivations are changing over the time. People are easily distracted, but when we are involved in certain activities, sometimes nothing else seems to matter. Csiksentmihalyi [73] defines flow as “*a state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will continue to do it even at great cost, for the sheer sake of doing it*” [73]. As the author [73]argues that when we are “in the flow” we feel strong, alert, in effortless control, unselfconscious, and at the peak of our abilities. We all experience flow from time to time and we recognize its characteristics [73].

Csiksentmihalyi posits seven stages that combine together to bring a sense of deep enjoyment and full energy in the flow state:

- ✓ *Focused and concentrated* – completely involved in what we are doing;
- ✓ *A sense of ecstasy* – feeling outside of everyday reality;
- ✓ *Great inner clarity* – knowing what needs to be done, and how well we are doing;
- ✓ *Goals and feedback* – knowing that our activity and skills are adequate to the task;
- ✓ *Serenity* – a sense of having no worries about oneself, and of growing beyond the boundaries of the ego;

- ✓ *Timelessness* – being thoroughly focused on the present, as hours seem to pass by in minutes;
- ✓ *Intrinsic motivation* – whatever produces flow becomes its own reward.

In this thesis we were particularly interested in the following dimensions of Flow Theory: concentration, sense of control, losing track of time, and loss of self-consciousness (see Figure 8).

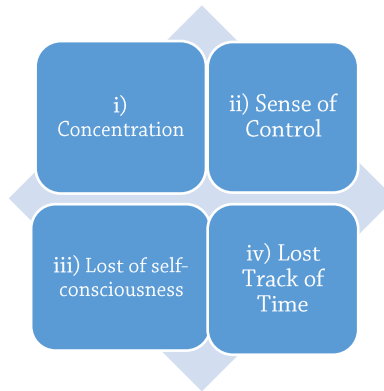


Figure 8 - Dimensions of Flow Theory

In order to assess the participants' mental well-being, we asked participants to select up to three adjectives from the following list: Surprised, Delighted, Laid back, Depressed, Pacific, Happy, Tired, Bored, Sad, Satisfied, Frustrated, Angry, Serious, Animated, Distressed, Creative, and Frightened.

2.3.3. External judging

The main focus of the Torrance Tests of Creative Thinking (TTCT) was understanding and nurturing qualities which help people express their creativity. These metrics are widely used to assess creative potential and have been subjected to a number of validity studies [74]. Using this psychometric approach, we used a group of external judges to rate the person's creative product – the writing challenge. Amabile [75] argues that creativity can be regarded as the quality of products or responds judges to be creative by appropriate observers, and it can also be regarded as the process by which something judged is produced. Christiaans [40] performed an analysis to determine whether human judgment of creativity is a reliable and valid method using design evaluations and selections. Comparing human judgments from experts, no experts, and people with an intermediate

level of expertise, his results show that as long as no absolute criterion of creativity exists, the assessment of creativity remains dependent on subjective judgment. We didn't provide a definition of creativity to the judges as suggested by Amabile [76], in order to allow people to use their own definition and make them more consistent. In order to assess if there were any differences between the results from participants and each condition, we recruited in the studies that was conducted experts in Creative Writing, Arts and Psychology to rate the creativity of all written data per writing challenge. They were not involved in the sessions in any way and rated individually the written data without knowing which tool the users had used. We asked them to for a score ranked in a 7-point Likert with the evidence scale for 1 (not creative) and 7 (very much creative) taking into account the three creative abilities per answer: Flexibility (production of different ideational categories), Originality (production of unusual ideas) and Elaboration (persistency on introducing details to products) from the Torrance Test of Creative Thinking (TTCT), [77] [78].

2.3.4. Creativity Support Index (CSI)

The Creativity Support Index (CSI) is a survey to assess a tool's creativity support which users provide ratings for six dimensions of creativity support: Enjoyment, Exploration, Expressiveness, Immersion, Results Worth Effort, and Collaboration [79].

2.3.5. Self-assessments and Post-experiment interviews

In this thesis interviews were conducted to collect qualitative data about the experience with questions such as "*Did you enjoy to write in this environment and why?*"; "*In this environment did you feel more creative and why?*" to know the participant's opinion about the whole experience, and also we asked participants to self-rate their creativity [80], answering the question "*I consider myself a creative person*" ranking a seven-point Likert with the evidence scale for 1 (totally disagree) and 7 for (totally agree).

2.3.6. Increased output

The results were analyzed from a perspective that triangulates the amount of words written, the average word length during a fixed amount of time, and the interviews to the participants. We started counting the number of words written per participant in each tool. Regarding the results obtained with the count of words written, we also considered

the average word length (that gives us the mean number of characters per word) for us to have more results to be analyzed [81]. Using the keystroke logging program called Inputlog [82], we had in some studies conducted, an overview of information's such as the average time in each session on the writing activity using the keyboard, the average time pauses in each session while writing and the average of switches between mouse and keyboard in each session.

2.4. Conclusions

This chapter presented a brief survey on design, models of human work and measurements to support creativity. We focused the analysis on the work-capturing models that were most motivating to the models and tools we will present in the following chapters. The importance of measuring and supporting creativity is proven and accepted nowadays. However, more research should be devoted to bringing creativity to the interaction and user-centered design tools themselves. In the following chapter, we will survey some of the creative writing tools that are currently employed by users in their quotidian endeavours.



PART I I
UNDERSTANDING
AND EVALUATING
CREATIVE
WRITING
ENVIRONMENTS

CHAPTER 3

UNDERSTANDING CREATIVE WRITING UI



Through the following publications:

- Gonçalves, F., Campos, P., Garg, A., (2015). *"Understanding UI Design for Creative Writing: A Pilot Evaluation"*. HWID, INTERACT 2015, Bamberg, 14-18 Sept., 2015.
- Campos, P., F. Gonçalves, M. Martins, M. Campos, and P. Freitas, (2014). *"Second Look: Combining Interactive Surfaces with Wearable Computing to Support Creative Writing"*, Proceedings of the Ninth ACM International Conference on Interactive Tabletops and Surfaces, Dresden, Germany, ACM, pp. 323–326, 11/2014.
- Campos, P., F. Gonçalves, M. Martins, M. Campos, and P. Freitas (2014). *"Second Look: Combining Wearable Computing and Crowdsourcing to Support Creative Writing"*, Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational, Helsinki, ACM, pp. 959–962, 10/2014.
- Buenafe, S., L. Guzman, N. Kannan, K. Mendoza, N. J. Nunes, V. Nisi, P. Campos, F. Gonçalves, M. Campos, and P. Freitas (2014). *"Yarn: A Product for Unraveling Stories"*, Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational, New York, NY, USA, ACM, pp. 1089–1094, 10/2014.
- Gonçalves, F., P. Campos, (2014). Towards supporting "in-the-moment" Creativity: combining Crowdsourcing with Interactive Surfaces. Workshop "Collaborative Meets Interactive Surfaces (CMIS): Walls, Tables, Tablets and Phones" in the International Conference on Interactive Tabletops and Surfaces, Dresden, Germany, ACM.
- Gonçalves, F., P. Campos, (2014). Towards Pervasive and Inspiring Workplaces for Creative Writers: Simple Interactions for a Complex Domain. Workshop "Human Work Interaction Design (HWID) for Pervasive and Smart Workplaces in the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational, Helsinki, ACM.

CHAPTER 3

UNDERSTANDING CREATIVE WRITING UI

This chapter revolves around gaining insights about the users' writing perspectives on their own writing process, as a way to naturally brainstorm tools and techniques that better support that process.

3.1. Dimensions for Creative Writing UI

From a previous study, Yarn² [83] a new writing application (see Figure 9), we learned significant aspects of what makes a good writer and what do writers need to do in order to unblock their ideas and produce creative pieces. This study reveal that writers need to be observant and empathetic, need to be tenacious and need to be inquisitive. Based on that user research, we realized that the activity of creative writing was based on several different aspects, and found six key insights:

1. Writers draw inspiration from anywhere and everywhere.
2. Community is integral for feedback and moral support.
3. Successful writers write daily and develop a routine.
4. Iteration helps improve the quality of writing.

² <http://www.the-yarn-app.com/>

5. The writing process is nonlinear and writers frequently have to reorganize their thoughts and written texts.
6. Writers find their best ideas and inspiration when they are unhindered and undisturbed.

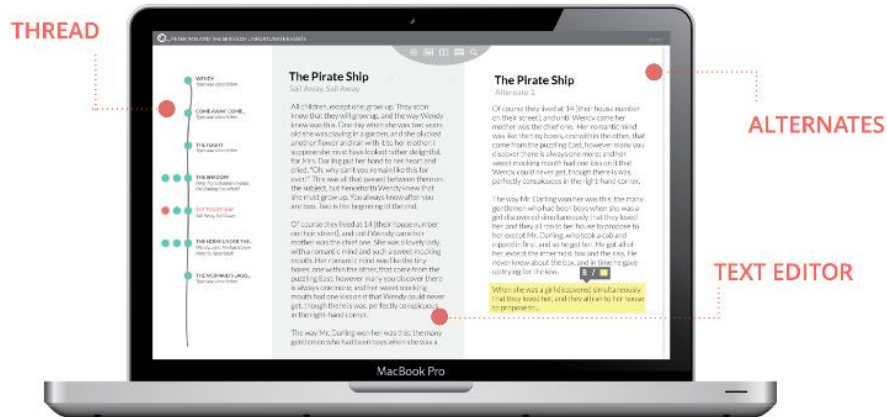


Figure 9 - Final look of the Yarn tool

Taking into consideration that digital tools for creative writing should help users produce more, some researchers note that the productivity expectations towards writers are higher than ever [2]. Therefore, there is a need for tools that can promote not just the writers' creativity but also their productivity levels. Our previous study contributed also for identifying a set of **design dimensions for creative writing tools**: serendipity, evolution, shuffle and haven (see Figure 10).



Figure 10 - Dimensions for creative writing tools.

3.1.1. Serendipity

Serendipity, the first dimension in the model, explores the notion that creativity can come at any place and at any time. This concept tries to capture rushes of inspiration then and there. We found out that there is a community aspect involved in the creative process; writers take ideas and inspiration from their friends, family, and their own peers. With those two ideas in mind we came up with Serendipity. The concept can become materialized in a mobile application where the writer could capture bursts of inspiration in audio, video or picture form and leave them in the geographical location. Other users of the application could also use the application to find these thoughts other writers have left behind, and use them as a way to inspire their own work. Writers find inspiration everywhere and tie places and people to their work. Therefore, this dimension involves mobility, geo-location, tagging of stories and other inspiration sources, and also an unpredictability factor that promotes discovery and ultimately creativity.

3.1.2. Evolution

In our user research proved that writers confront and evaluate multiple alternatives while writing. Most of the work that successful writers perform (up to 90% of their work) does not make it to the final version [1]. Yarn had to support the generation of new ideas (and elimination of old ideas), the comparison and evaluation of different ideas and alternatives, and provide writers with a sense of progression. We call this dimension “Evolution”, as any tool should support the brainstorming, revision, progress and individuality of different writing pieces.

3.1.3. Shuffle

Writers should be able to write and see their ideas in a non-linear fashion. This is an essential dimension for our approach. The final solution should allow writers the freedom to move ideas around, be flexible, shuffle and mix. Tools should adapt to the writer and not the other way around. Supporting the Shuffle dimension also implies being able to improve focus, supporting alternative plot writing, supporting both major and minor changes to manuscripts and a good degree of flexibility, in general.

3.1.4. Haven

Their final dimension is coined “Haven”. We all know writing is hard work, and writers often need a few conditions, their “sweet spot”, in order to do their best work. For some, it might be at home in complete silence, others at a coffee shop during peak business time. Haven, as a design dimension, implies immersion, relaxation, imagination, finding that “sweet spot” and the right conditions for creative writing.

3.2. Simple interactions for a complex domain

How we can obtain benefits from designers by connecting human work analysis studies and the interaction design to support creative writing, which is also a complex domain that can be studied under the Human Work Interaction Design (HWID) framework? It is difficult to design creativity support tools to unblock writer’s block, because to measure and to verify if the features of the tool are helping the writer and supporting “*in-the-moment creativity*” can seem like a simple task but it is actually very complex. Many different aspects such as emotions and cognitive abilities, skills, knowledge, directly affect that simple task for measuring the creativity of each user. To provide an easy understanding and to illustrate the coverage of this research topic, we developed an initial analysis for a simple process in human work, such as writing (Figure 11). Human Work Interaction Design, is a comprehensive approach in HCI, and to provide an easy understanding based on a revised version of the general HWID, we reproduce the characteristics of humans and work domain contents and the interaction during their tasks and decision activities, individually and collaboratively. Using the general framework, we then specialized a model for the process of creative writing based on this [57].

The result so far is shown in Figure 11. On the “Human Work” column, we identify the state of emotion. Keeping a story on track and a non-linear work style are essential foundations for the final writing work, and they should also shape the design of the tools supporting it. The whole process is quite complex and for instance one simple interruption can potentially break the whole creative thinking. Therefore, we created new scenarios that support and complement the process. In this quest for pervasive and inspiring workplaces for creative writers, we propose to leverage emerging wearable devices in order to come up with simple interactions for this complex domain.

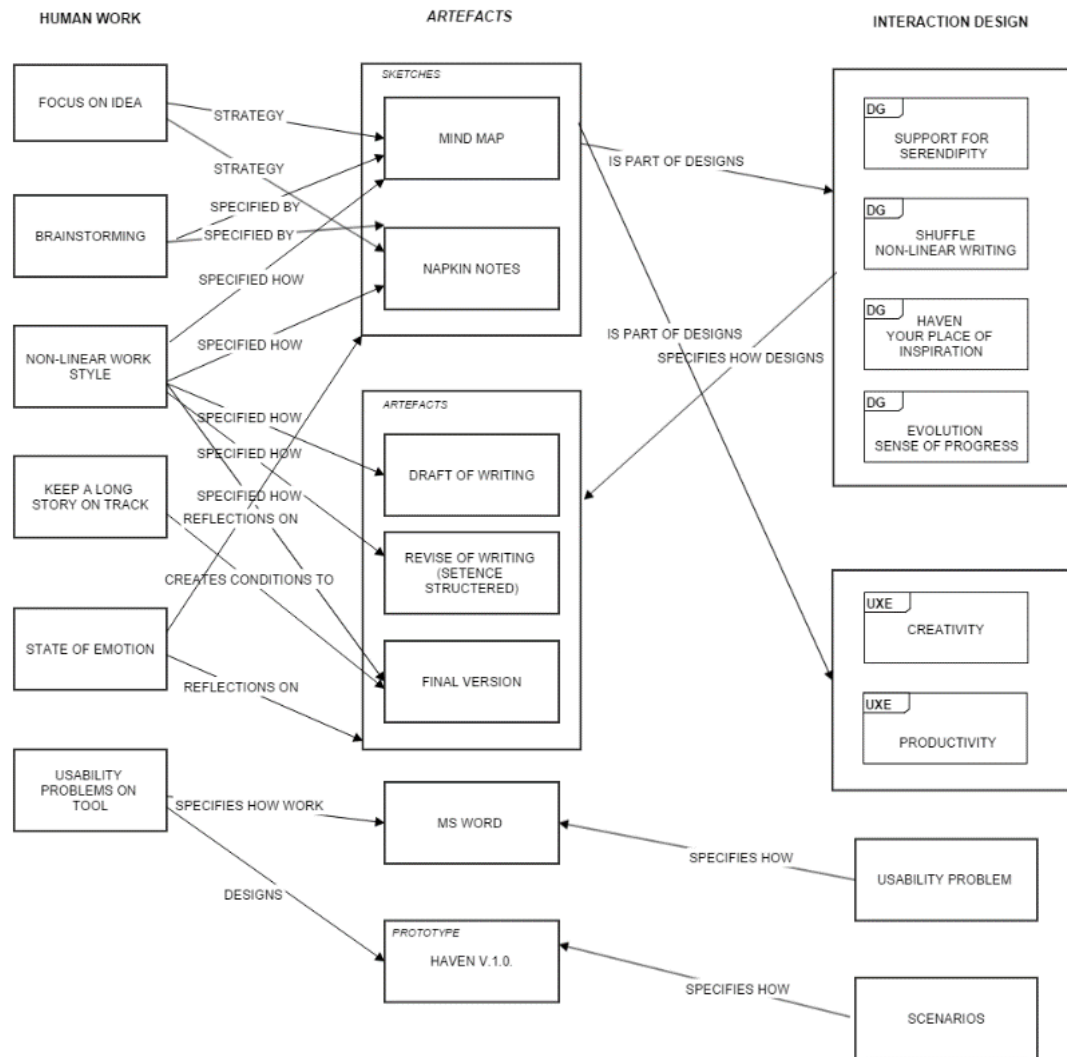


Figure 11 - Initial analysis of connections between Human Work analysis and Interaction Design in the case of creative writing.

This initial analysis was created with the intention to spark an initial discussion around human work interaction design, with the simple focus of analyzing the task of writing and then in more length with the near future, such as smart watches and smart glasses. This can be integrated with interactive surfaces in such a way that they could improve the creativity and productivity of creative writers and overcome writer's block. Therefore we propose a pervasive and hopefully more inspiring workplace for all writers.

3.3 Second Look

A primary challenge in developing and evaluating creativity support tools is that we are not able to detect when a person is being creative. We present “Second Look” (see Figure 12), a platform for helping people, in particular creative writers, to overcome writer’s block. This ubiquitous platform combines augmented reality (Google Glass and AR markers), ubiquitous computing (mobile phones), and crowdsourcing in order to improve the creativity, focus and performance of creative writers. Our approach improves current ones by exploring the “in-the-moment” creativity and supporting it with adaptive ubiquitous technologies that try to keep people in a creative experience peak for a longer period of time.

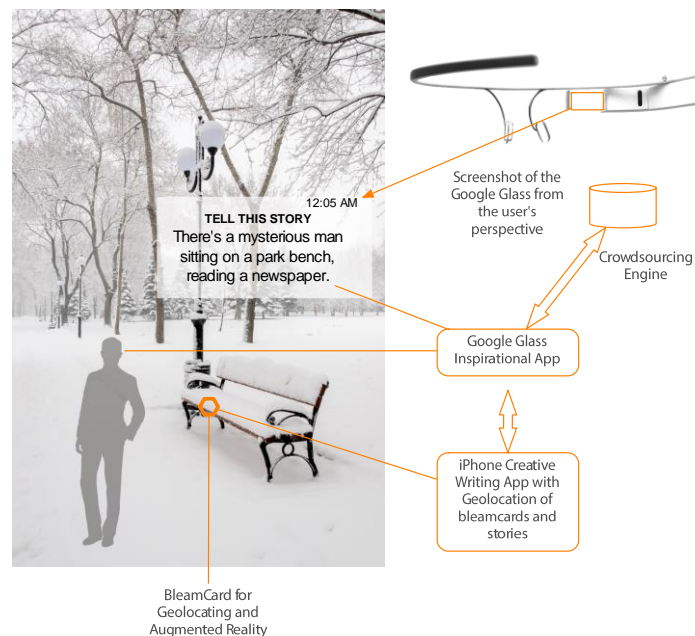


Figure 12 - A possible scenario for Second Look.

We describe a ubiquitous platform that aims at leveraging emerging ICT technologies to design, implement and take to market a novel set of products targeted at creative writers, especially those who work at creative industries SMEs and wish to become more creative by adopting better tools for creative writing. These products are a Google Glass app and a companion iOS (iPhone and iPad) app. The Glass app’s goal is to support serendipity and inspiration for writers on the move. The iOS app also supports that and allows the improvement of writing pieces as well as the evolution of creative texts, also on the move. These apps will connect to a crowdsourcing engine that will foster the sharing and

searching of creative bits (poetry, writing prompts, scenarios, photos, videos). They will also connect to a workflow engine that will tailor the writing process to individual needs.

Our proposal is better than the current state of the art tools, because it addresses the specific challenges faced by creative writers. Moreover, it embodies a platform for the creation, searching and sharing of creative bits that compose the essence of this activity. Second Look's tools are ubiquitous, which means for added support to the inspiration sources that come up everyday, anytime, anywhere. The wearable technology Google Glass has not hit the market yet, but developers are rushing to build apps for the new device to take advantage of what they hope is the "next big thing". In this poster, we argue that wearable devices, like the Glass, may also find application as a channel for creative expression. A final aspect of innovation worth mentioning is related to the way people collect and share bits of creativity, especially writing bits. A better understanding of how creativity is spread, stored and reused is a side effect result that will arise from the data we will sample through the platform, specifically from the crowdsourcing engine, which will embody a "collective intelligence" of creative writers.

Usage Scenario

Figure 13 shows one possible scenario of usage. A writer is taking a walk through a park. He is looking for something to inspire his next novel, and wearing a Google Glass creative writing app for supporting serendipity. The Glass's GPS is connected to a crowdsourcing engine that looks up the creative writing prompts for a particular bench in that park (which were placed there previously by another user who thought the bench was a good spot). The app then displays:

TELL THIS STORY:

She was sitting on a park bench, and touched the little box in her pocket with a big smile on her face.

The writer finds it curious, so he scans for an augmented reality tag that triggers a series of comments other creative writers have made about stories in parks, as well as other people's photos taken during moments of inspiration. Or if he is wearing an Apple Watch, the creative writing app connects to a crowdsourcing engine and shows the creative prompts by a watch message, ordered and ranked.

Finally, inspiration is found everywhere, and writers tie people and places to their writings. Taking advantage of the Glass's quick picture button, the writer takes a photo of

the park bench, something that he will revisit mentally when he goes back to his desktop-based creative writing app at home. With the Apple Watch the writer can send a quick message about the landscape he is seeing or feeling. We can also create new creative prompts about it. The next day, another user feels in need of inspiration and opens his mobile app to check if there are any AR markers near his location. He notices that there is one active in that same park that is just across the street from his house so he goes there in order to scan the card and be able to read the original prompt and the story written by all the other users relative to that card.

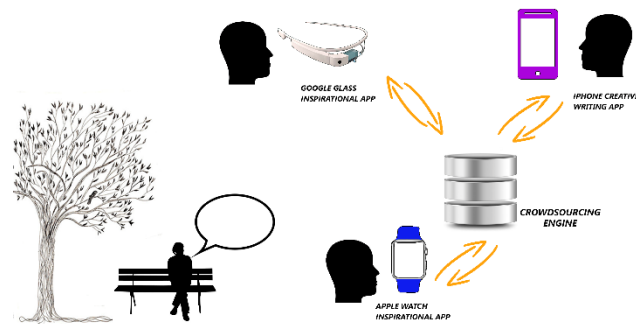


Figure 13 - The overall architecture based on the crowdsourcing engine.



Figure 14 - A Second Look user – a creative writer – spots an inspirational spot for her next novel and geotags some photos with Google Glass. At the same time she also uses the mobile app to write a few lines from her “in-the-moment” creativity and geotags them

In the near future, smart glasses or smartwatches, will not just be a scaled down add-on to existing devices but an augmentation of a user's primary sense (e.g., Figure 14). This

can be integrated with interactive surfaces (iPhone and iPad) in such a way that they could improve the creativity of users and overcome writer's block. The process for poetry generation or any other kind of creative writing is very strongly visual. A visual trigger is usually involved, and a textual leap from image or motion happens. We believe that mobile interactive surfaces coupled with Google Glass or similar devices will become a natural part in that chain, and that it also will help users to use their natural inventive process for writing and give them a pervasive and hopefully more inspiring workplace.

3.4. Conclusions

In this chapter, we investigate the current trends in tools for creative writing and design software applications in particular. Gaining insights about the user's writing perspectives on their own process, and combining them with the dimensions for creative writing, gives us useful perceptions about what tools and techniques can be more adequate to support the process of writing. In the following chapters, we will survey different techniques and methodologies using creative writing tools that are currently employed by users in their quotidian endeavours.

CHAPTER 4

EVALUATING CREATIVE WRITING UI



Through the following publications:

Gonçalves, F., Campos, P. (2017) "*Understanding and Evaluating the User Interface Design for Creative Writing*".
Submitted.

CHAPTER 4

EVALUATING CREATIVE WRITING UI

Recent decades brought us technological advances which have been able to significantly improve the writing activity. Everyone writes, and everyone has a wide variety of creative writing tools for that. In this study, we present a study with 23 user experiences and interviews, regarding four different writing environments in a within-subject design. We obtained a deep understanding of which tool promotes higher levels of satisfaction and creativity during the process of creative writing. First, we defined and compared what coin as creative writing Dimensions (Serendipity, Haven, Evolution and Shuffle), combined with the Technology Acceptance Model dimensions. Through distinct evaluation methods, we discuss the results about how the usage of different creative writing environments can produce results that allow a better understanding of the user interface design process for users.

4.1 Introduction

In this study we used triangulation methods [66], involving several temporal metrics, self-report and external judgments to assess satisfaction and creativity of users in four different writing environments: Microsoft Word, Scrivener, OmmWriter and Ulysses. We also explore how current tools can give us useful insights in order to develop a novel tool for supporting the creative writing process and how to help people overcome writer's block.

The remaining of this study is organized as follows: in the next section, we revise related work and then present a section describing the study itself. After that, we present the results with statistical support. Finally, we make a discussion of our results that also includes some reflections on the entire experience.

4.2 Dimensions for creative writing tools versus Technology Acceptance Model

Guzman et al. [84], based on user research, recognized that the activity of creative writing was based on several different aspects. They frame the results from the user research and they identified a set of design dimensions for creative writing tools: *Serendipity* (writers find inspiration everywhere and tie places and people into their work), *Evolution* (writers confront and evaluate several alternatives while writing), *Shuffle* (writers should be able to write and see their ideas in a nonlinear fashion) and *Haven* (writers need a sense of isolation and calm while writing).

The Technology Acceptance Model (TAM) attempts to predict and to explain computer-usage behavior, offering both researchers and practitioners a direct, pragmatic instrument to measure a given technology's degree of acceptance [85]. It is simple to use, and it is a cost-effective tool for evaluating applications, reliably predicting whether they will be accepted by users [85]. Based on the framework of Campos [7], we designed our framework (see Figure 15) that is basically an extension of TAM to compare the creative writing dimensions with that model as mentioned before.

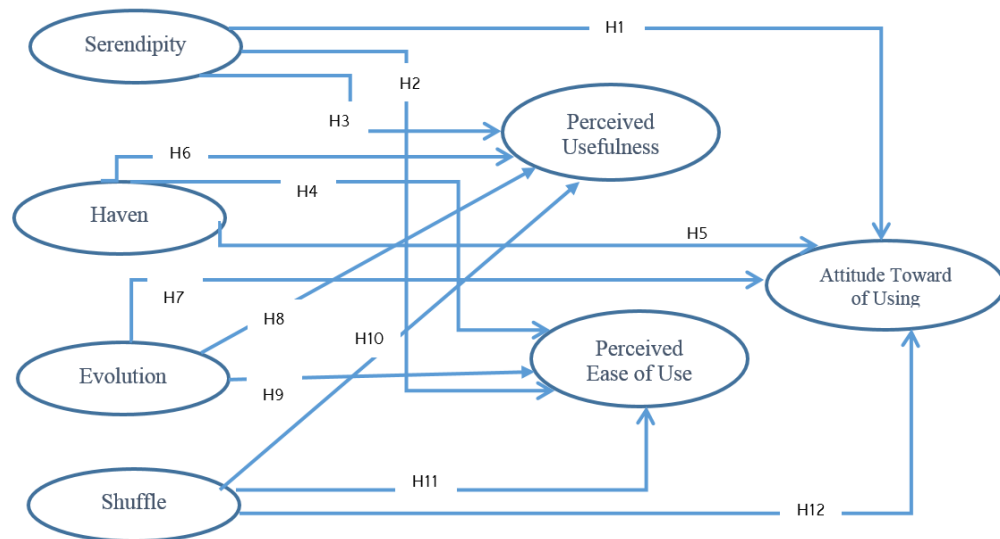


Figure 15 - Hypotheses considered in our framework.

We are basically considering the influence of the different creative writing dimensions on each of the TAM's constructs: Perceived Usefulness (PU) – the extent to which the user expects the system to improve his job performance within an organizational setting;

Perceived Ease of Use (PEU) – the degree to which the user believes the system’s use will be free of effort and Attitude toward Using (AU) – the user’s desire to use or favourableness feelings towards using the system [85]. We employed hypotheses such as for example- H1: Serendipity influences Attitude toward of Using.

4.3 User Study - Challenge to write

We used an experimental design based on a within-subject setting to investigate the influence of different creative writing tools in the users’ self-perceived satisfaction and creativity during a writing task. Since the study was geared towards understanding writing environments, as a prerequisite we recruited only participants that reportedly enjoy writing and had computer and Internet experience since our questionnaires are all online. To control for carry-over effects, the order of the conditions was counterbalanced between subjects.

Conditions

How to effectively design a usable user interface for supporting creative writing has been a challenge for UI designers. Everyone writes, and everyone has a large market of creative writing tools for that. We selected four different creative writing tools:

- I. **MS Word - baseline:** One of the most used tools, Microsoft Word has a larger variety of formatting options, including a variety of color choices, the ability to change font-weight and many other things that allows also users easy and near-instant textual input.
- II. **Scrivener - many features to discover:** Users can write and perform research at the same time. It is the most popular one for professional writers. With Scrivener, writers can organize content easily but this UI can also be a way to distract or annoy users [86].
- III. **OmmWriter - calm and relax environment to write:** This tool is clean and light, with music to provide inspiration to writers and a full screen mode [87].
- IV. **Ulysses - concentrate and write:** Very minimalistic and focused tool can keep all writers texts neatly stuffed in its intuitive library [88].

Task

Participants had to write a specific challenge using the addressing tool. Examples of the writing challenges included: *"It was a smile that darkness could kill..."*; *"You are walking through a field with your best friend..."*; *"And you thought dragons didn't exist..."*; *"If your life was a cartoon..."*. These were conceived by one of the authors. Experts in creative writing and literature evaluated them before the experience, taking into account the degree of

difficulty, in order to be as homogeneous as possible. The time was limited (5 minutes) for each writing challenge.

Participants

This experiment was conducted during two weeks and involved 23 participants (6 females and 17 males) aged between 18 and 35 years old ($M=24.5$; $SD=5.4$). They were recruited through a university-wide mailing list. We lead one session per person. All subjects were naïve to experimental conditions. All participants assumed that writes more than two hours per day.

Measures

During this study, we used the dimensions of creative writing (*Serendipity*, *Evolution*, *Shuffle* and *Haven*) to compare with the dimensions from the Technology Acceptance Model (TAM) and we made correlations with both, to determine the user's perceived satisfaction. The survey was divided into two parts. The first part was based on the following creative writing dimensions as stated above: Serendipity, Haven, Evolution and Shuffle [15, 14]. Four questions were designed for each dimension. The questions were developed by us and were based on previous studies [15]. Participants ranked a 7-point Likert with the evidence scale for 1 (not really) and 7 for (yes, very much). The second part of the survey was based in the Technology Acceptance Model (TAM) [85] with questions regarding three dimensions: Perceived Usefulness, Perceived Ease of Use and Attitude toward Using. Participants ranked a 7-point Likert with the evidence scale for 1 (not useful / disagree), 4 (neutral), 7 (very useful / agree). The questionnaire can be accessed online³.

A reasonable statistic to measure the efficiency and making comparisons to single tools across different instances of use and to determine how efficient the tool can be, we used the number of words written and also the average word length [81].

We collected qualitative data with a semi-structured interview with questions such as: *“Did you enjoy to write in this environment?”*; *“This environment gave you more conditions to be more creative?”*; *“The writing challenge helped you initiate your writing?”*; *“Is there any comment would you like to add?”*; *“The time was limiting your creativity?”*, in order to know the participant's view about the whole experience.

³https://docs.google.com/forms/d/1Y7iwsfRVPm-tkHWm166YSC_Rz4HnS291iA1uR2W_hEM/viewform

When analyzing creativity, in this study, we used a panel of judges. External judges are also often used in creativity research to rate person's overall creativity or to rate a person's creative product [66] [89]. We recruited five experts in Creative Writing, English Literature, Arts and Psychology to rate the creativity of all written data per writing challenge. They were not involved in the participatory sessions in any way and rated individually the written data by assessing a database without knowing which tool the participants had used. They were asked to provide a value ranked in a 7-point Likert with the evidence scale for 1 (not really) and 7 (very much) taking into account the three creative abilities per answer: Flexibility, Originality and Elaboration [77].

Procedure

A preliminary evaluation was conducted with five participants to examine the feasibility and accuracy of the data collection and identify potential bias. They were asked to write a short story during ten minutes using each creative writing tool. Participants reported that ten minutes was too long. It was considered the study may be conducted according the procedure but with less time for each writing challenged.

Participants were brought individually to a quiet room in our research laboratory (see Figure 16), previously prepared for the experiment. For the examination, we used two laptops computers with a screen size of 13.3 inches and a display resolution of 1920x1080 pixels.



Figure 16 - Performing the study in the research laboratory: Participants were seated alone in a quiet room to answer the writing challenges.

When participants entered the room, they were asked to sit and before they started the experience, the experimenter ran the tool and asked them if they wanted to change little things in the environment, such as font size/type or something else. They had a few minutes to know each tool. We did this because we were using different tools that they could be unfamiliar with as a way to reduce bias or any aversion to a given tool. During the experiment, the participants were seated alone to eliminate any noise from the tools

(some tools have background sounds) and also to not compromise the study with distractions.

When they finished the writing challenged, they were asked to fill the survey that captured the user's perceived satisfaction. Finally, participants were interviewed based on their experience using the tools.

The total time per user took over thirty minutes, it included the instructions, experiment and post-experimental semi-structured interviews. Participants were allowed to take breaks between each experimental condition.

4.4 Results

We analyzed the results from a perspective that triangulates the data from the questionnaire, the statements of the interviews and the quantitative measurable information of the writing challenges. We also discuss the particularities of each participant tool to elucidate the potential design qualities of singles features from each tool. We used SPSS 22 [90] for all statistical analysis.

Which tools can promote higher levels of satisfaction?

To assess the reliability of our questionnaire we used Cronbach's alpha [91]. The polarity of the scale was taken into account. Table 1 exhibits results for reliability analyses (internal consistency) for questions in each dimension.

Table 1 - Results of Cronbach's alpha.

		Cronbach's alpha
Creative writing dimensions	Serendipity	.804
	Haven	.791
	Evolution	.777
	Shuffle	.800
TAM	Perceived Usefulness	.889
	Perceived Ease of use	.882
	Attitude Toward Using	.874

Results show that the average inter-correlation among the items as well as the number of test items can be considered consistent [91] in the scale used from the questionnaire (seven-point Likert scales).

We compared the creative writing dimensions (*Serendipity, Shuffle, Haven, Evolution*) with the TAM dimensions, performing tests of correlation using Spearman's correlation coefficient [91] to verify if the creative writing dimensions influences the TAM dimensions. Table 2 shows the results regarding the correlation values we obtained between dimensions.

Table 2 - Correlation between survey items.

	Ulysses	Scrivener	OmmWriter	MS Word
H1	.953**	.695**	.569**	.723**
H2	.885**	.786**	.678**	.510**
H3	.823**	.599**	.704**	.738**
H4	.832**	.701**	.710**	.503**
H5	.897**	.816**	.865**	.654**
H6	.682*	.712**	.900**	.738**
H7	.891**	.628**	.805**	.719**
H8	.839**	.755**	.843**	.790**
H9	.867**	.507**	.736**	.399*
H10	.872**	.620**	.668**	.812**
H11	.760**	.541**	.532**	.717**
H12	.788**	.719**	.683**	.788**

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

Results are significant and the correlation values are positive. Therefore we can assume that the hypotheses are supported. The tools were significantly related to user's perceived satisfaction as shown previously, $p < .01$. From H9, Microsoft Word was correlation-significant at $p < .05$.

Creative writing dimensions & TAM versus Conditions

Table 3 exhibits statistical results for each creative writing dimensions and TAM dimensions in each tool.

Table 3 - Average (SD) for each Creative Writing Dimensions and TAM dimensions in each tool.

		Ulysses	Scrivener	OmmWriter	MS Word
Creative Writing dimensions	Serendipity	4.5 (1.33)	4.7 (1.40)	4.9 (1.19)	4.6 (1.33)
	Haven	5.1 (1.43)	4.6 (1.28)	5.5 (1.36)	4.3 (1.43)
	Evolution	4.7 (1.49)	4.2 (1.37)	5.3 (1.28)	3.9 (1.37)
	Shuffle	4.3 (1.34)	4.2 (1.49)	4.6 (1.22)	4.7 (1.49)
TAM	Perceived Usefulness	4.4 (1.68)	4.7 (1.46)	4.9 (1.57)	4.5 (1.46)
	Perceived Ease of Use	5.3 (1.57)	5.3 (1.40)	5.5 (1.34)	5.1 (1.30)
	Attitude Toward Using	4.9 (1.81)	4.9 (1.44)	5.2 (1.42)	4.8 (1.50)

Testing differences between each tool and creative writing dimensions using ANOVA with repeated measures with a Greenhouse-Geisser correction, the mean scores for *Serendipity* dimension ($F(2.526, 55.563) = 0.512, p > .05$) and the mean scores for *Shuffle* dimension ($F(2.558, 56.267) = 0.845, p > .05$) did not exhibit any significant differences.

A repeated measures ANOVA with the Greenhouse-Geisser correction determined that mean scores for *Haven* dimension differed statistically significantly between tools ($F(2.563, 56.391) = 4.241, p < .05$). Post hoc tests using the Bonferroni correction revealed that MS Word ($M=4.3; SD=1.43$) when compared with Ulysses ($M=5.1; SD=1.43$) was not statistically significant ($p=.180$). Were also not statistically significant ($p=1.000$) when participants used MS Word when compared with Scrivener ($M=4.6; SD=1.28$). However, participants when used OmmWriter ($M=5.5; SD=1.36$) was statistically significantly different when compared to MS Word ($p < .05$) and also when compared to Scrivener ($p < .05$). Therefore, we can conclude that participants when using OmmWriter, the tool elicits a statistically significant sense of isolation and calm while writing.

Using an ANOVA with repeated measures with a Greenhouse-Geisser correction determine that mean scores for *Evolution* dimension differed statistically significantly between tools ($F(2.785, 61.267) = 5.351, p < .05$). Post hoc tests using Bonferroni correction revealed that participants when used MS Word ($M=3.9; SD=1.37$) when compared with Ulysses ($M=4.7; SD=1.49$) and with Scrivener ($M=4.2; SD=1.37$) was not statistically significant ($p=.128; p=1.000$, respectively). However, participants when used MS Word when compared with OmmWriter ($M=5.3; SD=1.28$) the difference was statistically significantly ($p < 0.05$). Also when participants used OmmWriter when compared with Scrivener ($p < .05$). Therefore, we can conclude that participants when

using OmmWriter, the tool elicits a statistically significant to several alternatives while writing.

When we analyzed the TAM dimensions between each tool, using an ANOVA with repeated measures with a Greenhouse-Geisser correction, the mean scores for Perceived Usefulness ($F(2.879, 63.334) = 0.704, p > .05$) and the mean scores for Perceived Ease of use ($F(2.655, 57.755) = 0.335, p > .05$) and the mean scores for Attitude toward Using ($F(2.815, 61.933) = 0.404, p > .05$) did not exhibit any significant differences.

Triangulating the results with the interviews' statements allowed us to support that the experience and appraisal of the creative writing environments varied among participants. Some users described their experiences, usually emphasizing the tool they felt better with.

"I liked this tool because it allows us to concentrate and write freely, with this essential background environment." - [P7, Ulysses]; *"The music helped me not to be distracted."* - [P19, OmmWriter]; *"This feature with auto-correction is better because we do not waste time checking whether the text is correct or not."* - [P22, Scrivener], *"The type of letter and the self-correction feature helps the writing process"* - [P4, Scrivener]; *"Undoubtedly the full-screen in this tool allows abstraction and concentration to write"* - [P16, Ulysses]; *"This tool is good for when we already know what we want to write; this environment allows concentration"* - [P2, OmmWriter]; *"(...) music and the background can inspire you to write more and to be concentrated."* - [P8, OmmWriter]; *"(...) is the most engaging and does trigger thoughts to write without first thinking of them."* - [P6, OmmWriter].

Did the tool lead to increased output?

The results were analyzed from a perspective that triangulates the amount of words written, the average word length during a fixed amount of time, and the interviews to the participants. We started counting the number of words written per participant in each tool. Regarding the results (Table 4) obtained with the count of words written, we also considered the average word length (that gives us the mean number of characters per word) for us to have more results to be analyzed [81]. Because of technical reasons on the process of saving data, we only have written data for 20 participants using the tool Ulysses.

We used the Skewness and Kurtosis and Kolmogorov-Smirnov tests ($p < 0.05$) to analyze the deviation data normality, and our sample has a deviation from normality.

Table 4 - Average (SD) for amount of words written, amount words length in each tool.

	Ulysses	Scrivener	OmmWriter	MS Word
amount of words written	94.2 (45.48)	93.6 (37.93)	93.3 (47.93)	87.3 (46.80)
amount word length	522.95 (249.27)	494.45 (201.37)	516.70 (273.31)	469.30 (231.93)

Using an ANOVA with repeated measures with a Greenhouse-Geisser correction, the mean scores for amount of words written ($F(2.505, 47.598) = 0.375, p > .05$) and the mean scores for the average word length ($F(2.323, 44.128) = 0.707, p > .05$) did not exhibit any significant differences. As the results shows, we could not find any effect that impaired the efficiency during the process of creative writing despite the use of different tools.

Which tools can promote higher levels of creativity?

From TTCT [77] [92] the panel of judges took into account the definitions of flexibility, originality and elaboration to analyze the creativity of each answer in the writing challenges. Using OmmWriter participants exhibited higher creativity scores (Table 5) than the using the other tools (MS Word, Scrivener and Ulysses).

Table 5 - Statistics from expert rating about creativity

	Ulysses	Scrivener	OmmWriter	MS Word
Median	4.00	4.00	5.00	4.00
St. Deviation	.923	1.142	.733	.995
Mean	4.30	4.40	4.70	4.40
St. Error	.206	.255	.164	.222

However, using Friedman's ANOVA, this difference was not found to be statistically significant ($Fr(3) = 2.96, p > .05$).

Semi-structured interviews, conducted after the study, suggested that the participants considered that the writing challenges were the cause for triggering the writing process (34.8%), while others considered that writing challenges didn't increase the creativity levels for writing, because it limits the thinking (17.4%). On the other hand, 47.8% of the participants considered that both writing challenges and the tool makes a good trigger for the writing process. As stated in the interviews: "The tools are engaging and the sentences are inspiring"- [P6]; "They are both useful." -user9; "The writing challenge helps, such as the

environment and the relaxing music”-user15; “The writing challenges and the tool makes flow the text to write” – [P21].

Five (5 out of 23) participants said that they had a “*block in their minds*” during writing, and reported being distracted to change some features (such as font color, type and background) only after a certain time since they started to write. One participant, after starting the experience with one tool, stopped writing after one minute and a half and waited for the timeout. When we asked him why he did that, he said: “*I didn’t remember anything to write, and I lost creativity*”- [P6, Scrivener]. He stated that it was not anything related to the tool itself, he simply couldn’t find anything to write. 34.78% of the participants enjoyed writing with Scrivener.

From a qualitative perspective, 30.43% users had not realized that the time had passed when they were using the OmmWriter tool or Ulysses (26.08%). All participants did not consider the fixed time a reducer of creativity or writing, e.g., “*I lost track of time*” – [P23]; “*I was completely concentrated to write down everything that came to my mind.*” – [P7]; “*The thoughts were falling*”- [P1]; “*I was oblivious to write, I enjoyed the experience*”- [P3]; “*The time passed quickly; I was enjoying writing*”-[P22]. When asked about what made them lose track of time, participants said that it was the environment of each tool that provided them that sense. For instance: “*This environment provided a special engagement so that I could write and lose time*”- [P18, OmmWriter]; “*It was good to be writing with this environment and I lost track of time*”-[P10, Ulysses]. When we asked about which other features they felt that could have also influenced them, they said that it was the music and the minimalistic features. When participants were interviewed, 43.5% of them expressed genuine interest in the background soundtrack. Others assumed that the background soundtrack helped to focus initially, but then could distract them, “*although the tool allowed the flow of ideas, after some while it only distracted.*”[P14].

Finally, regarding the user’s intention to adopt the tools, it was clear that they demonstrated a positive attitude towards using them. 17.39% of the participants disliked MS Word.

4.5 Discussion

In general, we could acquire that participants were excited about writing in different environments and the novelty of this type of experience might be one possible

explanation. However, as they weren't familiar with all environments, the factor of novelty was facilitating to a great extent. They were concentrated on the writing moment and it was clear that all participants felt somewhat creative during the experiment.

Results show that creative writing dimensions such as *Haven* and *Evolution* had a substantially significant effect, while using the creative writing tool OmmWriter. This tool could stimulate a sense of isolation and calm in users while writing as well give them several alternatives while writing. Despite the fact that some participants didn't enjoy the feature present in OmmWriter such as the background soundtrack, most of them really liked it and expressed natural and absolute interest in this type of features. Therefore, we can assume that this particular feature can give writers the ability to make them write more and can also provide additional values. Another interesting finding about features of creative writing environments are the minimalistic features such as the back-ground desktop, full screen mode and auto-correction features.

In the light of this finding, we believe it is important to improve design in user interfaces for writing, but taking into account this type of features. As Norman [93], suggests, designing computer systems for people is especially difficult for a number of reasons, but the final goal is always a user interface that provides an intelligent and pleasant tool. The author also suggests that design must be considered as a whole, and not an isolated piece. This study, despite being small, is a contribution to the field of HCI especially in the development of UI's for creative writing as suggested the use of this type of features.

We could note during the experience that participants were expectant and curious to know what tools would be used, maybe because they only knew one. In a qualitative way, we could also see them focused and in absolute concentration during the activity. According to the interviews, some participants lost track of time, others were deeply involved with the task of writing. Csikszentmihalyi [73] defines this state of consciousness called flow as "*a state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will continue to do it even at great cost, for the sheer sake of doing it.*" Also Norman [94] states that the trick to be focused is to avoid interruptions. This was possible in our experience and supports the loss of self-consciousness as reported from our qualitative data. According to the interviews, some participants lost track of time, others were deeply involved with the task of writing.

Addition relevant findings in this experience include the fact that participants considered both writing challenges and different environments generated a good trigger for the writing process. Therefore, we observed that a feature such as “writing prompts” could be a good kick-start to the creative writing process and a useful feature that can be designed and incorporated in this type of tools.

The question we raised was: *Can certain user interface features can promote higher creativity levels of satisfaction and creativity, during the process of creative writing?* Our findings corroborate aspects regarding user satisfaction and leave a door open to creativity that can be extended through more research in this area.

One limitation of this study is the subjective way of measuring the creativity of the tools with a panel of judges. Despite this limitation, we didn't want to lose the opportunity to have more findings about the tools. We chose experts that have a great experience in the evaluation field in order to reduce the potential bias. We used the definitions of flexibility, originality and elaboration TTCT [77], to restrain the subjectivity. Another limitation of this work is that we did not asses creativity with self-report scales by each user after using each tool, and we only have qualitative data about it. Our study also, does not consider the long-term usage of these specific tools. Therefore, conclusions are limited to an inchoate usage of the different creative writing user interfaces. However, this is still very useful data, since it brings new findings about creative writing user interfaces.

4.6 Conclusions

Because of today's diversity of possible technological ways to write, creative writing is a constant activity in many sectors and professions in the modern world.

In this study we presented a novel evaluation approach that addresses the study of creative writing dimensions and evaluates how participants write using different user interfaces. We described an experience that analyzes the impact of different creative writing interfaces on the satisfaction levels of participants. This paper also presented an overview of the creative writing dimensions compared to the Technology Acceptance Model (TAM). We compared Microsoft Word (our baseline), a calming and relaxing user interface (OmmWriter), a very popular tool among professional writers (Scrivener) and a minimalistic and focused tool (Ulysses). From a satisfaction perspective, our results suggest that for the Evolution and Haven dimensions OmmWriter was the most

satisfying tool, as perceived by the users. From an efficiency perspective of creative writing, we could not find any effect that impaired or accelerated the process of writing.

We could identify some design implications for creative writing user interfaces. For instance, explicitly notifying the user of errors or exceptions that are relevant and of interest to the user through a clear feature of self-correction; feedback helps the writing process and keeping the user in the flow of his writing. Background environments and full-screen mode are important in this type of tools because they allow users to be concentrated and to be focused in the writing process. When experiencing a moment of writer's block (or some inability to write) they can have all needed options to restart their writing. This can be made possible with the use of writing prompts or with the simplicity of a background soundtrack, which can trigger the thoughts and inspiration of users for writing or during writing. There are many aspects of this study that remain open for future investigation such as our results about creativity. Measuring creativity is an important approach that will lead us to different impacts of specific creative writing tools. These tools can have features to increase the creativity of writers and also contribute to unblock writer's block. In future work, we think it is important to intensify the research on designing user interfaces that support creative writing and build novel tools that can be used by several people. Moreover, it will be interesting to develop new techniques to measure the creativity of the creative writing process.

CHAPTER 5

ENHANCING CREATIVITY THROUGH THE USE OF A CROWDSOURCED PLATFORM - CREATIEWALL



Through the following publications:

Gonçalves, F., Sousa, I., Campos, P. (2017) *"Triggering your creativity and mental well-being while writing: CreativeWall - A novel Crowdsourcing Platform!"*. Submitted.

CHAPTER 5

ENHANCING CREATIVITY THROUGH THE USE OF A CROWDSOURCED PLATFORM - CREATIVEMALL

This study presents a novel crowdsourcing platform called CreativeWall, where users can preserve their creative writings and share them with the community, thus creating an interactive way for users to develop their abilities in writing. CreativeWall has also a Microsoft Word Add-In that helps writers to trigger their creativity while writing. We show that for a creative task such as writing, our creativity support tool can enhance the creativity and mental well-being of its users. To support this argument we highlight some results triangulating qualitative and quantitative data. Results show that users performing the tasks with CreativeWall lost track of time more often than participants using our baseline. From interviews it was clear that the tasks performed with the CreativeWall add-in were more enjoyable and that users had no problems starting to write, which could mean that these tools can help in the initial phase of the creative writing process.

5.1 Introduction

Search engines like Google can help you find ideas on what to write about but it takes a lot of time to analyze the thousands of results that are presented, even though they are shown in an optimized way. Social networks like Facebook or Pinterest can help you as well, with groups that are created with the objective of helping writers, but they lack categorization and can be really distracting. The best way to gather enough data for such a creativity tool is to take advantage of crowdsourcing. This way one can raise a community who is interested in writing and give them the opportunity to share their creative writings. These writings can then be used by the tool to help other writers with their own work.

In this study we present a novel crowdsource platform – *CreativeWall* and a Microsoft Word Add-In to enhance the creativity and mental well-being of users in the creative writing process. One of the problems that usually drives writers away from their goals is writer’s block. Writer’s block can last for whole days [95] and become a real source of frustration when people are anxious about deadlines and really need to get the writing done. One of the methods used to avoid writer’s block is the use of writing prompts [96] [26], which consists of a small text that is supposed to help writers to have ideas on what to write. We decided to take this method and refine it by adding some more components that can help the writer have the creativity he needs. By using images, moods and locations we create a more visual perspective of a moment that can bring creativity to the writer.

5.2 Crowdsourcing

Crowdsourcing is a concept that, although very powerful and effective, is relatively recent and still doesn’t have a solid theoretical knowledge base that allows it to have a clear definition [97]. According to Howe [98] crowdsourcing can be defined as “*the act of taking a task traditionally performed by a designated agent and outsourcing it by making an open call to an undefined but large group of people*”. Another example of a definition comes from Brabham [99], who says it can be defined as “*a new web-based business model that harnesses the creative solutions of a distributed network of individuals through what amounts to an open call for proposals*”. As for Kleemann et al., [100] crowdsourcing can simply be defined as “*the outsourcing of tasks to the general internet public*”. These are all valid definitions but there is no consensus regarding what would be a definitive and complete definition. For the purpose of this work we will only focus on two types of crowdsourcing [100], product design and product rating by consumers and consumer profiling, which are the ones that better suit our needs.

5.3 Moods, Emotions and Colors

As Baas et al. [101] states, there are differences between moods and emotions. According to the reference, moods are long lasting while emotions are more related towards a specific stimulus, for example, an emotion would be a person feeling happy because he/she found some money on the ground. This situation forces an emotion onto the person, the emotion of happiness. On the other hand, a mood is something that is more general, for example, a person feeling happy because he/she just feels great. With this we can conclude

that there really are differences in terms of intensity of feelings, being that emotion is generally stronger than a mood. Another definition of mood states that moods are the accumulation of emotions and other affective events [102]. Moods can have multiple dimensions, but only three of those dimensions have been proven to be related to creativity. They are hedonic tone, activation level and regulatory focus.

The hedonic tone, or valence, simply put, describes whether the mood is positive or negative [101] [103] (e.g. happiness has a positive tone while anger has a negative tone). This dimension is usually related to creativity as some studies refer [104]. The same studies state that moods with a positive tone help a subject produce more original word associations which means that there might be a boost in creativity.




Activation relates to whether or not the mood can generate active behaviors in the subject (e.g. calm is a deactivating mood while fear is activating). According to De Dreu et al. [103] activation is a necessary precondition for creativity to come by while hedonic tone determines the route through which creative fluency and originality is achieved. They also argue that activating moods are more likely to generate creativity than deactivating moods.

Regulatory focus refers to the motivation an individual has to complete a task. According to studies made in this area, regulatory focus plays an important role in triggering creativity [105]. There are two types of regulatory focus, the promotion focus and prevention focus. Promotion focus comes from the desire of accomplishing something, while prevention focus comes from the will of securing something [101]. A good example of this would be the attackers and goalkeepers in a football game. The objective of the attackers is to score goals and that's their motivation for playing (promotion focus). On the other hand, goalkeepers want to prevent goals, and that's their motivation for playing (prevention focus). Color can lead to feelings, and that have been proved by several studies in this area [106] [107]. A good example of this statement is a cloudy day. A cloudy day has a predominant color, which is gray, and gray is related to sadness, so people usually feel sad on cloudy days. If you look outside through a yellow window you can see that a feeling of warmth comes to you and everything feels a bit happier, as states by Goethe [108]. It's curious to see that the relation between color and emotions (or feelings) was already object of research more than 100 years [108]. Kaya et al. [106] [107] performed

user studies in order to be able to map colors to emotions and the result were somewhat similar to the statements made in the [108]

After considering the statements above, a list of moods and a mapping to colors was produced by us. Table 6 shows the mapping between color and emotion.

Table 6 - Moods mapped into colors.

Happy	Yellow	
Hopeful	Green	
Excited	Orange	
Energetic	Light Blue	
Loved	Pink	
Fearful	Black	
Angry	Red	

Even though fearful and angry are not considered to be creativity enhancing moods, they were included in the list in order to give users some variety to choose from.

5.4 CreativeWall Platform

CreativeWall is a crowdsourcing platform (Figure 17) where its users can share their creative writings along with images, locations and moods, creating what we call a creative moment (Figure 18). This concept of creative moment came to life from the idea that people sometimes have ideas for creative writings when they are, for example, walking on the street and see something that triggers their creativity. That is the essence of the creative moment. They have an image that triggers an idea that is described by the text. A certain mood is also associated to that moment and it happens in a certain location, date and time. When brought together, all these aspects generate our creative moment. Figure 19 illustrates how a Creative Moment is shown on the platform.

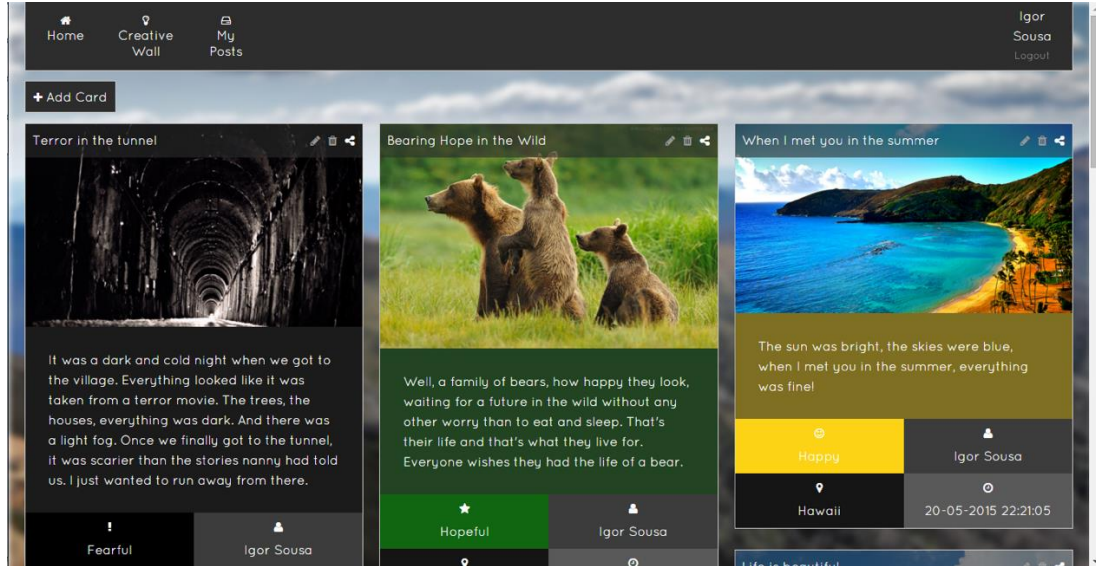


Figure 17 - Final prototype of the CreativeWall platform.

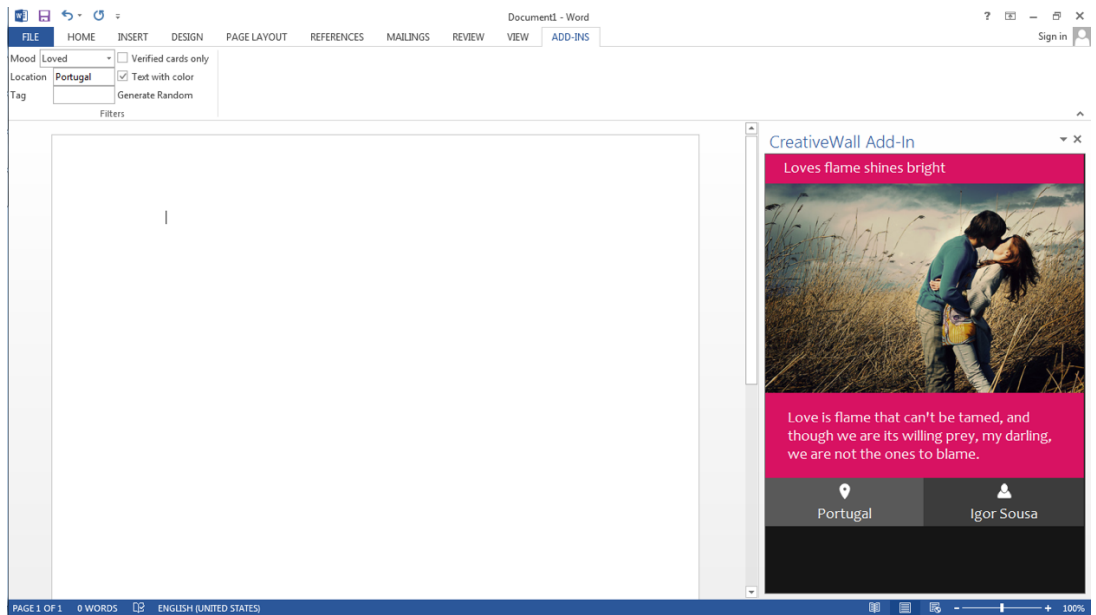


Figure 18 - The integration on the word processor tool Microsoft Word.

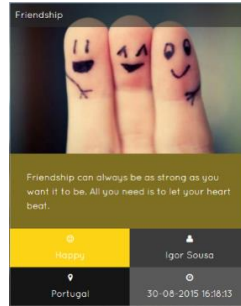


Figure 19 - Example of a Creative Moment

With this kind of information, other users can recreate the moment mentally and maybe absorb some kind of creativity from it giving birth to their own ideas based on what they see and feel with the moment recreation.

There are two main sections on the platform, the Creative Wall and My Posts:

Creative Wall

In this section users can check out creative moments shared by other users. They can also report, flag the moments as well written, or rate them. The first option, the reporting of moments, allows users to report other user's moments for offensive content, copyright violation, etc. As for the second option, the well written flag, it allows users to flag the moments that have a correct syntax and semantics, and with this make them part of the moments that appear when a user selects the well written filter. The last option, the moment rating, allows users to rate a moment from 1 to 5 stars where 1 means very uncreative and 5 means very creative. By doing this users make shared moments more and more relevant. These three options are part of a very important component of a crowdsourcing platform, the quality control, and can only be accessed by users that are logged in the platform. Below we can see these three options and how the user interacts with it. Figure 20 shows the three options described above.



Figure 20 - Top bar of the moment showing the three options available

In this case the moment has already been rated, but is not checked as well written. Figure 21 shows how a user can interact with the system in order to rate a moment.



Figure 21 -Top bar of the moment showing the rating feature

We can see that the user rated the moment with two stars. This means that the moment was uncreative and should not appear on the top of the relevant moment's list.

Another important feature that was implemented is a filter system where users can insert the conditions that most suits them and the platform will look for the moments that match those conditions. There are three fields on the filters bar, mood, location and tag. These three fields help users categorize their searches for faster finding of the moments they want. Each moment can be associated to a group of tags that can then be used for search purposes. There is also an option for sorting the results for a variety of options. Figure 22 shows the list of options that are available for sorting.

For the first two options, they are self-explanatory. On the relevance option, the moments that are presented first are the ones with a higher average rating. This average is calculated by dividing the sum of all the ratings by the number of ratings assigned to that moment. As for the well written, the first moments that are presented are the ones with a higher count of well written flags. With this feature, it is possible to make sure that only quality content is shown and that the user does not have to pay extra precious attention to error check on moments shared by other users.

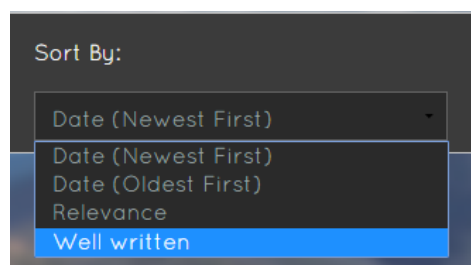


Figure 22 - Sort feature showing the options available

My Posts

In this second section, users can see all the moments that they have already created, share them, add new ones and edit or remove the existing ones. Users can choose whether or not they want to share their moments. They can use the platform just for saving their moments without making them available for other users to see. To share a moment, users

just have to press the share icon and the moment is made available for every user. To edit or delete a moment, users just have to press the according icon.

When a user deletes a moment a confirmation dialog box is presented to make sure that this is the desired action. As referred before, a user can also create a new moment in this section. When the user presses the button to add a new moment, a dialog box is presented with all the fields necessary to create the new moment. Figure 23 shows all the information the user can insert to create the new moment.

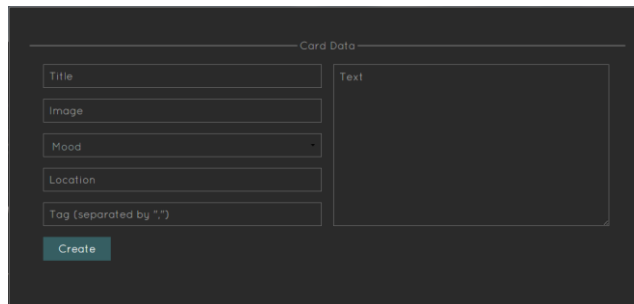


Figure 23 - Dialog box showing the possible fields for creating a new moment

The final prototype can be seen in Figures 17, 18 and how the section My Posts looks. The design chosen was achieved and we felt very happy with all the design choices that were made. No specific tests were performed for the crowdsourcing platform as it acts only as a tool to populate the database with data to be used in the MSWord Add-In.

5.5 CreativeWall MSWord Add-In

CreativeWall MSWord Add-In is a plugin (called Add-In by Microsoft Office) for Microsoft Word that uses the data created in the CreativeWall platform in order to provide users with a way to trigger creativity while writing in the Microsoft Word application.

This plugin requests creative moments from the API according to some filters chosen by the user and then shows those creative moments in Microsoft Word. By doing this, the user can use the creative moments for triggering creativity in the word processor tool itself without having to change applications and search for creative moments in the online platform.

The features that were implemented help the user getting what he wants as fast as possible, and that was the main goal of the interface implemented. The plugin has a ribbon that contains a set of buttons and inputs which the user can use to interact with the plugin. As described before, the ribbon contains a set of buttons and inputs that can be

used to interact with the plugin. Figure 24 shows the ribbon and the elements available for interaction.

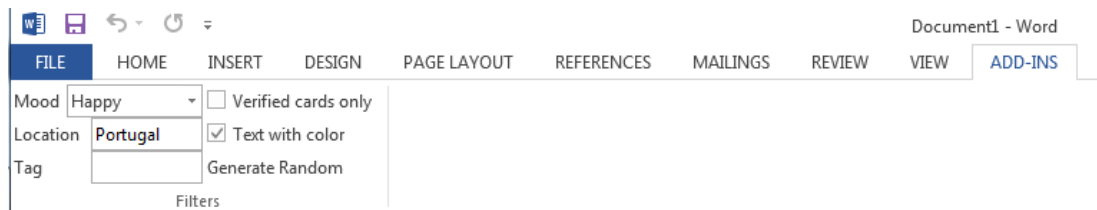


Figure 24 - CreativeWall Add-In ribbon with buttons and inputs available

The first three options, mood, location and tag are self-explainable, they apply filters to the results. The checkbox for “Verified cards only” will return cards that have average ratings over 4 stars and at least 5 well-written tags. This helps the user get data that has a minimum of quality and is not just random words with no meaning. This also helps the user getting creative moments that are written correctly. As for the option “Text with color”, it defines if the creative moment should be shown with a gray background or with a background according to the color associated with the mood of the creative moment. The button “Generate Random” generates a random creative moment according to all the filters selected on the other options. If the user inserts a set of filters to which there are no creative moments associated, an error message is displayed. The add-in creative moments interface is basically the same as the one in the CreativeWall web platform, it just has less fields. Each of the creative moments shown have a title, image, text, location and author. Figure 25 shows an example of a creative moment in the add-in.

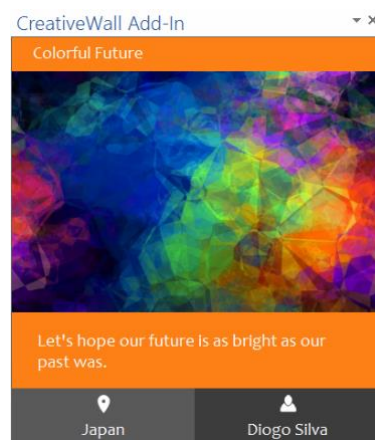


Figure 25 - Creative Moment in the Microsoft Word Add-In

After all the implementation was done a final prototype (see Figures 17 and 18), that is to be used in the user study, was achieved. This prototype has all the features described above

and they are all usable. It can be used by users after running a setup to install all the registry entries needed to use it on Microsoft Word as an Add-in. This prototype is just one example of an application using the add-in, since it may be used by any other word processor tool that wishes to implement our approach. All they need to do is register for usage of the API and after they set a client id and a client secret, they can start making requests to the API in order to receive the desired data.

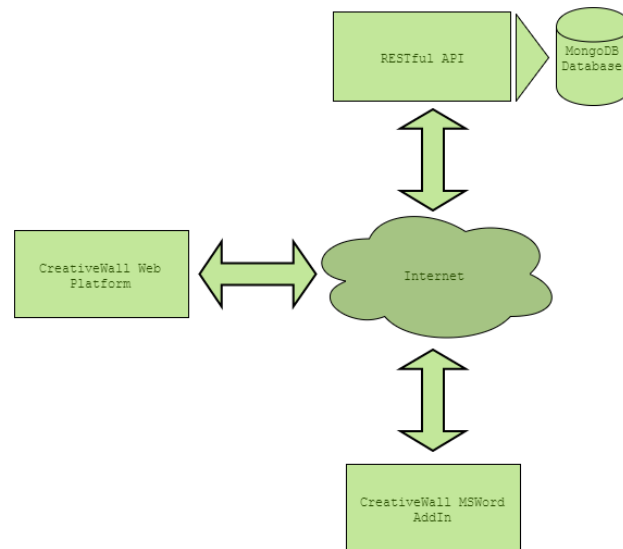


Figure 26 - Software architecture including the platforms implemented

In order to build a usable prototype a decision about the architecture (Figure 26) of the software was needed. One requirement that was important was the scalability of the whole software structure. It is important, in the context of our approach, to be able to provide data to any word processor plugin or platform that wants to use the data created in our crowdsourcing platform, as long as they have previously applied for it. The solution is to build a client-server architecture. Having a centralized server (in our case the API works as both the server and an abstraction communication layer) it is possible to provide data to as many clients as we need. All connections should be made through HTTPS so the connection data (e.g. tokens or client credentials) is not exposed through package sniffing. For the purposes of this work we won't be making those HTTPS connections because this kind of features has high costs associated to it and it is not relevant for our user studies. This should be considered as future work. All the clients have read-only permissions, except for the crowdsourcing platform that sends data to the API for it to be inserted on the database. Before being able to request any data from the API the clients must be

registered and define a client ID and a client secret so they can be authenticated before establishing a connection. This protects the data from being accessed by unauthorized clients.

5.6 User Study - CreativeWALL

We addressed the following research question: *What is the influence of the CreativeWall Add-In UI on the participants' mental well-being and creativity, when compared to the Microsoft Word Simple UI?* The experimental design was based on a within-subjects design in which each individual performed a creative task – writing in the three proposed conditions:

Condition A: Baseline. Using Microsoft Office Word without any kind of add-in related to creativity to write a text based on a given context;

Condition B: Using Microsoft Office Word with the *CreativeWall Add-In* with a gray background to write a text based on a given context;

Condition C: Using Microsoft Office Word with the *CreativeWall Add-In* with a colorful background to write a text based on a given context.

To reduce a limitation such as order effect, we counterbalanced the order of each conditions for each participant.

The individuals were assigned a random order of tasks in order to guarantee that no knowledge was passed from one task to the other as that would influence the results. As a prerequisite participants had to have prior writing skills and had to be interested in writing.

Participants

A total of 11 individuals (7 males and 4 females) aged between 20 and 32 years old ($M=25.8$; $SD= 3.5$), took part of this study. Every participant was a Software Engineer, and they were recruited through the university mailing list. All participants reported having a normal or corrected visual acuity and none participant was colorblind. We conducted one session per subject. The total time per subject including questionnaires, experiment, breaks and semi-structured interviews took over one hour.

Procedure

Before starting the study, every participant was introduced to the tools they were going to use and were informed about the rules of the task. During the task, the participant was left alone in a room with the computer at his disposal.

Participants were asked to write a short text using the tool designated to the task they were assigned to do. Each one of the task had a 10 minutes maximum duration. The time was monitored by the person responsible for guiding the participant through the tasks and after it reached the 10 minutes mark the participant was instructed to stop writing. The participant could ask to stop whenever he felt like he had finished writing. The text written in that time was then saved on the computer.

The tasks were labeled as task A, B and C, respectively. All participants were presented with a context for each one of the tasks. For task A, the participants were given a context that was not produced by our crowdsourcing platform. This task was considered a baseline. Figure 27 shows the context given on the task A.

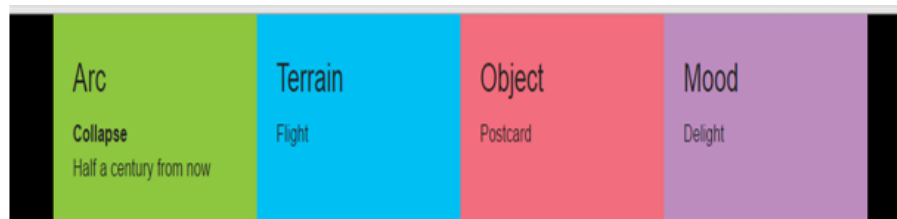


Figure 27 - Context given to the user on the first challenge

For task B, participants were given a context created on our crowdsourcing platform. This context is a creative moment that was created and shared by a user who was registered on the CreativeWall. Figure 28 shows the context that was presented for the task B. In order for this context to be presented in grey, the option “Text with color” on the MSWord Add-In has been turned off.



Figure 28 - Context given to the user on the second challenge

For task C, participants were given another context created on our crowdsourcing platform. Again, this context is a creative moment that was created by a registered user on the *CreativeWall* platform. Contrary to what happens on the second task, the option “Text with color” was turned on for this task. Figure 29 shows the context used for the task C.



Figure 29 - Context given to the user on the third challenge

After completing each task, participants were asked to fill out self-reported survey. The survey contained some general questions like age, or gender and some Likert scale questions. Also a multiple choice question about how the user felt during the task was included. The Likert scale questions were ranked from 1 (totally disagree) to 7 (totally agree). The first question was about whether the participant considered himself a creative

person. The other Likert scale questions were based on four dimensions of the Flow Theory [73]: 1. Intense and focused concentration on the present moment; 2. Sense of personal control or agency over the situation or activity; 3. Loss of reflective self-consciousness; 4. Distortion of temporal experience. For these dimensions questions such as “*I felt very concentrated during the challenge*” or “*I lost track of time during the challenge*” were included. Finally we collected qualitative data with a semi-structured interview with questions such as: “*Which condition did you enjoy using the most?*” or “*Is there any comment that you would like to add?*”, “*Did time limit your creativity?*” in order to know the participant opinion about the whole experience.

5.7. Results

We evaluated the study from a perspective that triangulates the results, using the answers from the surveys, the statements of the interviews and the qualitative measurable information of the writing challenges. We used SPSS 22 [90] for all statistical analysis.

To assess the reliability of our survey, we used Cronbach’s alpha [91] as a measure. It was taken into account the polarity of the scale. Table 7 exhibits results of reliability (internal consistency) analyses for questions in each dimension of flow.

Table 7 - Cronbach's alpha related to each of the dimensions.

Flow Dimensions	Cronbach’s Alpha
Concentration	.629
Sense of Control	.797
Lost Self-Consciousness	.672
Lost Track of Time	.633

Results show that the number of test items can be considered with an acceptable consistency [91] in the scale used, from the survey, on seven-point Likert scales.

As mentioned before, the first question of the survey was about how creative the participant considered himself.

63.3% of participants considered themselves a creative persons in a seven-point Likert scale. 18.2% of participants considered themselves creative persons in a five-point values, 9.1% in a three-point values and 9.1% in a two-point values.

To assess the participants mental well-being we asked them to select up to three adjectives from the following list: animated, creative, distressed, fear, serious, angry, satisfied, frustrated, sad, astonished, depressed, bored, tired, happy, delighted, pacific and relaxed.

Figure 30 shows the total count for each of the adjectives selected and presented on the above list. The words that were used the most were animated, creative, happy and pacific, being that creative was the most used for Condition B and Condition C, and serious was the most used for Condition A.

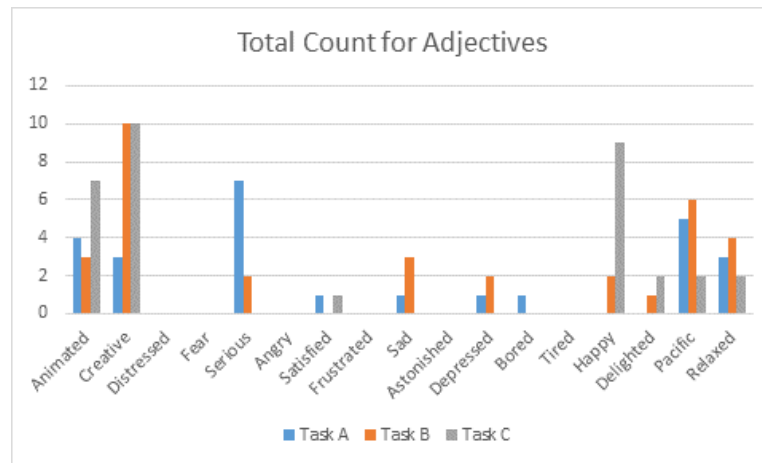


Figure 30 - Chart relating the tasks with the adjectives used in them

After analyzing the results we are able to conclude that users who were in Condition B and Condition C report to feel more creative that users in Condition A. The most balanced word counts were relaxed and pacific, as they were selected at least twice for each conditions. These aspects might indicate that users felt ease when writing.

We proceeded using repeated measures such as Friedman’s ANOVA [91] [109] approach to testing differences between each condition. The Flow dimensions Concentration ($Fr(2) = 5.20, p > .05$) and Lost Self-Consciousness ($Fr(2) = 1.90, p > .05$) did not have statistical significance when compared with each condition.

For the other dimensions Sense of Control ($Fr(2) = 10.21, p < .05$) and Lost Track of Time ($Fr(2) = 17.43, p < .05$) results were statically significant. Therefore the non-parametric Wilcoxon tests [91] [109] were used to display if there were any differences for each pair or conditions, using Condition A to compare as a baseline.

Results showed that, participants in Condition A, when compared with participants in Condition B ($T=0$, $z= -2.06$, $p<.025$, $r=-.44$), for the dimension Sense of Control were not statistically significant. Also, participants in condition A when compared to participants in Condition C, for the levels of Sense of Control, even though the value is in the border line, it was not statistically significant as well ($T=0$, $z= -2.23$, $p<.025$, $r=-.48$). We applied the effect size that gives us the magnitude of the effect investigated [91].

For the dimension Lost Track of Time, the results showed a significant difference between the participants in Condition -A when compared to participants in Condition B ($T=0$, $z= -2.71$, $p<.025$, $r=-.58$). For the same dimension, the differences between participants in Condition A when compared to participants in Condition C were also statistically significant ($T=0$, $z= -2.72$, $p<.025$, $r=-.58$). We used the Skeweness and Kurtosis and Kolmorov-Smirnov tests ($p>0.05$) to analyze the data normality of the average number of words produced. Figure 31 shows that the sampling distribution is normal. T-tests were used to compare the statistical significance of the samples using a 95% level of confidence.

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
ToolA_NumberWords	,149	11	,200 [*]	,934	11	,458
ToolB_NumberWords	,170	11	,200 [*]	,946	11	,592
ToolC_NumberWords	,155	11	,200 [*]	,950	11	,649

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 31 - Sample distribution

Participants in Condition B wrote on average more words ($M=186.1$, $SE=49.3$) than in Condition A ($M=156.2$, $SE=54.5$). For the same condition the difference was statistically significant ($t(10) = -3.20$, $p<.05$).

In Condition C, participants wrote on average more words ($M=185.7$, $SE=65.1$) than in Condition A ($M=156.2$, $SE=54.5$). The difference was statistically significant ($t(10) = -2.23$, $p<.05$) for the same condition. Table 8 shows statistics from the time and sequence in which the users completed their writing tasks.

Table 8 - Statistics from time in minutes spent on each condition.

	Condition A	Condition B	Condition C
Mean	8.73	9.55	9.27
Median	9.00	10.00	9.00
St. Deviation	1.01	0.69	0.79

By statistically results reported in Table 8, we can see that most of the participants did not used the ten minutes for the writing task.

When interviewed, 81.8% of participants did not considered the time limit a factor to restrict their creativity in the writing task. This might indicate that even though the conditions used for the experience helped the participants start writing, they are not as effective when it comes to keeping a constant creativity flux and therefore helping only on the first steps of the creative process.

Triangulating the results with the semi-structured interviews conducted after the writing task apparently suggest that, by unanimity of the answers registered, Condition A was the less enjoyed condition. 63.6% of participants really liked the Condition C, and 36.4% liked to write in Condition B. According to some participants (27.7%), the lack of image and texts is important for their creativity to flow, *“Condition A is very limited because it lacks the image, and the image is very important for creativity.”*(P6).

Another interesting fact is that, for the majority of participants, color helps but does not influence creativity when they don't find the text creative, *“Even though color is a very interesting component, the most important ones are the text and image. If the text is not creative then the color won't make a difference.”*(P4); *“Color helps the user remember of something. For example, the yellow resembles the joy of the summer.”*(P6); *“Color helped, but the most important thing was the text and the image.”*(P8).

Some other participants refer to the color as being a source of distraction or did not considered as an important factor, *“Color helps as well but is not as decisive as the text and image. Color can also be a motive for distraction. A less intense color might have been better.”*(P3); *“The color is a little bit distractor.”*(P2).

With this we assume that our initial idea that color would help triggering creativity through the emotion it generates on people can't be applied to every participant. Even though some participants enjoyed having the color together with the image and the text, and stated that it helped their creativity to flow, they are still a minority. *“I think that in this case, color really helped, because the text was about summer and yellow resembles the summer. It did make me feel kind of happy.”* (P7); *“The color and the image encourage creativity. In fact, I felt some ease on Condition C. The image and color helped me idealize some ideas.”*(P1).

5.8. Discussion

The main goals of this work were to investigate if a creative writing support UI could enhance a user's mental well-being and creativity, and to check whether color could influence creativity in any way. Although the number of participants in the tests was limited, it was possible to develop some statistical results and take some conclusions from them. Even so, as future work, the idea of performing more studies for more solid results should be considered.

As for the results obtained through the user study, we were able to conclude, through statistical evidence that participants performing the tasks with the *CreativeWall Add-In* (Conditions B and C) lost track of time more often than participants using the simple Microsoft Word UI without any add-ins (Condition A). Another aspect that was statistically relevant was the fact that users using the *CreativeWall Add-In* were able to produce more words. It must be taken into account that efficiency can't be measured by the number of words alone as this can be misleading. Even so, having significant difference in number of words between different conditions might indicate that their efficiency was affected. Also, taking into account the answers that results from the semi-structured survey performed after each of the sessions, it was clear that the tasks performed with the *CreativeWall Add-In* were more enjoyable and participants had no problems starting to write, which could mean that these conditions help in the initial phase of the creative writing process. This could also mean, that, by consequence of the previous statements, this approach can be effective when trying to overcome writer's block. About the color, the majority of participants stated that color does not influence their creativity, and can be somewhat distractive. With this kind of statements we can assume that color does not always influence the creativity of users.

One limitation of our study is that it does not consider the long-term usage of CreativeWall platform and add-in. Therefore, conclusions are limited to an incipient (11 participants) usage of the different creative writing tasks using the addressing conditions. However, it is still very useful to have this data.

5.9. Conclusions

In summary, in this pilot evaluation of our novel crowdsourced platform, our findings suggest that, from a mental well-being perspective, it was clear that participants felt more

inspired, more focused, more creative and more immersed when using the *CreativeWall Add-In*. From a “productivity” perspective, our results suggest that the users using the *CreativeWall Add-In* were the most efficient. Taking into account, the conclusions made in previous the color feature should be reviewed in order to try and take the most out of it. This includes reviewing the concept and reviewing the color itself. Trying to make color less intense would be one of the solutions for some of the problems presented in the user study, namely the distraction caused by it.

We have addressed these somewhat sensitive issues and tried to empower participants with different user interfaces to help them overcome writer’s block and to express themselves in a different way. The current prototype is only a first implementation of our ongoing work on the concept of creative writing user interfaces and new guidelines to creative support tools in writing. We would like to conduct a long term study, to obtain more results about creativity, and mental well-being of its users. Finally, we considered that it’s important to increase the number of moods in order to include other creativity enhancing moods. We are also interested in the strong relationship between the user interfaces for supporting creative writing and the level of creativity of its users.

CHAPTER 6

CREATIVE WRITING UIS TO EMPOWER UNDERSERVED YOUTHS



Through the following publication:

Gonçalves, F., P. Campos, Hanna, J. Ashby, S. (2015). *You're the Voice: Evaluating User Interfaces for Encouraging Underserved Youths to express themselves through Creative Writing*. C&C '15, June 22 - 25, 2015, Glasgow, United Kingdom, 2015 ACM. **Nominated for Best Contribution to Creative Communication.**

CHAPTER 6

CREATIVE WRITING UIS TO EMPOWER UNDERSERVED YOUTHS

Minority groups are the fastest growing demographic in the U.S. In addition, the poverty level in the U.S. is the highest it has been in the last 50 years. We argue that the community needs more research addressing this user segment, and we present a novel study about how underserved youths react when presented with different UI designs aimed at promoting creative writing. The act of creative writing per se can become the driver of change among underserved teenagers, and researchers should strive to discover novel UI designs that can effectively increase this target group's productivity, creativity and mental well-being. Using MS Word as baseline, our contribution analyzes the influence of a Zen-like tool (designed by the authors and called Haven), a nostalgic but realistic typewriting tool (Hanx Writer), and a stress-based tool that eliminates writer's block by providing consequences for procrastination (Write or Die). Our results suggest that the Zen characteristics of our tool Haven were capable of conveying a sense of calm and concentration to the users, making them feel better and also write more. The nostalgic Hanx typewriter also fared very well with regard to mental well-being and productivity, as measured by average number of words written. Contrary to our initial expectations, the stress-based UI (Write or Die) had the lowest productivity levels.

6.1. Introduction

Creative writing gives a voice to marginal groups in society, helping them to tell their stories. In this sense, new tools for creative writers can be used to support community-based writing projects and encourage people from all backgrounds to find their voice and tell their unique stories. But we also believe that creative writing can be used not only for the mental well-being of underserved populations but also as a way to empower people to tell their unique stories and thereby increase society's awareness

of their situations and challenges. However, there are very few studies about what makes a good user interface design for creative writing as there is no consensual approach to evaluating them. In this study we propose an approach that addresses, for the first time, a minority user group of underserved youths, by evaluating how they write using different user interfaces. We triangulate data from different sources to assess productivity, creativity and mental well-being of users writing in four different user interfaces: MS Word (the baseline), Haven (our own tool), Hanx Writer (a nostalgic retro-futuristic typewriter), and Write or Die, a stress-based tool that combats writer's block by providing consequences for procrastination.

6.2. Empowering Minority Groups

Broadly speaking, our research addresses the needs of minority groups, such as underserved youths, working on the premise that creative writing can empower people in these demographics by allowing them to better express themselves, thus enabling them to share their specific challenges with the larger society. In addition, the simple act of creative writing can improve mental well-being, a problem that is more and more prominent in today's world.

Yardi and Bruckman [1] show that minorities are the fastest growing demographic in the U.S., and note that the poverty level in the U.S. is the highest it has been in 50 years. Their results show that socioeconomic differences both reflect and reinforce technology use at home. Our work builds on this growing user segment, a segment that is often overlooked both in research and product design.

Other researchers have studied the role of digital storytelling for the empowerment of marginalized youth through a series of workshops conducted in the context of Palestinian refugee camps in the West Bank and East Jerusalem [4]. Among other relevant conclusions, they note that the most challenging part of all youth workshops is the story development phase, which needs greater focus from educators and more effective tools and processes to be successful [4].

Researchers have also targeted other types of underserved groups. For instance, Cooper et al. [5] observed that the enrollment and interest in Computer Science (CS) at the university level has not increased in proportion to the rise in demand for computing technologies, which has been very rapid in recent decades. They identified key success factors, such as the value of strong partnerships, clear establishment of roles, accomplishment of needs assessment, field-testing, and effective team

communication. However, this study was focused on a multidisciplinary effort targeted at improving CS interest among global underserved youth and showing how to make a difference. Minority groups have also been the subject of studies regarding participation of women in the Information Technology workplace [6], career development of minorities, ensuring that a greater number of women and minorities progress to a full career in cyber security [7], and even more specific cases, such as using statistical means and survey data to analyze the success in Germany of ethnic Germans (the majority group) in relation to four different minority groups [8].

To our knowledge, however, there are no studies dealing with bringing the power of creative writing UIs into the hands of underprivileged youths. These users make up the core group of our research.

6.3. Creative Writing user interfaces

We are all writers, the difference is that some of us write, and others don't.

– J. Saramago, Nobel of Literature

This work addresses the general research question of how to design user experiences where the creative side of people is fostered by the peculiarities and elements of the user interface. We started out by addressing the study, design and evaluation of novel user interfaces for supporting creative writing. Our initial goals included the design and evaluation of a new application, which supports creative writers by helping them shape and articulate their thoughts, review texts, and become more creative and productive, as compared to using the currently available tools. After completing the design and development of this tool, called Haven, we selected two more, in different categories: Hanx Writer and Write or Die. In this section, we describe these three different UIs.

6.3.1. Haven: a “Zen” Creative Writing UI

Haven, which was developed previously by our team based on creative writing techniques and the needs of writers, is one of the user interfaces we evaluated during this research.



Figure 32 - Snowy writing theme.

Haven includes: a plot generator, a writing prompts generator, background soundtracks, typewriter sounds, and other elements. Most importantly, it features a “Zen-like” design with different writing “themes”, as illustrated by Fig.32 and Fig. 33, which show, respectively, a “snowy white” theme and a “moonlight writing” theme.

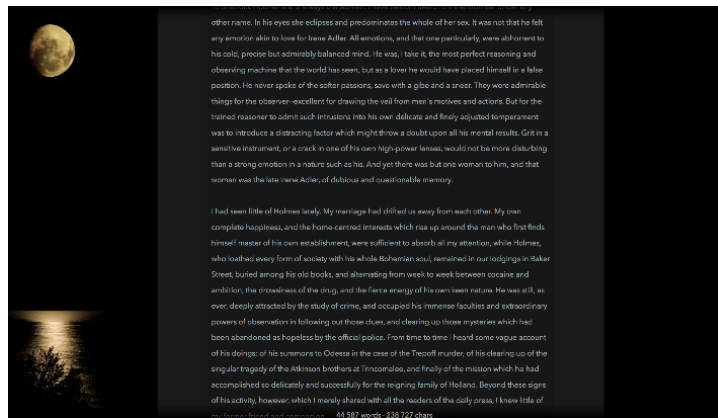


Figure 33: Moonlight writing theme.

The writing prompt is a popup window that displays dozens of different story triggers that can be used to spark the writer’s imagination. Fig. 34 shows an example of this.

Tell this story:
He turned the key in the lock and opened the door. To his horror, he saw...

Figure 34: An example of a writing prompt.

The plot generator is similar, but in this case it structures a story plot around two random characters, sets them in a random place (e.g. a river, a university, etc.), in a given situation (e.g. a marriage proposal, a blind date, a love triangle), and suggests a theme for unifying the story (e.g. vengeance, rebirth, opportunity, etc.).

6.3.2 Hanx Writer: the Return of the Nostalgic Typewriter

Just like the cachet of vinyl in an mp3 world, some facets of the typewriter can instill hipster appeal in a writing interface for a post-media user group. After some research, we chose to evaluate the impact of Hanx Writer⁴. This tool was recently launched by Tom Hanks, the actor, and gained momentum due to the solidness of its design, which realistically mimics the mass and metal of a real typewriter.



Figure 35: Hanx Writer.

Hanx Writer has a proper sheaf-rolled-in typewriter interface complete with ribbon color choice and margin measurements. Figure 35 illustrates its look. We hypothesized that the retro analogue appeal could positively influence the creativity, productivity and even mental well-being of our target group of youths.

6.3.3 Write or Die ... no tagline needed!

Write or Die⁵ aims to eliminate writer's block by providing consequences for procrastination. The users write to avoid annoying sounds and alarm warning colors, i.e. if a certain threshold of time passes by without any new words being added to the manuscript, a visual stimulus is triggered and coupled with annoying sounds. Figure 36 illustrates this UI, taken at a time when the background was becoming more and more red in color.

⁴ <http://www.hitcents.com/b2b/work/hanx>

⁵ <http://writeordie.com>

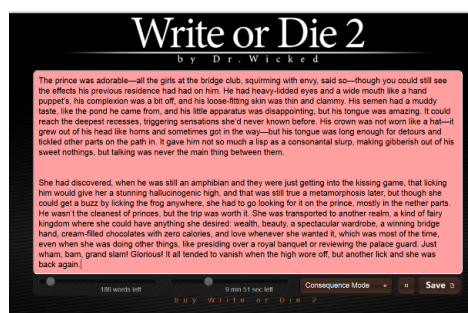


Figure 36: Write or Die.

We hypothesized that our target user group would enjoy the excitement and gaming aspect of this tool, and would be more productive due to the challenge this particular UI brings.

As an introduction to the following experiments, we will first focus on what they have in common: the participants we chose. Since we were interested in empowering marginalized groups by providing them with creative writing tools, we targeted teenagers with learning difficulties, cognitive deficits, and problems of socialization. These teenagers (aged between 12 and 18 years old) were taken from their family environment for various reasons: suffering physical, sexual, or mental abuse; lacking the care and affection appropriate to their age and personal situation; being forced into age-inappropriate conditions such as excessive work; and so on. They currently live and study in a full-time formal education institution at Estabelecimento Vila Mar in Funchal, Madeira. Figure 37 illustrates the environment where they study.



Figure 37: The youths in the educational establishment.

In the next three sections, we will describe the evaluations: including the participants, method, procedure and results of each. All the data taken from the experiments was made completely anonymous.

6.4. First study: zen UI VS. BASELINE

Words were not given to man in order to conceal his thoughts.

– J. Saramago

Our first evaluation study included a two-week experience in the previously mentioned educational institution for underserved youths. We addressed the following research questions:

RQ1: Can a “Zen-like” creative writing UI positively influence the productivity of users?

RQ2: Can a “Zen-like” creative writing UI positively influence the mental well-being of users?

RQ3: Can a “Zen-like” creative writing UI positively influence the creativity of users?

Participants

This preliminary experience involved 14 students from the institution’s population, aged between 12 and 18 years old. There were five females and nine males. We conducted fifteen sessions and used two Mac Minis and eight PCs. As a prerequisite, the participants had to have some interest in writing and a basic amount of computer and Internet experience.

Method

Our experimental design was based on a between-subjects design, in which two groups of students were randomly assembled according to different conditions such as gender, age, computing experience, and Internet experience, to ensure that the groups were similar as possible. The conditions to compare were two tools: MS Word (as baseline) and Haven (a Zen-like tool). The control group used MS Word, a tool without any explicit creative writing features, and the experimental group used the Zen-like creative writing user interface Haven.

Setting

Before starting the experiment the scope of the study and the rules were explained. Each group was instructed to start by answering the daily challenges and then responding to a daily survey. During the challenges, the two groups were separated in different rooms. Since we were using our tool, Haven, we introduced them to the tool and then left them to try it for a few minutes before they began on the first day.

Procedure

Participants were given a daily writing challenge, and were asked to fill in a very short Likert scale survey about how that daily experience made them feel. No time limit was set for completing the writing tasks.

Examples of the daily writing challenges included: *“Write about a time when you used your inner strength to get through a tough situation”*; *“Write about the bravest thing you have ever done”*; and *“Write about when someone hurt your feelings”*. These were conceived by one of the authors (a creative writing instructor), who also took into account the age of the participants.

The daily survey was based on the following Flow Theory dimensions: (i) intense and focused concentration on the present moment, (ii) sense of personal control or agency over the situation or activity, (iii) loss of reflective self-consciousness, and (iv) distortion of temporal experience. Participants ranked a 7-point Likert scale based on questions such as: *“I felt very concentrated during this challenge”* and *“I lost track of time during this challenge”*.

6.4.1 Results

We analyzed the results from a perspective that triangulates the words written, the data from the surveys, feedback from the teacher, interviews with the students and the stories themselves.

Productivity was measured using the average number of words as an estimate. Creativity and mental well-being were measured using subjective, quantitative (Likert scale-based) daily surveys which were constructed from the Flow Theory’s concepts [2]. Note that each student completed a daily writing challenge during the period of 15 days in a row, for a total of 43 data points, as the average number of participants, per day, was around 9 (not all students participated every day).

RQ1: *Can a “Zen-like” creative writing UI positively influence the productivity of users?*

To analyze the deviation data normality we used the Skewness and Kurtosis and Kolmogorov-Smirnov tests ($p < 0.05$). We concluded that our sample had a deviation of normality as showed in Figure 38.

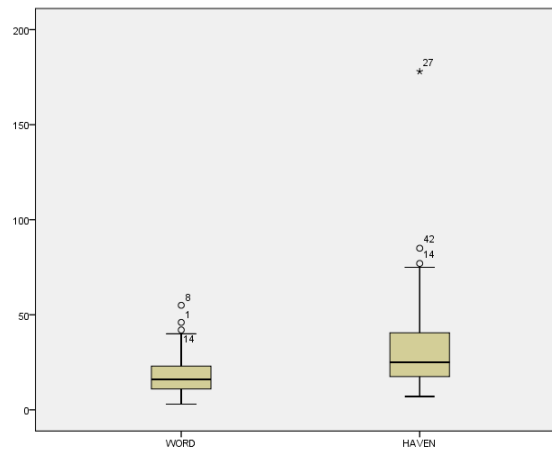


Figure 38 - Box Plot.

Regarding data dispersion, users in the experimental group (using Haven) wrote more words ($M=34.3$, $SE=4.3$), than those in the control group using our baseline MS Word ($M=18.3$, $SE=1.7$). The non-parametric Wilcoxon test was applied to evaluate MS Word and Haven deviation differences. For students using Haven the results were significantly higher than students using MS Word ($T=9$, $z=-3.7$, $p<.05$, $r=-.56$).

RQ2: *Can a “Zen-like” creative writing UI positively influence the mental well-being of users?*

In order to assess the participants’ mental well-being as well as its evolution along the two weeks of this study, we asked them to select up to three adjectives from the following list: Surprised, Delighted, Laid back, Depressed, Pacific, Happy, Tired, Bored, Sad, Satisfied, Frustrated, Angry, Serious, Animated, Distressed, Creative, and Frightened.

Figure 39 shows all the word clouds automatically generated according to each daily writing challenge (the numbers indicate the corresponding day). We can see that Happy and Creative were increasing slightly along the weeks, although the most relevant observation is simply the confirmation that most adjectives indicated a positive mental well-being.



Day	Adjective	
	Happy	Creative
D1	3	4
D2	3	2
D3	4	3
D4	3	5
D5	4	4
D6	5	4
D7	4	4
D8	6	5
D8	5	6
D9	4	5
D10	7	6
D11	7	5
D12	6	6
D13	8	7
D14	10	8
D15	10	7

Figure 39 - Word clouds for the adjectives that participants selected at the end of each daily challenge. Numbers indicate the day.

Figure 40 displays the total count for each adjective selected by the participants. We can see that Happy, Animated, Laid back, Satisfied, and Creative are the most chosen adjectives, especially when using Haven.

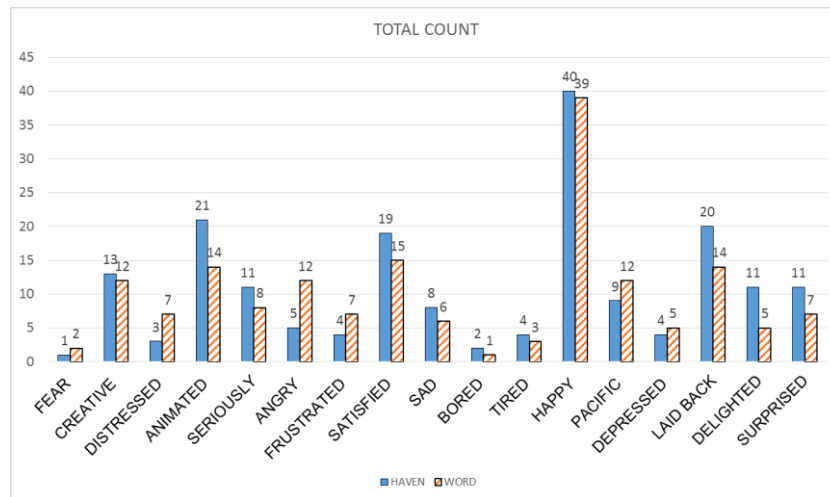


Figure 40 - Total count for the adjectives chosen by participants.

We proceed using repeated measures such as Friedman’s ANOVA approach to testing differences between each tool from the answers in the survey based on the dimensions of Flow Theory and ranked by participants in a seven-point Likert scale.

The dimensions (ii) sense of personal control or agency over the situation or activity, (iii) loss of reflective self-consciousness and dimension, and (iv) distortion of temporal experience did not have statistical significance when compared with each tool.

For the other dimension, (i) intense and focused concentration on the present moment, $F(1)=4.00, p<.05$ was statically significant. Therefore Wilcoxon tests were used to display if there were any differences between the control group using MS Word and the experimental group using Haven. The results showed that for the participants in the experimental group, concentration levels were significantly higher than in the control group ($T=24, z=-2.05, p<.05, r=-.25$).

RQ3: *Can a “Zen-like” creative writing UI positively influence the creativity of users?*

Regarding the stories written, and from a creativity perspective, we found some differences between the control and experimental group, with Haven apparently allowing for greater levels of creativity. However, it was not possible to establish this difference with sound confidence. In the remainder of this section we include excerpts taken from the students’ writings.

“In the place where I grew up, there were many, many trees, some more pretty than others, but they all had their particular enchantment, an enchantment that leaves me nostalgic now that I don’t live there anymore. I am now an adult, but I am nothing but a problem for people around me. The only thing I have left is the memory

of those beautiful trees living in freedom, dancing in the wind, freeing their leaves during the Winter so that children like me could play in them.” –User4-Haven

*“Three wishes? I just wish for my family to be happy, that would be a real dream.”
–User7-Haven*

“I hit my father hard. Yes it’s true. And it was all because of fighting over school. If I had the power to make something disappear, I would vanish the terror I have from the possibility of being arrested and put into prison.” –User9-MSWord

None of the users had ever taken an experiment such as this one. In the beginning, we found a slight initial resistance to meet the first daily writing challenge, as they were not very familiar with this kind of exercise. Later, students were curious to know what challenges would be proposed next, and that increased their desire to write. Note that the challenges were the same for both the control and experimental groups, and there was no transfer of learning as we were using a between-subjects experimental design. Triangulating the results with semi-structured interviews allowed us to corroborate some of these results and observations. When interviewed, all expressed genuine interest in creative writing and most users emphasized that the background soundtrack in the Zen UI was very helpful in making them relax and thus respond better to the writing challenges. Many of these underprivileged students have had very difficult lives, but we should highlight that some of them aspire to become amateur or even professional writers in the future, and showed great interest in the writing challenges we proposed. Some students claimed to use personal diaries in their daily lives, in which they would record their most meaningful and deeply felt experiences.

6.5. Second study: NOSTALGIC TYPEWRITER VS. ZEN UI

In our second evaluation, we investigated whether Hanx Writer’s nostalgic, retro appeal could positively influence the students’ creativity, productivity and even mental well-being, as compared to the Zen UI of Haven. In this context, the second study addresses our research question 4.

RQ4: *What is the influence of the typewriter UI on the participants’ productivity and mental well-being, when compared to the Zen UI of Haven?*

Participants

In this experiment, the participants were 8 students (five male and three female) of a similar age as the same group from the first experiment. We conducted one session and used two iPads running Haven and Hanx Writer.

Method

We employed a within-subjects experimental setup, where we divided the students into two groups: one using the Haven iPad app and another group using the iPad with the Hanx Writer app, randomizing the order. When they finished, we switched the tools and gave them a different challenge, also randomly picked.

Procedure

In this evaluation, we gave the same writing challenge to all students and conducted the sessions in the same room. Each group of participants was instructed to start by answering the challenge in 10 minutes and completing a short survey in the end. The survey was basically the same as in the first study.

6.5.1 Results

We evaluated the overall impact of both the Zen features and the nostalgic, realistic, retro-futuristic typewriter. Again, productivity was estimated as the average number of words produced, and mental well-being was estimated through the Flow Theory survey (the same as in the previous study). We used the Skewness and Kurtosis and Kolmogorov-Smirnov tests ($p < 0.05$) to analyze the data normality. Results show that our data was normal. T-tests were used to compare the statistical significance of the samples using a 95% level of confidence.

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
HANKWRITER	,228	8	,200 [*]	,896	8	,266
Haven	,196	8	,200 [*]	,859	8	,117

^{*}. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 41 - Test of normality

From observation, both tools aroused the curiosity of the participants. The most effective elements were the keystroke sounds and realistic animations in Hanx Writer, and the background soundtracks of Haven. Haven does not allow writing in landscape orientation (we used iPads) and that created some disappointment with users, since they felt it would be easier to write in that orientation. Note that, for these students,

anything that does not make them achieve their objectives immediately creates a great sense of anxiety and frustration, as the teacher told us when interviewed:

“For these students, when we give a different type of routine other than the ones they are accustomed to, and if for some reason they do not achieve their objective, they tend to react in a frustrated manner, much more than the average teenager or student.”-Teacher.

A threshold of ten minutes was set in this experiment, but only three participants used the time in its entirety. The remaining participants wrote their short stories in less time.

Using Hanx Writer, participants wrote on average more words ($M=41.3$, $SE=6.5$) than using the Zen UI of Haven ($M=38.5$, $SE=9.6$). However, this difference was not found to be statistically significant ($t(14)=0.22$, $p<0.41$). Both tools were effective in putting users into a good mood, selecting the adjectives that reflect this attitude: animated, happy, creative, and so on.

We also used repeated measures such as Friedman’s ANOVA approach to test differences between each tool when compared with Flow Theory. In all dimensions, (i) intense and focused concentration on the present moment, (ii) sense of personal control or agency over the situation or activity, (iii) loss of reflective self-consciousness, and (iv) distortion of temporal experience, results were not statistically significant when compared with each tool.

We complemented this information with semi-structured interviews performed after the experiment, which suggest that both Haven and Hanx Writer were equally pleasing and effective.

6.6 Third study: WRITE OR DIE

Finally, we hypothesized that our target user group of marginalized youths would enjoy the excitement and pressure brought by Write or Die, and would be more productive due to the challenge element of this particular UI.

RQ5: *Can the pressure and stimulus provided by Write or Die positively influence the productivity of participants?*

Participants

In this experiment, 10 students participated (eight males and two females) with a similar age to the same groups before. We conducted one session and used 10 PCs.

Procedure

In this case, we did not divide the participants into groups. Instead, they were all together in the same room. The writing challenge was solved using the tool Write or Die. All participants began responding to the challenge at the same time and were given 10 minutes as a max timeout. They finished the experiment and then answered a short survey (the same as the second study survey). The experimental setup and procedure were thus exactly the same as in the second study.

6.6.1 Results

This experiment was based on a premise taken from our observations of previous experiments: we wondered whether the student would write more if presented with a UI that used pressure as a motivation tactic.

Results showed that the participants using Write or Die wrote an average of 26.6 words ($SE=5.7$), which contrasts clearly with both Haven ($M=38.5, SE=9.6$) and Hanx Writer ($M=41.3, SE=6.5$). For exactly the same conditions and experimental setup, the difference was not statistically significant when comparing Write or Die with Haven ($t(14)=1.22, p<0.12$), but was significant when comparing Write or Die with Hanx Writer ($t(14)=1.87, p<0.05$).

Semi-structured interviews conducted after the writing challenges suggest that participants did not find the auditory stimulus (an alarming noise that Write or Die produces when the user is not writing, not to be confused with Haven's calming soundtrack) to be a productive influence; in fact almost all participants found it too stressful, which is particularly significant since they were very excited with this new tool at the beginning of the experiments. Figure 42 plots the total count of adjectives selected by the participants at the end of the experiment's survey. We can see that users' mental well-being was also very good, as most of the adjectives selected were positive (happy, animated, satisfied, and creative). In fact, the downside of Write or Die was lower productivity, as measured by average number of words written.

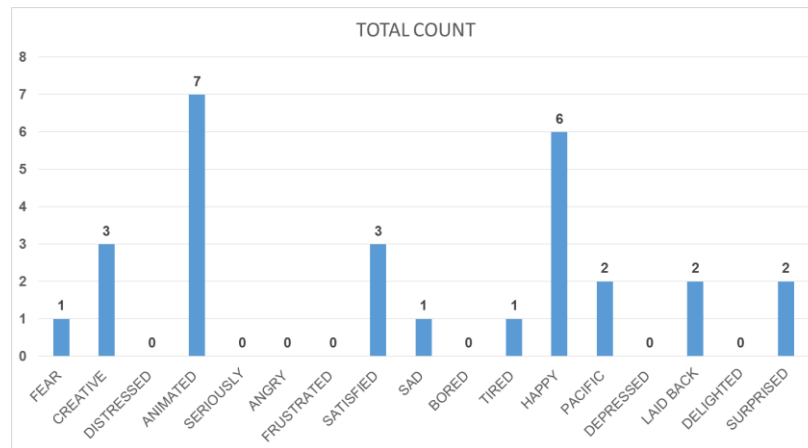


Figure 42 - Total count for the adjectives selected by the participants when using Write or Die.

6.7. Comparing creative writing user interfaces

Finally, it is possible to combine productivity (as measured by the average number of words written) with the Flow Theory dimensions into a single radar chart, normalizing the results (average number of words written) into the 7-point Likert scale. This allows a fast and useful comparison of different tools.

Figure 43 shows the combined results for our experiments and the different tools involved. By looking at the figure, one can see that the sense of control was not a significant issue for any of the tools we evaluated. MS Word, Haven, Hanx Writer and even Write or Die exhibited high Likert-scale values in this dimension. The same observation is valid for the Concentration dimension. The greater difference between the tools was found to be in the Loss of self-consciousness and Distortion of time dimensions. According to the survey, participants reported feeling less self-conscious while using Hanx Writer and Write or Die. The same happened when asked about losing track of time.

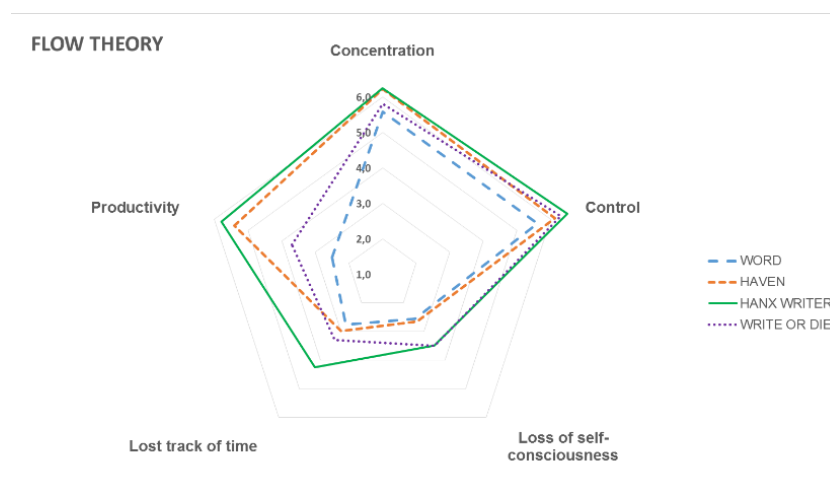


Figure 43 - Framework and chart for plotting and comparing creative writing tools.

6.8 Discussion

During all of the experiments, it was clear that the participants became intensely focused in the writing moment. A loss of reflective self-consciousness was also reported. From a qualitative perspective, some users described their experiences, usually emphasizing the tool and writing challenges they felt better with. For instance: *“In the story we had to write about a man sitting on a park bench, that’s when I felt most creative, because having that jump start a lot of things came into my mind and I felt in the mood for writing, forgetting about everything else. It was my longest text.”* (User9-Haven). Therefore, the writing prompts were observed as effective tools for kickstarting the creative writing process. Another effective feature was the background soundtrack: *“With the music, so many things started to come to my mind ... without the music my thoughts got lost”* (User5-Haven).

It was clear that all participants felt somewhat empowered and creative during the experiments, especially when using Haven. *“I thought about things I had never imagined before, I felt very creative”* (User11-Haven). According to the teacher who observed later, if one considers the low levels of education, socialization and problematic past experiences and behaviors of the test subjects, then both Haven and Hanx Writer were effective user interfaces for getting these users writing. The students became more creative and even felt better, happier and more relaxed. Finally, regarding the users’ intention to adopt the tools, it was clear that they exhibited a positive attitude towards using them, for example: *“We should use this tool during class or to do our homework. It makes me want to write more.”* (User 4-Haven).

One limitation of our study is that it does not consider the long-term usage of these tools. Therefore, conclusions are limited to an incipient (two-week) usage of the different creative writing user interfaces. However, it is still very useful to have this data, since overcoming initial resistance is the key to unleashing the creativity and writing skills that these teenagers possess.

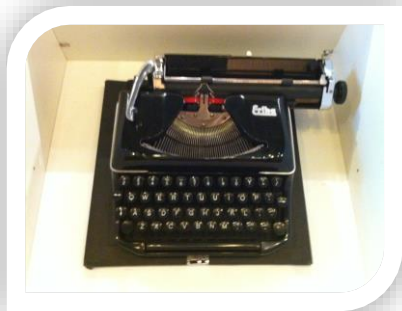
6.9 Conclusion

Public access to culture, especially literary culture, is one of the greatest achievements of modern civilization. Writing is among the oldest human activities and creative writing is an essential activity in many industries and professions. Creative writing is also often used as a pedagogical tool to increase literacy and can be used to build positive relationships and encourage dialogue across diverse communities. Creative writing gives a voice to marginal groups in society, allowing them tell their stories.

In this study we presented a novel approach that addresses, for the first time, a minority user group of underserved youths and evaluates how they write using different user interfaces. Specifically, we described three experiments that analyzed the impact of different creative writing user interfaces on the productivity and mental well-being of underserved youths. We compared MS Word (our baseline), a “Zen” user interface (Haven), a nostalgic typewriter (Hanx Writer), and a stress-based tool called Write or Die. From a productivity perspective, our results suggest that the typewriter UI was the most effective, followed closely by the Zen UI. From a mental well-being perspective, it was clear that this marginalized group felt more inspired, more focused and more immersed when using the Zen UI and the typewriter UI. Contrary to our initial expectations, the stress-based UI (Write or Die) showed the lowest productivity levels. We have addressed these somewhat sensitive issues and tried to empower underserved youths with user interfaces that help them to find their inner voices and express themselves. Moreover, our results have a practical utility for interaction designers who are interested in devising new interaction styles and designs that can promote positive relationships and even encourage dialogue across diverse communities. Our tool Haven is a first step, but certainly there is plenty of room for advancement and many discoveries to be made. By presenting a perspective on how underserved teenagers use creative writing tools, we hope this paper might inspire the design and development of novel and empowering digital tools.

CHAPTER 7

MILD PLACE ILLUSION



Through the following publication:

Gonçalves, F., Campos, P., "*Mild Place Illusion: A Virtual Reality Factor to spark Creativity in Writing*". Submitted to International Journal of Virtual Reality (August 2016).

CHAPTER 7

MILD PLACE ILLUSION

Developments in technology have modified the creative potential of each individual. We introduce a new concept, called "mild place illusion", as a new paradigm for designing user interfaces targeted at stimulating creativity. We show that for creative tasks such as creative writing, new product ideation, and brainstorming, a "just-enough" amount of place illusion leads to a greater self-perception of creativity, as opposed to a "full-level" place illusion. This is a somewhat unexpected result since one would suppose, a priori, to have the full-level place illusion as the optimal setup for stimulating creativity.

7.1. Introduction

"The capacity for creativity is essentially human and it holds the constant promise of alternative ways of seeing, of thinking and of doing" - Ken Robinson⁶

Creativity is a complex and multifaceted phenomenon [64], an inspiration [110], and is not a purely intellectual process. Includes discovery or invention of a significant idea, pattern, method, or device that gains recognition from accepted leaders in a field [111]. It can be defined as the "process of having original ideas that have value" [111], involving our imagination. It is one of the most frequently cited 21st century skills [112] [113] [114] [115] [116]. As Carroll et al. argue [66], there is no single theory or definition that can fully account for the phenomenon of creativity. Creativity often knocks into areas of consciousness that are not regulated by conscious thought. It may draw on all areas of human consciousness, such as feelings, intuitions, imagination, as

⁶ In book "Out of Our Minds- Learning to be creative" [2].

well as knowledge and practical skills [112] [63]. Researchers reinforce a lot of effort in developing numerous methods for supporting creativity, such as triangulating several temporal metrics, including self-report scales, external judgments and physiological measurements [66] [76] [117]. And some researchers also consider that it is appropriate to adopt a variety of methods to investigate it from a multitude of perspectives [64] [118]. Certainly, well-designed creative writing tools can help users in generating multiple levels of “flow” [73] or generating the sense of “being there” [119] combined with their creativity during the process of writing and tracking their creativity choices. Slater [119] states that place illusion – “*It is the strong illusion of being in a place in spite of the sure knowledge that you are not there.*”

In this study, we present a new experimental method based on virtual reality for studying place illusion in a writing context, along with the correlation of the degree of creativity. More specifically, we study three different creative writing environments (No PI; “Mild” PI; “Full” PI) and how they can affect the writer’s self-perception of creativity. We evaluate the participants’ experiences and proficiency with data from different sources during a creative writing task. In the experiment, we observed that participants felt more creative in the “Mild” PI condition, i.e. a “just-enough” amount of place illusion leads to a greater self-perception of creativity, as opposed to a “Full-level” PI or No PI.

7.2. The Illusion as a factor to spark creativity

Illusions have historically been of great use to psychology for what they can reveal about perceptual processes [120]. Slater [119] argues that when users experience place illusion (PI) - the qualia of having a sensation of being in a real place, “being there”, often called “presence” – and the illusion that the scenario that has been depicted is actually occurring - Plausibility Illusion (Psi), participants in both PI and Psi know for sure that they are not “there” and that the virtual events are not occurring. That is, when both PI and Psi occur, participants will respond realistically to the virtual reality.

Waterworth et al. [121] suggests that virtual and mixed reality environments can produce vivid experiences and generate powerful emotions. Their view of creativity rests on the idea of collaboration between consciousness and the unconscious, between the virtual and real as well as between presence and absence. The authors also explored ways in which perceptually-seductive technology (PST) can be a tool to enhancing both memory skills and creativity. By presenting information in different

perceptually-seductive and emotionally-stimulating ways, they suggest that PST can provoke creative ideas, robust learning and possibly also more engagement in the learning process [121] [122]. The relation of the individual to the technology, and with the world through the technology, is also considered in PST. It is suggested that in order to stimulate and support the creative process, IT environments should encourage both presence (perceptual or experiential mental activity) and absence (conceptual or reflective mental activity) which are seen as the end points of a continuum comprising the Focus dimension of PST [123]. The other two dimensions are Locus (whether attention is directed towards the virtual or the physical world) and Sensus – which is the level of attentional arousal, on a continuum from completely unconscious to fully conscious [121] [123]. In a different study, PST is applied to a virtual environment as a way to stimulate curiosity, leading to a sense of control and empowerment, at the same time as the user experiences, explores and investigates her own feelings and emotions [124]. The sense of presence is a key aspect of experience in virtual environments but in order to understand and evaluate those experiences we need more than mere presence.

7.3. User Study

We conducted a within-subject experiment to investigate the influence of the PI amount on the users' self-perceived creativity. We selected creative writing because it is a popular activity [15], which made it feasible for us to properly recruit participants. All data taken from the experiment was made completely anonymous. This experiment was conducted throughout six months.

Conditions

The creative activity in this experiment included writing in three creative writing environments (Figure 44): no place illusion; mild place illusion and full place illusion. To control for carry-over effects, the order of the conditions was randomly counterbalanced between participants.

Control condition - No PI. Our baseline is a text processor (Microsoft Word) that allows users an easy and near-instant input. It has a large variety of formatting options, including a variety of color choices, the ability to change font-weight.

"Mild" Place Illusion - ("Mild" PI). In this condition we used Haven [14] which is a clean and lightweight tool text processor, with audio soundtracks to provide inspiration, a full screen mode and a virtual reality landscape with subtle animations.

“Full-level” Place Illusion - (“Full” PI). In this condition, we simulate a virtual reality-based creative writing environment within the Haven tool.

The conditions were defined like this so that we could correctly address our research question in a focused manner: to assess the influence of the PI amount on the users’ self-perceived creativity.



Figure 44 - Creative writing conditions in the experiment (from left to right): No PI; “Mild” PI; “Full” PI.

Task

Participants were required to write in the three different writing environments. We had to define three different fairytales of a similar degree of complexity that participants were equally familiar with. In each condition, participants received a fairytale to read. After that, they had to brainstorm ideas (Figure 45) in a white paper with different-color pen or pencils (we gave them pen or pencils from different colors so that they could feel free to write using their preferred color). In every condition, they initiated their writing based on their ideas obtained during the brainstorming stage. No time limit was given.



Figure 45 - Participants in the brainstorming stage

Participants

We recruited only persons who had already taken creative writing courses, reportedly enjoyed writing or were actual writers. They were recruited through a university-wide mailing list. Nineteen people enrolled in this study, but we dismissed the collaboration

of three people because they didn't show up on the appointed day. Others changed the agreed date, and scheduled another date because they did not feel in the mood to write on the appointed day.

Sixteen subjects participated in this study, 8 male and 8 female, ages between 21 and 56 years old ($M=29.25$; $SD=9.46$). All had normal or corrected normal vision; three wear glasses or contact lenses. All subjects were naïve to the experimental conditions. We lead one session per person.

Measurement approach

Creative Behavior Inventory

We used thirty items from the original CBI, [89] particularly the specific examples of creative activities from literature, miscellaneous, performing arts, science and music [69]. We used the CBI as a psychometric tool to ask about past creative behavior and activities, and as a way to categorize how creative the participants were. An item score was based on response category: zero points for never, one point for once; two points for twice, three points for 3-4 times, four points to 5-6 times and five points for more than 6 times [68]. We classified subjects that had less than 30 points on the CBI as being *less creative*, and participants that had more than 30 points on the CBI as *highly creative* [18].

Flow Theory dimensions and Perceptual Effects

In this study, we were particularly interested in the following of Flow Theory dimensions: concentration, sense of control, losing track of time, and loss of self-consciousness. Since PI is a *qualia* and there is no way to directly measure it, as suggested by Slater [119], we used these dimensions based on questionnaire as an indirect assessment. After each condition, the participants were asked to fill out a Likert scale survey about how the experience made them feel based on the Flow Theory dimensions [73] (“*I felt very concentrated during this task*”; “*I was able to solve this task without any problem*”; “*I lost my attention during this task*”; “*I lost track of time during this task*”), and also about Perceptual Effects (“*It felt as if the writing was drifting towards a very good way*”; “*I sometimes felt as if I was actually writing at the environment’s location*”; “*Sometimes I felt that the environment was providing me inspiration*”; “*At some moment I felt that the virtual environment was influencing my thoughts*”; “*It sometimes seemed as if the creativity I was feeling came from somewhere between my mind and the virtual environment*”; “*It sometimes seemed as if I was feeling more creative than ever*”; “*The flow of my writing was caused by the virtual environment*” based on [120] [125]. They ranked

a seven-point Likert with the evidence scale for 1 (totally disagree) and 7 for (totally agree).

Self-assessments and Post-experiment interviews

An interview was conducted to collect qualitative data about the experience with questions such as *"Did you enjoy to write in this environment and why?"*; *"In this environment did you feel more creative and why?"* to know the participant's opinion about the whole experience, and we asked participants to rank the creativity of their written data (a self-assessment) [69] in a Likert scale (one to seven). One month after the experience was over, users received the written texts, without knowing what condition the texts belonged to. They had to read the texts and carry out the rating of their creativity, again in a Likert scale (one to seven).

External judging

In order to assess if there were any differences between the results from participants and each condition, we recruited three experts in Creative Writing, Arts and Psychology to rate the creativity of all written data per writing. They were not involved in the sessions in any way and rated individually the written data without knowing which tool the users had used. We asked them to for a score ranked in a 7-point Likert with the evidence scale for 1 (not creative) and 7 (very much creative) taking into account the three creative abilities per answer: Flexibility (production of different ideational categories), Originality (production of unusual ideas) and Elaboration (persistency on introducing details to products) from the Torrance Test of Creative Thinking (TTCT), [77] [78].

Procedure

A preliminary evaluation was conducted with four participants in order to examine the feasibility and accuracy of all the creative writing environments. Participants were asked to write a very short story during ten minutes about one of these topics: nature, food, trips and holidays. Subsequently, participants were asked whether any of the conditions disturbed them during the writing task. Since all participants reported not being disturbed, we considered that the study could be conducted according to the procedure.

Participants were brought in individually to the research laboratory (Figure 46), previously prepared for the experiment. For the *No PI* and *"Mild" PI* conditions, we used one portable computer with screen size 13.3', display resolution 1920 x 1080

pixels. In the *Full PI* condition, we used a large white wall (5.2m x 2.20m) and a projector with a full HD resolution, 3D-sound columns and a wireless keyboard.

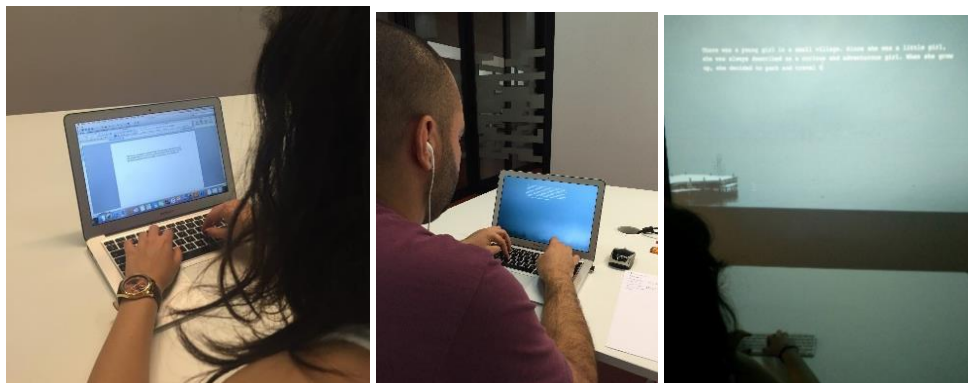


Figure 46 - Performing the study in the research laboratory. Participants were seated alone in a quiet room to write their ideas in each specific environment (No PI | “Mild” PI | Full-level PI).

After participants filled in the inventory (CBI), the writing task was explained. During the writing task, users were interrupted to pinpoint the state of flow regarding how they were feeling about the creative writing environment and the writing task. They were interrupted 10 minutes after they started writing. A researcher (the first author) made the record, through observation, of the whole process in terms of writing fluency, completion time for each task, and all qualitative elements that could be useful in the experiment.

When users finished the writing task, they were asked to fill a survey about Flow Theory dimensions and a questionnaire about Perceptual Effects. Finally, they were interviewed and ranked their creativity in each condition.

The total time per subject including pre-questionnaire, instructions, training, experiment, breaks and debriefing took over two hours. Subjects were allowed to take breaks (10 minutes) between each experimental condition.

7.4. Findings

Were the participants creative?

Regarding reliability, our 30-item CBI inventory exhibited a Cronbach’s alpha value of .72. We found (*see Table 10*) that six males ($M=46.83$, $SD=17.66$) and six females ($M=45.0$, $SD=8.87$) were highly creative (more than 30 points in CBI) when compared to the other of its kind, two males ($M=26.0$, $SD=4.0$) and two females ($M=19.5$, $SD=8.5$).

Table 9 - Participants Age, Gender and score points in CBI

Age	Gender	Points in CBI
28	Male	22
31	Male	51
31	Female	44
23	Male	37
36	Male	54
28	Female	54
25	Female	37
20	Male	30
30	Female	28
21	Female	31
20	Male	48
21	Male	43
22	Male	48
37	Female	11
56	Female	48
39	Female	56

We compared the gender of the subjects with their creative level of the self-report scale in CBI to see if there were any differences between genders. On average, male participants experienced greater creativity in past activities ($M=41.62$; $SD=11.12$) than to female participants in past activities ($M=38.62$; $SD=15.08$). This difference was not significant ($t(14) = 0.45$, $p > 0.05$); however, it did represent a small-sized effect $r = .12$. Results of the self-report scale, suggest that our sample was likely "homogeneous" in terms of past creative actions.

Did the creative writing environments lead to increased levels of "flow"?

The polarity of the scale was taken into account in Flow Theory dimensions survey. Results show that the average inter-correlation among the items and the number of test items can be considered good, consistent [91], in the scale used by the questionnaire on seven-point Likert scales: Flow Theory dimensions ($\alpha = .81$). As a first step, we used repeated measures (Friedman's ANOVA [91] [109]) approach to testing differences between each environments.

The Flow dimensions: *Concentrate* ($Fr(2) = 8.74$, $p > .05$), *Sense of Control* ($Fr(2) = 1.42$, $p > .05$) and *Lost track of time* ($Fr(2) = 0.23$, $p > .05$) did not significantly change the way users used the creative writing environments.

The results were substantially significant regarding the Flow dimension *Loss of Self-Consciousness* ($Fr(2) = 6.05$, $p < .05$). Therefore, the non-parametric Wilcoxon tests [91] [109] were used to assess if there were any differences for each pair of creative writing

environments using the *No PI* to compare as a baseline. A correction was applied and so all effects are reported at a .025 level of correction.

Regarding the dimension *Loss of Self-Consciousness*, the statistical analyses showed that participants using *No PI* when compared with "*Mild PI*", ($T=2, z=-2.07, p<.025, r=-.36$), were not statistically significant, the same for participants using *No PI* when compared to "*Full PI*" ($T=2, z=-2.23, p<.025, r=-.39$). We applied the effect size that gives us the magnitude of the effect investigated [91], by performing a *post hoc* analysis, identifying a medium effect size. These results may be due to the fact that participants were interrupted during the task to mark its psychological state of flow [115]. Figures 47, 48 and 49, show that the overall distribution of the psychological states of the participants when interrupted during the creative writing challenge was different for each environment.

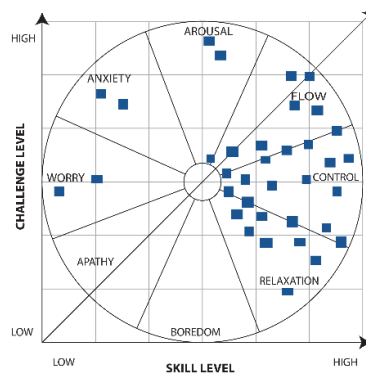


Figure 47 - No Illusion Session

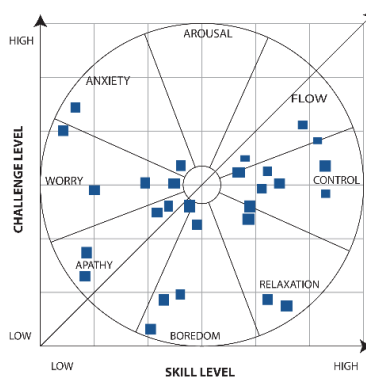


Figure 48 - Mild Place of Illusion Session

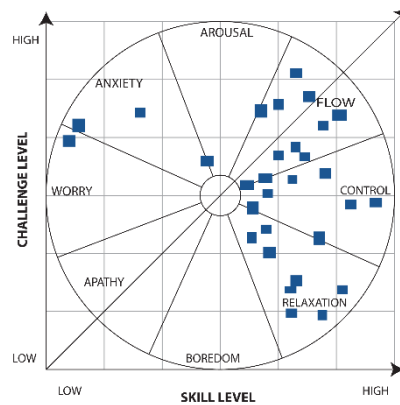


Figure 49 - Full-level of Place of Illusion

In the "*Mild*" *PI* condition, we can see that most participants went into flow, control and relaxation states, and experienced a better balance between skills and challenge. In contrast, in *No PI* session results shows low levels of flow state. However, it is interesting to see that in the *No PI* session a high number of participants were in the state of boredom, apathy and worry. In "*Full*" *PI*, we can see a low balance between skills and challenge when compared to "*Mild*" *PI*.

Triangulating the results with the statements in the interviews and from the observations after the interruption, when participants were interrupted to pinpoint their state of flow (regarding how they were feeling about the creative writing environment and their writing task), the results show that most of participants in the "*No PI*" condition did not want to continue with the writing activity (43.75%) contrasting with the 12.5% in the "*Mild PI*" condition and "*Full PI*" condition (12.5%). Thus, participants in "*Mild*" *PI* session after interrupted continued immersive and focused on writing (75%), contrasting with the 56.21% in "*Full*" *PI* session (56.25%) and *No PI* session (43.75%). Also, we observed that after being interrupted, 12.5% of the participants completed the writing challenge in "*Mild*" *PI* session. In contrast, most of participants in the *No PI* session ended the writing task (43.75%), compared to 12.5% in the "*Full*" *PI* session.

31.25% of the participants in the "*Full*" *PI* session stopped to think and restarted writing, while only 12.5% in *No PI* session did so and 12.5% in "*Mild*" *PI* session.

When participants were interviewed as they had felt at the interruption in the challenge, most expressed that had no effect on the continued writing task, e.g.,

*“...I returned to back on track because I was with the ideas on my mind” – [P1];
“...did not break the reasoning” – [P9]; “...I did not lost all the ideas that I had”-
[P15].*

Others assume that in *No PI* session they had more difficult to regain focus, e.g.,

“I stopped writing in no illusion session, because I found it difficult to return to resume the story”- [P14]; “I didn’t lose the ideas on writing in haven”-[P12]; “I just start writing with no difficulty in mild session, but in the other, the full-level session, I was more distracted with the environment and because of that I stopped writing” – [P11]; “I just had a block in no illusion session, and I stopped” - [P10].

Following from what is known about creativity, concentration is an important ingredient to engage participants in an activity with high involvement, enjoyment and intrinsic motivation [73]. Once they were interrupted they were no longer in flow of their fleeting state, but from results we could notice a small number of participants had finished writing after the interruption in the *“Mild” PI* environment in contract to other two environments. We can assume that the conditions available in this environment allowed participants to return to the flow state.

Did the creative writing environments lead to increased perceptual effects?

Through Cronbach’s alpha, the survey based on perceptual effects [120] [125] was found to be reliable ($\alpha = .84$). Results on the question *“It felt as if the writing was drifting towards a very good way”* ($Fr(2) = 3.95, p > .05$) were not significant.

Regarding the questions *“I sometimes felt as if I was actually writing at the environment’s location”* ($Fr(2) = 8.27, p < .05$), *“Sometimes I felt that the environment was providing me inspiration”* ($Fr(2) = 14.53, p < .05$), *“At some moment I felt that the environment were influencing my thoughts”* ($Fr(2) = 7.56, p < .05$), *“It sometimes seemed as if the creativity I was feeling came from somewhere between my mind and the environment”* ($Fr(2) = 8.35, p < .05$), *“It sometimes seemed as if I was feeling more creative than ever”* ($Fr(2) = 11.61, p < .05$) and *“The flow of my writing was caused by environment”* ($Fr(2) = 7.14, p < .05$) results were substantial significant. Correcting the 5% level of significance ($p < .025$), and using *No PI* to compare as a baseline, Wilcoxon tests were used to display if there were any differences for each pair of environments [91] [109].

Pair 1: No PI versus Mild Place of Illusion

Regarding the questions *“I sometimes felt as if I was actually writing at environment location”* ($T=3, z=-2.54, p < .011, r=-.45$), *“Sometimes I felt that the environment was*

providing me inspiration" ($T=1, z=-3.19, p<.001, r=-.56$), *"At some moment I felt that the environment was influencing my thoughts"* ($T=2, z=-2.85, p<.004, r=-.50$), *"It sometimes seemed as if the creativity I was feeling came from somewhere between my mind and the environment"* ($T=2, z=-2.29, p<.022, r=-.40$), *"It sometimes seemed as if I was feeling more creative than ever"* ($T=2, z=-2.84, p<.004, r=-.50$), results were statistically significant.

The results from the question *"The flow of my writing was caused by environment"* ($T=2, z=-2.11, p<.035, r=-.37$), were not statistically significant.

Pair 2: No PI versus Full-level of Place of Illusion

Regarding the questions, *"I sometimes felt as if I was actually writing at environment location"* ($T=3, z=-2.59, p<.009, r=-.46$), *"Sometimes I felt that the environment was providing me inspiration"* ($T=2, z=-2.55, p<.011, r=-.45$), *"At some moment I felt that the environment was influencing my thoughts"* ($T=3, z=-2.34, p<.020, r=-.41$), *"It sometimes seemed as if I was feeling more creative than ever"* ($T=2, z=-2.67, p<.008, r=-.47$), results were statistically significant.

In questions, *"It sometimes seemed as if the creativity I was feeling came from somewhere between my mind and the environment"* ($T=3, z=-1.91, p<.056, r=-.34$) and *"The flow of my writing was caused by environment"* ($T=2, z=-2.14, p<.032, r=-.38$), results were not statistically significant.

Taking into account the results, in both environments – *"Mild" PI* and *"Full" PI* when compared to *No PI* – participants felt that the environment was not a direct factor in the flow of their writing.

"Mild" PI versus Full-level of Place of Illusion

When we compared the *"Mild" PI* condition with *"Full" PI* condition, using an ANOVA with repeated measures with a Greenhouse-Geisser correction, the perceptual effects for participants were not statistically significantly different ($F(1.000,15.000)=0.23, p>0.005$).

When we asked them if there were any features they really liked and if those features influenced the ideas to write, some of them expressed genuine interest in the relation to the background environment, clean view and audio soundtrack (present in mild PI and full-level PI conditions) and they commented, e.g.,

"...I felt somewhat empowered and creative during the mild place of illusion session given the sounds and clean background"-[P4]; "...the music helps to inspire and

seems like the text is flowing a little”- [P3]; “...sound helped to keep me writing with a clear mind”-[P5]; “I was feeling pressured by the environment...I wanted to give another direction to the story that I was writing, but the environment influenced to have other purpose...and also I changed the music during the writing task because it’s was giving bad feelings ”- [P7]; “...changing the environment to write is a very good thing, because we can adapt the background and that can help us to write more... that was what I did”- [P12]; “..I used the sound of the rain in my story...and also the feeling that you are writing (from the sound of keyboard-another feature) and listening to the constant noise, makes you want to continue to write, ”- [P2].

Only two users assumed that the sound was very distracting, “...I just turned off the sound...it was distracting me”- [P13]; “I got lost in my thoughts and did not write much, I was more attentive to the sound”- [P16].

Did the transition between creative writing environments lead to enhancing their writing?

We compared the perceptual effects with the flow dimensions; the results were based on the survey performing tests of correlation using Spearman’s correlation coefficient [109] [91], to verify if the intense and focused concentration on the present moment, if the sense of personal control or agency over the situation or activity, if the loss of reflective self-consciousness and if the distortion of temporal experience influences the perceptual effects of the environment. Table 11 shows the results regarding the correlation values we obtained between flow dimensions.

Table 10 - Correlation between survey items

	No PI	Mild Place of Illusion	Full-Level of Illusion
<i>Flow dimensions versus Perceptual Effects</i>	.643**	.569*	.519*

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

Results are significant and the correlation values are positive. This suggests that flow is related to perceptual effects, in the sense that when one occurs the other also is likely to occur. We asked participants in the interviews, if they felt any difference in the process of writing and the transition between each environment (recall that the order was counterbalanced), and they comment,

“I felt I was more focused on the text in mild place illusion and in the other (full-level of place illusion) I was more distracted by the environment (...) the no illusion is

more standard, more “office”-way, so I felt that I was not able to develop my ideas”- [P1];

“(...) It’s funny, because in the no illusion session I described more the environment into the story and in the other two sessions I described more the characters”- [P2];

“(...) I felt that I was repeating myself in the full-level session, and I was keeping my writing, but my thoughts were in that thing (...) on contrary, during the mild-place illusion session I felt more closely”- [P3];

“I felt that the ideas are very melancholic in no illusion, because it is static, while the other environment, the full place illusion, I felt lost in the ideas, I didn’t like it (...)”- [P4];

“I felt more immersed in full-level of place illusion, the surround sound was very good”- [P5];

“(...) the environment didn’t influence what I was feeling (...) but in the full-level of place illusion I felt more creative, but my thoughts were not synchronized (...). There wasn’t a mapping between the environment and thoughts and I was feeling stressed about it (...) also it was good to adapt the mood of the environment to the stories that we want to write” - [P7];

“(...) the full-level of place illusion simulates the real environment, it seemed that I was there, I was more immersed in writing but I prefer the mild place illusion because it was more proximal”- [P8];

“(...) allowed to be more focused on the task that I was doing (mild place illusion), the no illusion session is normal, it’s “work”- a white sheet (...) otherwise the other (full-level of place illusion) I eventually feel I lost thoughts”- [P12];

“(...) I was bored (no illusion session) (...) I felt happy in the other environments and I could write more”- [P15].

Did the creative writing environments lead to increased output?

We estimated the amount of words written by each participant. We used the Skeweness and Kurtosis and Kolmorov-Smirnov tests ($p>0.05$) to analyze the data normality, Figure 50 shows that the sampling distribution is normal.

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
NoIllusionUI	,150	16	,200 [*]	,891	16	,057
MildPlaceOfIllusion	,153	16	,200 [*]	,907	16	,103
FullLevelPlaceOfIllusion	,161	16	,200 [*]	,876	16	,034

*. This is a lower bound of the true significance.
 a. Lilliefors Significance Correction

Figure 50 - Sample Distribution

T-tests were used to compare the statistical significance of the samples using a 95% level of confidence. When using "Full" PI, participants wrote on average more words ($M=327.4$, $SD=56.0$) than when using No PI ($M=230.0$, $SD=30.5$), however, the difference was not statistically significant ($t(15) = -1.77$, $p > .05$)

When participants used "Mild" PI condition, they wrote on average more words ($M=354.3$, $SD=37.1$) than when using No PI ($M=230.0$, $SD=30.5$), and the difference was statistically significant ($t(15) = -3.001$, $p < .05$).

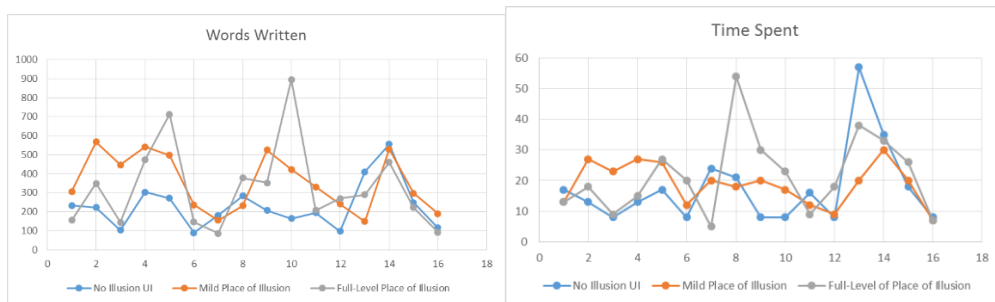


Figure 51 - Number of words written by each participant versus time spent

During the No PI condition, participants spent on average less time writing ($M=17.44$, $SD=12.92$) when compared to the "Mild" PI condition ($M=18.81$, $SD=6.83$) and "Full" PI condition ($M= 21.56$, $SD=12.96$). Still, this difference was not statistically significant ($F(2) = 1.67$, $p > .05$). Triangulating the data of the words written and the time spent in writing (Figure 51) with interviews, we can observe that users were more focused on the task in the "Mild" PI condition, since they did not write for a long time but they produced more words. Figure 52 shows some of the participants' ideas in the brainstorming before they started to write.

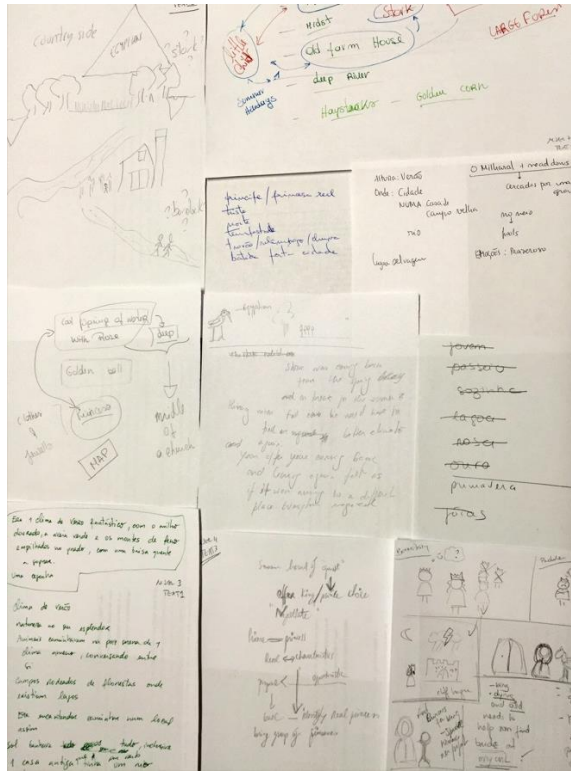


Figure 52 - Some of the participants’ ideas during brainstorming, before they started to write.

In the semi-structured interview, we asked participants if they used the ideas written during the brainstorming and what comments or feeling they had about that. Below are some of the comments:

“(...) I used it to collect textual ideas (...) only served to start writing.”- [P2];

“Having brainstorming ideas from the text I read, helped me to create and to have a basis for the story. It's like the difference between having objects and describe them as opposed to not having them. There is always a purpose behind writing, so that helped me to start the basis of it.”- [P3];

“(...) to start is good (...) it's like having a skeleton, but then I developed many of the ideas when I was writing and forgot the others from the brainstorming (...) as I was writing, other ideas were emerging.”- [P4];

“It helped me to have a beginning to the writing, characters, etc., rather than simply asking to write about something”- [P5];

“(...) the text helped me trigger the writing (...) I wrote the ideas on the paper that I retained through brainstorming, but when as I was writing I had other ideas and

have not used those that had written in the paper(...) and also I did not remember them when I was writing the story.”- [P8];

“(...) the text and the brainstorming was not important to start write”- [P9];

“(...) it helps to start writing (...) having a goal it’s easier to write and the inspiration appears and I have to say that also the environment helps”- [P10].

From the qualitative data obtained in the interview and as stated previously, we can see that some participants were able to generate more ideas at the time of writing, and even some of them did not used the initial ideas in their writing task.

Did the creative writing environments lead to increased levels of experienced creativity?

After the experiment, participants self-rated their creativity [80]. A month later, we sent by e-mail the written text by each user for them to rank their creativity again. We didn’t receive answers from participant six (user6) and participant thirteen (user13). This analysis does not take into account those users. From the results (Figures 53, 54 and 55) we can see how subjective the creativity ranking can be, the same text can have different assessments made by the same person concerning his/her creativity. They read back their text with a time difference, analyzed and evaluated them differently using the same rating scale. We know that human memory has a vast capacity, storing all the semantic knowledge, facts and experiences that people accrue over a lifetime [126], and perhaps the participants knew which tool referred to each text. Still, we obtain widely different initial results.

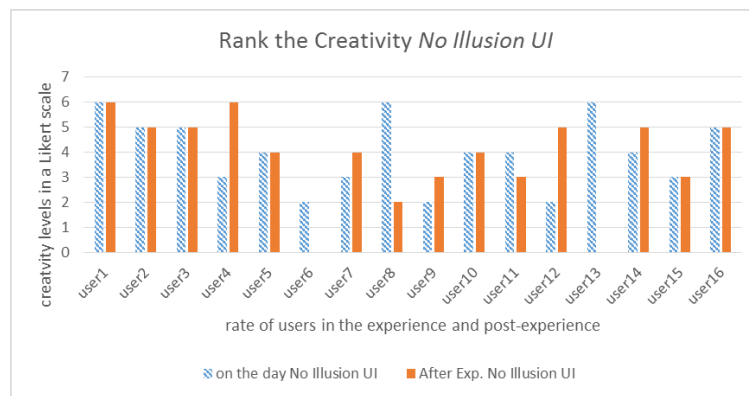


Figure 53 - Participants self-perception of creativity in the No PI condition.

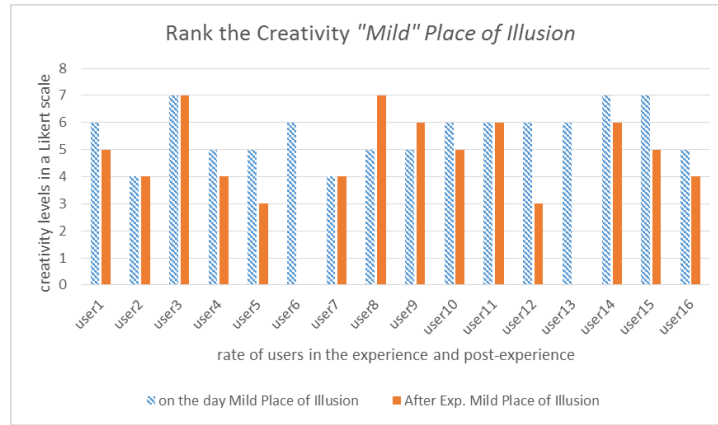


Figure 54 - Participants self- perception of creativity in the "Mild" PI condition.

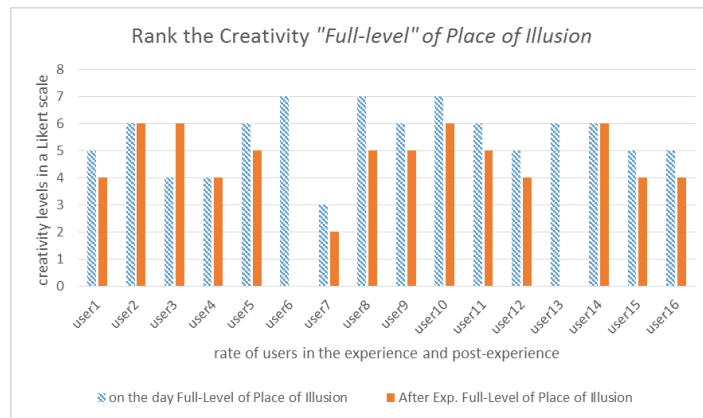


Figure 55 - Participants self- perception of creativity in the "Full" PI condition.

We found significant differences in self-perception of creativity on the day of the experience when we compared the *No PI* condition ($M=4.00, SD=1.30$) with the *"Mild" PI* condition ($M=5.57, SD= 1.10$), ($t(13)=-3.56, p<0.003$) and also when we compared *No PI* with *"Full" PI* ($M=5.36, SD= 1.15$), ($t(13)=-3.39, p<0.005$). When we compared *"Mild" PI* with *"Full" PI*, there were not significant differences ($t(13)=0.543, p=0.596$).

When we compare the differences in self-perception of creativity after the experience, results show that in the *No PI* condition ($M= 4.28, SD=1.20$) versus the *"Mild" PI* condition ($M=4.92, SD= 1.33$), there are no significant differences ($t(13)=-1.12, p=0.280$). Also, for the same condition when we compare it with *"Full" PI* ($M=4.71, SD= 1.14$) ($t(13)=-0.95, p=0.362$) - results were not significantly different.

Some statistics results from the experts' rating about the creativity present in each written text are shown in Table 12. Coefficient of inter-judge reliability ($\alpha=.37$). In the *"Mild" PI* condition, participants exhibited higher creativity scores, than in the *No PI*

and "Full-Level" *Place Illusion* conditions. Using Friedman's ANOVA, ($F(2) = 2.98$, $p > .05$) this difference was not found to be statistically significant.

Table 11 - Statistics from experts' rating about the texts' creativity.

	No PI	Mild PI	Full-Level PI
Mean	4.71	4.92	4.3
St. Error	0.19	0.22	0.28
Median	5.0	5.0	4.5
St. Deviation	0.76	0.86	1.09

From the results, and triangulating with the self-assessments and the interviews, we can assess that evaluating creativity itself is a broad concept and means different things to different audiences in terms of what needs to be done to evaluate it [127]. Through a suggestion by the authors [18] [69], we used different ways to measure creativity in each environment to obtain more concrete results. Self-assessments [69] about individual creativity are not standard parts of batteries and can lead us to different results every time we try to measure them.

7.5. Discussion and Conclusions

Place illusion is defined as "*the qualia of having a sensation of being in a different place*" [119] and is constrained by the sensorimotor contingencies afforded by a virtual reality system. Creative professionals – such as writers – often report they feel more creative when they are working at a special place or location or setup that increases their creativity [9]. In this study we presented a new approach called "Mild Place Illusion", as a new paradigm for designing virtual reality user interfaces specifically targeted at stimulating creativity.

We showed that for creative tasks such as creative writing, new product ideation, and brainstorming, a "just-enough" amount of place illusion leads to a greater self-perception of creativity, as opposed to a "full-level" of place illusion. In general, the analyses in this study confirm that a "*Mild Place Illusion*" environment is capable of providing higher levels of creativity and can lead to better results. We considered that the methodology in this work was fairly complex, but our results show – through a data triangulation approach – that we were able to identify more consistent and personal creative experiences. As suggested by Hewett et al. [128], within the limits of human working memory, the greater the variety of concepts that one considers, the greater is the probability that creative ideas will occur.

As Carroll et al. [18] suggest, we empower users to harness and embrace their creativity through the use of creativity support tools. Technology is only capable of turning *on* or turning *off* human creativity. Creativity Support Tools can enhance the intellectual resources and improve collaboration among users through more rapid discovery processes. They can also promote, accelerate and facilitate creativity [41]. We tried to balance a creativity focus on the individual (CBI and Self-Assessments) and their flow state while carrying out the writing task and their previously acquired skills.

Bonnardel and Zenaschi [129] suggest that the development of new technologies should be dependent on the individuals' cognitive processes. More precisely, they argue that technology developments should be adapted to the individuals' cognitive processes instead of requiring users to adapt themselves to new technologies. It was clear that most of our subjects felt somewhat empowered and creative during the experiment, especially when they were in the Mild PI condition. LeBoutillier and Marks [130] suggest that a particular procedural context, is multifarious, with styles, forms, contents and contexts of imaging, which can account for the role of mental imagery in the creative process. Our quantitative and qualitative results have been promising:

- a) With an emphasis in everyday creative activities in the past work of each participant such as literature, miscellaneous, performing arts, science and music actions we could reduce bias with self-assessments results from the CBI and results showed that our sample was likely "homogeneous" in terms of past creative actions.
- b) Results from the Flow Dimension *Loss of Self-Consciousness* were substantially significant but when comparing each pair of environments, they were not statistically significant. These results suggest that in the future we will not interrupt participants during the task to mark their psychological state of flow. However, it was interesting to see that the participants in the *No PI* condition were feeling more apathy, boredom and worriedness during the execution of the task.
- c) When comparing each environment with the state of Perceptual Effects, only the results about the question "*It felt as if the writing was drifting towards a very good way*" were not significant. Triangulating the quantitative results with the qualitative data that we collected from the interviews, we can assume that participants were feeling more immersive, more concentrated and more creative in "*Mild*" PI session. We could also observe that most participants were

really thoughtful and engaged in the activity during Mild PI, rather than during full level of PI.

- d) Generating multiple possible solutions by reading the text to trigger their creativity and afterwards using the brainstorming technique to generate ideas was a good way to ensure that we would not be restricting the creativity of participants, giving them freedom to write through their own (previously-generated) ideas. Results show that participants in "*Mild*" PI wrote more words than *No PI* or "*Full*" PI, without spending a lot of time. Triangulating these results with interviews, we can assume that they were more focused on the task itself and felt more creative.
- e) Self-assessments are also as complex as creativity itself. Despite the fact that we could not establish differences with sound confidence in order to assess the relationship between self-assessments of creativity and ratings of external judges, results suggest that users in Mild PI were more creative, during the writing task.

The contribution of this paper is a new paradigm for designing VR user interfaces targeted at stimulating creativity by showing that a "one-illusion interspace" leads to a greater self-perception of creativity.

The study reported has some limitations, because we did not sample all creative domains and have been focused on a limited sample population. Like any habit, creativity can either be encouraged or discouraged [131]. Moreover, it can be perceived differently by each person. Although our findings are consistent with "Mild PI", the present study is unable to rule out the alternative interpretation that either general "presence", intelligence or spatial ability is the common factor underlying both creativity itself and creative thinking. Overall, it seems plausible that the common factor underlying was the creative writing task that could lead and trigger a different creative process for each participant.

Sanchez-Vives and Slater [132] suggest that the concept of "presence" refers to the phenomenon of behaving and feeling as if we are in the virtual environment and can break the deep, everyday connection between where our senses tell us we are where we are actually located. In contrast Turner et al. [133] conclude in their work that recreating real places as a distinct from virtual spaces or environments raises a series of significant challenges.

Finally, and despite the limitation that we did not consider the long-term usage of each environment, the present study did find empirical support for what has previously been a large debate about measuring creativity. Also, our study can be replicated in different domains combining several approaches that have the common goal of better supporting peoples' creativity. Today, there is ample potential in VR technology to further advance these efforts. One of the most important long-term prospects of this study resides in the assessment of different VR qualities (e.g. Place Illusion) and its impact on user's creativity. Studying these qualities will enable VR designers to come up with more engaging environments to support creative activities. VR has been employed in so many domains (health, entertainment, military) and there is ample room for improvement of current creativity support tools using VR. However, this improvement should be properly informed by focused studies such as the one we presented, especially because emotion, flow and mood play an important role in human creativity, and they can be negatively impacted by improper VR settings.

CHAPTER 8

WHAT SHALL I WRITE NEXT? PRIMING CREATIVITY



Through the following publication:

Gonçalves, F., Caraban, A., Karapanos, E., Campos, P., "*What Shall I Write Next? Subliminal and Supraliminal Priming as triggers for Creative Writing*". Submitted.

CHAPTER 8

WHAT SHALL I WRITE NEXT? PRIMING CREATIVITY

Creative writing requires the manipulation of language in demanding ways, as individuals attempt to express themselves in unique forms. However, people are commonly faced with writer's block: a stress reaction that affects people's ability to write. Addressing this issue, creativity support tools focus on prompts as triggers of the writing process. Nevertheless, this imposes cognitive load and can distract from the writing task. In this study, we evaluate the effectiveness of subliminal and supraliminal cues as a novel creativity support technique. We present a writing tool that provides textual hints whenever inspiration is needed. We explored the impact of subliminal and supraliminal cues on self-experienced creativity, during a creative writing task. Results showed that participants in the subliminal condition experienced more loss of self-consciousness when compared to the control condition, with statistical difference. We found no other significant differences in individuals but eye-tracking data and post-experiment verbal accounts revealed subtle differences regarding the impact of the cues on the self-perception of creativity. Some participants considered that the cues did influence their thoughts and consequently their writing, others considered that they were in their implicit memory and used them in later conditions.

8.1. Introduction

Creative writing is an essential human activity and a central component to a breath of industries, including filmmaking, advertising, the video game industries and many others [9]. There is evidence suggesting that the regular practice of creative writing induces positive moods, and it also leads to an increased involvement with related tasks, thus having the potential to increase the likelihood of professional success, an important component of human wellbeing [134]. Despite its beneficial effects, creative writing is a cognitively demanding task. As Robinson states, [63] language is

primarily a system communication: first we have our thoughts and then we find the words to convey them. As there are millions of subjects a writer can write about and thousands of ways to express the same idea, writing is more challenging than it initially appears to be. It is considered a problem solving activity, a process that requires the generation, planning, reading and reviewing of the writer's thoughts [135]. Deciding what to write about can sometimes be surprisingly tricky and during that process, some writers often have blocks. Writer's block is a temporary inability to write, and it can last from minutes to weeks. It is a frequent source of frustration and fatigue for authors [136]. This "stuck" mind-set has been acknowledged as a "creativity killer". It comes up when writers become too judgmental and apprehensive about their writing, resulting in a potential loss of productivity and feelings of self-doubt, which aggravate this state. As writers' anxiety levels increase, it becomes more and more difficult to write [137].

Over the year, researchers have been investigating different strategies to make writing a more pleasurable and easy-going experience, one that fosters creativity and copes with stress. Successful methods have included the provision of *story prompts*, as modeled-stories or picture-sequences to inspire and initiate the creative process [138], the design of *distraction-free interfaces* to reduce anxiety levels and help focus on the craft [139], [87], [140], or *brainstorming and free associations techniques* to stimulate the overall flow of the writing tasks [138]. However, at present, all creative writing support tools still rely on the writers' ability to enhance the creative process and break their mind-set when a block occurs, which might not happen, causing writers to abandon the writing activity when faced with this burdensome situation. Moreover it has been suggested that writers' block reflects the conflict between the two modes of human thinking: the automatic mind and the reflective mind [141]. The automatic mind formulates thoughts and judgments quickly and unconsciously, guided by intuition and past experiences. The reflective mind, in contrast, is guided by conscious reasoning. Hence it is slower, more effortful, and comes into place only when a decision cannot be made intuitively. The conflict arises when the reflective mind is confronted with writer's feelings of self-doubt, causing the mind to overthink and anticipate possible outcomes, inhibiting the automatic mind that seeks to create. Although they collaborate, decisions are likely to be different, even with the same input, since they are made by one mode [9].

In this study, we analyze the influence of the automatic mind processes as triggers for the creative writing process. More specifically, we study how different prompting

techniques can be applied in a subliminal and supraliminal way and how they subconsciously affect the writer's self-perception of creativity. We evaluate the participant's experiences and proficiency with conscious and unconscious cues during a creative writing task. In the experiment, we observed that participants did not realize that they were actually being influenced by textual cues: in post-experiment interviews, some considered that the cues influenced their thoughts and consequently their writing, others considered that the cues were in their implicit memory and used them in later conditions.

8.2. Creativity and the Automatic Mind: Explicit vs. Implicit cues

Researchers [26] have studied diverse user interfaces for creative writing with different features such as themes composed of sound and images, to foster inspiration, focus and confer immersion on creative writing tasks. Also, Wang et al. [24] and Andolina et al. [25] applied other stimuli to support creativity, such as visual stimuli, images and text, which seem to increase both the originality and the diversity of ideas during brainstorming. While these approaches focused on the provision of explicit cues to stimulate the writing flow, recent research has been investigating the potential of implicit cues triggering the creative process. For instance, Fitzsimons et al. [142] found that presenting a brand identified as creative (e.g. Apple logo), unconsciously, motivated users to behave creatively. This resulted in a higher number of creative responses. Lewis et. al [143] explore how affections influence creative performance by presenting positive, negative and neutral images during a creative task. They found that when exposing people to positive-affect images (e.g. a laughing baby) in the absence of conscious awareness, people's quality of ideas were positively influenced.

A large body of literature suggests that that our ability to produce creative insights comes from the unconsciousness rather than from a conscious process [144] as it is the automatic mind that owns the ability to spontaneously produce new concepts, due to its proficiency to make or generate elements available for associations (e.g. through thoughts and past-experiences [145]). Ritter et. al [145] posit that writer's block leverages the conflict between our two modes of thinking the automatic and the reflective mind. While the unconscious (automatic) mind is bonded with novelty generation, the conscious mind is tied with the evaluation of ideas [145] as so, when we consciously think about an idea, our creative mind is suppressed with a deliberate weight of how creatively the ideas are perceived. Ritter et al. [145] recently found that

people performed better by recognizing creative ideas when they thought about the ideas unconsciously. One way to leverage the unconscious mind is by presenting a stimulus that is not consciously perceived, i.e. subliminally. Subliminal Priming is a technique validated across a number of domains that has the potential to influence individual's thoughts instinctively and trigger action by means of associative inferences. This is accomplished by presenting a stimulus below the threshold of conscious perception; in a way that its repeated exposure automatically increases a predisposition and preference toward an action [146] [147]. While previous research posits that creativity is lead by a motivated state [148], subliminal prompting has the potential to arouse interest and enjoyment in the writing tasks by providing hints that uphold the user's flow and inspires creative thinking without conscious awareness and while the practice is conducted (i.e. by prompting topic suggestions, logical connections, random words, etc.). In this study, we analyze how the creative process can be triggered and influenced by means of different prompting techniques (e.g. subliminal versus supraliminal) when the user's writing flow processes are compromised.

8.3. User Study – Priming Creativity

We conducted a within-subject experiment to investigate whether textual cues, subliminal or supraliminal, affect people's creativity during creative writing. We chose a creative writing task a) because it has been reported to be among the most demanding creative tasks [16] [15], and b) because in its different forms, writing is part of the everyday routine – a brief e-mail, a composition, a report, an article – and as such, our insights may have broad application to a wider range of cognitively demanding tasks, beyond that of creative writing. As a prerequisite, participants had to have some interest in creative writing and a computer and Internet experience since our questionnaires are all online. All participants went through three conditions: subliminal, supraliminal and control (no cues). To control for carry-over effects, the order of the conditions was counterbalanced between participants.

Control condition - No Priming. In our control condition, we used a clean and lightweight word processor with a full screen mode, without any cues either explicit or implicit.

Subliminal Priming: In this condition, users performed the task using the same interface with cues projected within individual's foveal vision (center field of vision).

Participants were exposed to a new cue every three seconds, which was displayed in the highest visual acuity: the foveal vision. The cues were presented subliminally with a duration of 60 milliseconds (*ms*), which has been found to be an exposure presented outside of conscious awareness [149]. Cues were presented with a 60pt font size, in Helvetica.

Supraliminal Priming (Figure 56): In the supraliminal condition, the textual cues (font size=60pt) were initially displayed in the center of the screen and were gradually driven (animated) to one of the corners of the interface. The animation would last for three seconds.



Figure 56 - Example of Supraliminal Priming.

Cues

Participants were exposed to a total of 60 randomly selected cues during the 5-minute task. We selected a total of 250 words from a dataset⁷, containing words related with different topics, including activities, emotions, objects, animals, adjectives, etc.

Task

We used a simple creative writing technique [150] for this purpose. Due to the use of a within-subject design, we defined three different writing tasks of a similar degree of complexity that participants were equally familiar with. Therefore, we showed the corresponding magnetic fridge (Figure 57) to the participants and told them to treat the object as a trigger for bringing their senses into the writing task. The time was limited to 5 minutes.

⁷ <https://myvocabulary.com/word-list/travel-and-leisure-vocabulary/>

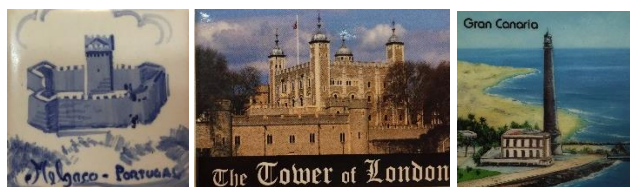


Figure 57 – Magnetic fridge used as a creative writing prompt to initiate the writing for it users.

Participants

This study involved 14 participants, 6 males and 8 females, aged between 23 and 45 years old ($M=28.4$; $SD=5.6$). All selected participants reported having a normal or corrected visual acuity, and enjoyed writing, with eight participants (57.1%) writing at least one hour per day, and six (42.9%) at least two or more hours per day. They were recruited through a university-wide mailing list. Most of the users consider themselves to be creative persons (71.4% of participants ranked themselves with values higher than 5). The experiment was conducted within a single week.

Measures

Before they started the experiment, participants were asked to fill a very short survey in order to collect some demographic data and they also ranked their own creativity (“Do you consider yourself a creative person?”) in a Likert Scale (0-10 values) [69] [80]. Also, we applied the Creative Behavior Inventory (CBI) [71] [72], which was used as a way to categorize how creative the participants were, and a questionnaire inquiring how often they write and if they were familiar with behavioral priming. We used thirty items from the original CBI [72] [71], particularly the specific examples of creative activities such as: literature, miscellaneous, performing arts, science and music [69].

After finishing the writing task, they were asked to fill a Likert scale survey about how that experience made them feel using the Flow Theory dimensions [73] and the survey about Creativity Support Index [79]. Also participants were asked to rank their self-perception of creativity [80] in a Likert Scale (0-10 values).

The Flow Theory survey was based on the following dimensions: (i) intense and focused concentration on the present moment, (ii) sense of personal control or agency over the situation or activity, (iii) loss of reflective self-consciousness, and (iv) distortion of temporal experience. Participants ranked a 10-point Likert scale based on questions such as: “I felt very concentrated during this condition” and “I lost track of time during this condition”.

To access the participants' mental well-being, we asked them to select up to three adjectives from the following list: Surprised, Delighted, Laid back, Depressed, Passive, Happy, Tired, Bored, Sad, Satisfied, Frustrated, Angry, Serious, Animated, Distressed, Creative and Frightened.

Finally, we interviewed them based on their experience using the tool (*"Did you see the cue?" "Did you use it? etc."*), and they were asked to rank their creativity in each condition (*"How do you rate your creativity in this condition?"*) in a Likert Scale (0-10 values) [69].

Procedure

Participants were brought individually to a control room, previously prepared for the experiment. For the examination, we used one iMac with Retina LED IPS 13.3", display resolution 1440 x 900 pixels (Figure 58) and one screen-based eye tracker (Tobii Pro X2-30) [151] to capture gaze data.

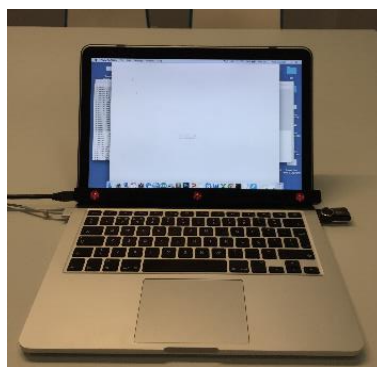


Figure 58 – Experimental setup

A preliminary evaluation was conducted with 3 participants to examine the feasibility and accuracy of the eye tracking calibration and assess the perception of the cues in a short trial. While nobody noticed the subliminal cues, eye tracker data revealed that all participants scanned them. Moreover, since participants reported not being interrupted by the explicit cues during the task, we considered that the study could be conducted according to this procedure.

Then, they were asked to sit about 70 cm away from the screen, and to report any kind of visual impairment before starting the calibration procedure of the eye tracker. They were informed that their eye tracking behavior would be recorded. We tracked gaze-aware region, active region (click), panable region (scroll), gaze point, eye positions and fixations. Our aim was to identify and analyze patterns of visual attention during the writing task.

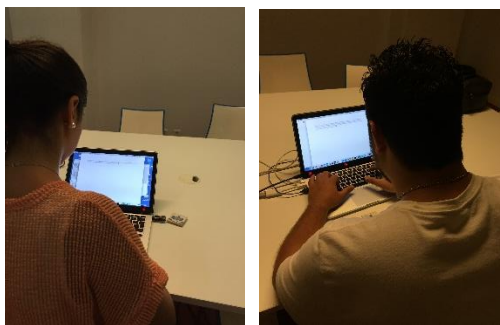


Figure 59 - User performing the study in the research laboratory.

After filling the inventory, the writing task was explained. When they finished the writing task, they were asked to fill the survey based on Flow Theory dimensions, the adjectives from the list we gave, and the survey about Creativity Support Index. Lastly, we interviewed them.

The total time per user took over thirty minutes, it included a pre-questionnaire, instructions, experiment and post-experimental semi-structured interviews. Participants were allowed to take breaks between each experimental condition.

8.4. Results

To inquire into the impact of subliminal and supraliminal priming on users' apparent and experienced creativity we triangulated different data sources: eye tracking data, behavioral data, users' verbal accounts during task execution, self-reports using psychometric scales of creativity, and data from our exit interviews.

The CBI inventory was found to be highly reliable (30 items; $\alpha = .88$). Regardless of the self-report scale in the 30-item CBI that could capture a creative accomplishments and activities in past behaviors, our results suggest that our sample was likely "homogenous" in terms of past creative actions. 64.3% (nine out of fourteen) of participants had a more than 30 points on the CBI and 35.7% (five out of fourteen) participants had less than 30 point on the CBI.

Did priming lead to increased experienced creativity?

All in all, we found no significant difference between pre ($M_{pre}=6.07$; $SD_{pre}=2.33$) and post measures of experienced creativity in either of the three conditions: No priming ($M_{post}=6.04$; $SD=2.31$); *Subliminal* ($M_{post}=5.28$; $SD=1.97$); *Supraliminal* ($M_{post}=6.00$; $SD=2.11$). Moreover, no statistically significant difference was found in post measures between the three conditions.

From the results (Figure 5) we can see that most of the users consider themselves creative persons (64.4% of participants ranked themselves with values higher than 5). In the conditions *No Priming* ($M=6.4$; $SD=2.3$), and *Supraliminal Priming* ($M=6.0$; $SD=2.1$), they reported having experienced more creative moments than during *Subliminal Priming* ($M=5.3$; $SD=2.0$). Using Friedman's ANOVA, this difference was not found to be statistically significant ($F(2) = 2.94$, $p > .05$). When we compare the self-perception of creativity before ($M_{pre}=6.07$; $SD_{pre}=2.33$) and after each condition (Figure 5) the difference was not considered to be statistical significant ($F(3) = 2.85$, $p > .05$).

Yet, qualitative data revealed that the experience and appraisal of the three conditions varied among participants. Initially, most participants seemed to prefer the supraliminal condition as a strong creativity trigger:

"I liked this condition because the words came fast and this was good to get ideas" [P10]; *"The words are good to get an idea and start writing"* [P7]; *"I was concentrated in writing the story, I did not use any cue, but they gave me ideas"* [P12]; *"I was writing and I had a block (...) I was waiting for another word to appear. Sometimes, the word did not fit, but gave me ideas (...) in the last condition [no priming] I missed the cues. I was checking to see when they would appear"* [P8]; *"I was waiting for another word to inspire me"* [P4].

This preference, however, seemed to fade away during the course of the tasks, as well when the words were not directly relevant to the topic:

"It became frustrating as none helped" [P8], *"After a while the words became annoying, they were not related"* [P7]. Some participants felt overwhelmed: *"The words started being intrusive. I felt forced to use them"* [P14]; and others felt distracted during the tasks *"It was annoying. The words distracted and broke the flow of my writing. I was frustrated"* [P1]; *"Since I had the story already set in my mind, I found them annoying. I wanted to write 100% original"* [P5].

Did priming lead to increased output?

Participants wrote an average of 125.3 words in the *Subliminal Priming* condition ($SD=57.50$), an average of 118.4 words in the control condition ($SD=39.1$), an average of 124.9 words in the *Supraliminal Priming* condition, ($SD=32.6$). A Friedman's ANOVA revealed no statistically significant difference among the three conditions ($F(2) = 2.81$, $p > .05$).

Some participants showed mixed feelings about the supraliminal cues:

“The words helped me getting the first idea, yet after a while I overlooked them because I wanted to focus on my idea” [P9]; “I did not use the words, but they helped to remember others. Some words made me stop writing to think. Later they were always in my memory, but did not know how to use them to make sense of the text that was being writing” [P6]. For other participants, the supraliminal condition had no effect, e.g., *“I continued writing, I was concentrated and I ignored words” [P2].*

Lastly, further participants showed to be dependent of them *“I keep on waiting for the next cue” [P13]; “I was always waiting for more interesting words, after a while I wanted them to stop” [P10].*

64.29% of users in the *No Priming* condition chose the adjective *Relaxed* in contrast to 42.86% of users in the *Subliminal Priming* condition and 57.14% in the *Supraliminal Priming* condition. 57.14% of users in *Subliminal* and *Supraliminal Priming* conditions selected *Creative* compared to the 71.43% selected in the *No priming condition*. *Satisfied* was chosen 42.86% in the *Supraliminal Priming* condition, 50.0% in the *Subliminal Priming* condition and 57.14% in the *No Priming* condition. The most relevant observation is simply the confirmation that most of the chosen adjectives indicate a positive mental well-being.

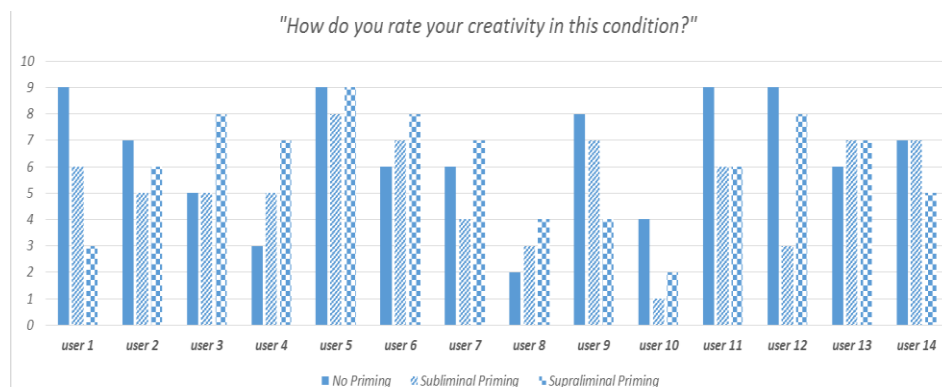


Figure 60 – Users perception of creativity after each condition.

Did priming lead to increase the flow of participants?

Some statistical results are shown in Table 13, to test differences between each condition from the answers in the survey based on the Flow Theory dimensions [152].

Table 12 - Average (SD) for Flow Theory dimensions in each environment.

	No Priming	Subliminal Priming	Supraliminal Priming
(i) Concentration	7.86(1.92)	6.43(2.44)	7.29(2.55)
(ii) Sense of Control	7.64(2.10)	6.36(2.06)	7.36(2.34)
(iii) Loss of self-consciousness	3.50(3.80)	6.00(3.16)	6.43(3.50)
(iv) Lost Track of Time	3.14(2.66)	4.57(2.93)	4.64(3.79)

By looking at the Table 13, one can see that the *Loss of Self-consciousness* has higher average levels for Subliminal Priming ($M=6.00$; $SD= 3.16$) and Supraliminal ($M=6.43$; $SD= 3.50$) in contrast to the No Priming condition ($M=3.50$; $SD= 3.80$). Using an ANOVA with repeated measures with a Greenhouse-Geisser correction, the mean score for *Loss of Self Consciousness* of participants in Subliminal Priming when compared with No Priming condition was statistically significantly different ($F(1.000, 13.000)=5.759, p<0.05$).

The *Lost Track of Time* dimension was not considered by participants for any of the conditions we evaluated (No Priming $M=3.14$; $SD=2.66$); Subliminal ($M=4.57$; $SD=2.93$); Supraliminal ($M=4.64$; $SD=3.79$)). The *Concentration* dimension (No Priming $M=7.86$; $SD=1.92$); Subliminal ($M=6.43$; $SD=2.44$); Supraliminal ($M=7.29$; $SD=2.55$)) results were most consistent and similar in all conditions also in the *Sense of Control* (No Priming $M=7.64$; $SD=2.10$); Subliminal ($M=6.36$; $SD=2.06$); Supraliminal ($M=7.36$; $SD=2.34$)). However, using Friedman's ANOVA, this difference was not found to be statistically significant ($Fr(2) = 1.13, p > .05$).

Did priming lead to support the creativity support tools?

We used the CSI [79] as a way of evaluating how well each condition (no priming, priming subliminal and priming supraliminal) supported the creativity of the participants.

14 participants generated an average overall CSI score as shown in Table 14 for a creative writing challenge in each condition. Tables 15, 16, 17 show the average factor counts, average factor score, and average weighted factor score for each of the six factors on the CSI in each environment session.

The most important factors for the task were "Enjoyment" and "Immersion", as shown on Tables 15, 16 and 17, although we did not find any significant difference through statistical analysis, there is a tendency of higher scores with Subliminal Priming and

Supraliminal. Experiments among all the conditions revealed themselves as being quite diverse amongst all the participants.

Table 13 - Overall CSI Score in each environment.

	No Priming	Subliminal Priming	Supraliminal Priming
Overall CSI Score	M=56.81; SD= 18.54;	M=50.98; SD= 23.16;	M=54.64; SD= 23.03;

Table 14 - CSI Avg. Factor Counts (SD): Sum of Results of Two Questions by Factor.

	No Priming	Subliminal Priming	Supraliminal Priming
Results Worth Effort	11.83 (4.45)	9.85 (4.85)	12.08 (5.14)
Exploration	10.75 (3.91)	9.08 (5.38)	10.00 (5.10)
Collaboration	7.75 (5.24)	6.00 (4.53)	6.25 (4.99)
Enjoyment	10.83(4.39)	8.67 (5.33)	11.25 (5.56)
Expressiveness	11.67 (4.85)	10.00 (5.15)	11.08 (4.93)
Immersion	13.50 (5.32)	9.50 (5.40)	11.92 (6.08)

Table 15 - Avg. Factor Score (SD).

	No Priming	Subliminal Priming	Supraliminal Priming
Results Worth Effort	3.00 (1.60)	2.58 (1.56)	2.58 (1.31)
Exploration	3.08 (1.31)	3.42 (1.08)	3.17 (1.27)
Collaboration	0.42 (1.00)	0.33 (0.89)	0.42 (0.79)
Enjoyment	1.08 (1.44)	1.33 (1.56)	1.33 (1.44)
Expressiveness	3.33 (1.44)	3.33 (1.44)	3.67 (1.23)
Immersion	2.67 (0.98)	2.67 (0.89)	2.50 (1.09)

Table 16 - Avg. Weighted (SD).

	No Priming	Subliminal Priming	Supraliminal Priming
Results Worth Effort	37.17 (23.82)	26.17 (21.42)	33.42 (23.66)
Exploration	32.58 (21.88)	32.17 (23.59)	29.58 (20.20)
Collaboration	3.17 (7.41)	1.17 (2.76)	3.67 (7.76)
Enjoyment	14.25 (22.25)	14.83 (21.46)	19.17 (24.15)
Expressiveness	39.92 (27.20)	29.33 (17.29)	38.50 (21.03)
Immersion	37.00 (21.81)	26.92 (19.35)	31.58 (25.63)

The Subliminal condition, however, provided surprising results as the cues were perceived consciously by 21% of our participants (3 out of 14), with total of 69. Every cue was only perceived once, the same was verified in the Supraliminal condition.

Thus, when asked about their preferences and experiences with the subliminal cues influencing their ideas, participants reported similar thoughts to the Supraliminal condition, e.g.

“I saw them, but I did not use them, because I had my clear-cut ideas” [P3]; “I notice but I did not use them, [...] the words came and went too fast” [P4]; “The words bothered me, because they disappeared too quickly and influenced my writing. It was stressful” [P7]; “I did not use the words, but I can still remember some of them” [P12].

Interestingly, participants who reported not seeing the cues, were the ones who used them across their stories – *“I thought it was a problem with the program or the screen [P5]; “I did not see them, I was concentrated in my writing” [P7].*

Did priming lead to increased "writer's block"?

The analysis of the participant's gaze with the eye tracker data revealed that only 36% participants saw the cues enough time for them to be perceived (either consciously or unconsciously). In fact, we observed that 21% (3 of 14 participants) looked down at the keyboard the entire time after start writing. The rest of our participants were not looking to the screen while the cues were briefly displayed or they were focused in the text. Moreover, we noticed that during the Supraliminal condition every time the participants faced a block, they were looking for a cue.

We expected that providing participants with random cues during the writing activity would lead to lower overall number of blocks, when compared to the control condition. However, this was not verified (*No Priming = 13, Subliminal = 19 and Supraliminal = 13*). Nevertheless, considering only the participants that glanced across the subliminal cues, results show lower blocks in the Subliminal condition (n=9) (*see Table 18*). We acknowledged a block when noticing a longer interruption during the writing, a distant look or anxious movements [136]. Moreover, participants self-reported and confirmed those blocks at the end of the experiment, during the interviews, e.g., *"(...) when I had a block, I waited to see the cue." [P9-Supraliminal].*

Table 17 - Number of writer's blocks across the conditions. Participants in the Subliminal condition that noticed the cues are identified with *.

User	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No Priming	0	1	1	0	3	1	2	1	2	0	1	0	1	0
Subliminal	1*	2*	3*	2	3	2	0	1*	0	0	0	2	2*	1
Priming														
Supraliminal	0	5	1	2	1	3	0	0	0	0	1	0	0	0
Priming														

Table 18 - Comparison between the number of words seen and used in the supraliminal and subliminal conditions.

User	# seen		# used	
	Supraliminal	Subliminal	Supraliminal	Subliminal
1	14	0	20	0
2	25	5	13	0
3	5	0	15	0
4	13	5	0	0
5	2	0	0	0
6	3	0	0	0
7	14	5	0	2
8	15	0	1	0
9	13	0	0	0
10	11	0	0	0
11	13	1	0	5
12	11	0	0	0
13	12	1	20	5
14	15	15	0	0

Additionally, we observed participant's behaviors when they were having a block. The eye tracker data (Table 19) showed that during the Supraliminal condition all participants searched for a cue and waited until an interesting one appeared or an idea came out of their minds. This information was triangulated with qualitative data from the interviews "I was waiting for another word" [P8].

8.5. Discussion

As suggested by Carroll et al. [66] and Silvia et al. [69], we used different ways to measure creativity in each condition to obtain more consistent results. Silvia et al. [69] also argue that self-assessments about individual creativity is not standardized and

can lead us to different results every time we try to measure it. Boden [153] states that creativity is a puzzle, a paradox, and in some ways a mystery. Creativity can either be encouraged or discouraged [118], so we used a simple creative writing technique such as showing the fridge magnet [150] to trigger the creativity in users performing the writing tasks. This was important to make users harness and embrace their creativity through the use of our creative support tool. Creativity support tools promote or accelerate or facilitate creativity [154] but in this case, from the results, we could notice that implicit cues – Subliminal Priming – were not considered by the users as a good tool to boost creativity. CSI results suggest that the Immersion factor had one of the lowest scores. Also, according to the results we could see that users rank their self-perception of creativity with lower values rather than with Supraliminal Priming or without any priming.

Using triangulation methods [66] with semi-structured interviews, results and observations, we could acquire that our sample was usually engaged with creative activities, with an emphasis in literature, miscellaneous, performing arts, science and music actions, as reported by the CBI. Results indicate that the study was not biased by highly critical self-assessments.

As stated by Csikszentmihalyi [155], flow is the state in which people are so involved in a given activity that nothing else seems to matter. Giving our creative task, we could observe that some participants were concentrated in the writing task that they did not even see the implicit cues (subliminal priming). Also, most of the adjectives chosen by participants were positive, indicating a good mental well-being. Results from the Flow dimension *Loss of Self-consciousness* were a significant issue in the Subliminal priming condition. Moreover, results from *Concentration* and *Sense of Control* dimensions were most consistent and similar in all conditions.

Cherry et al. [79] presented a study from a collaborative writing experiment using Google Docs (with no stimuli) where their results were higher when compared with our results. The top two factors in their study were Expressiveness and Collaboration, whereas in our study the top two were Enjoyment and Immersion.

When comparing each condition with CSI results and qualitative data it is suggested that participants were really thoughtful and engaged in the writing activity. They put less amount of effort in producing a similar outcome among other conditions (see Table 5 “Results worth effort”). Moreover, while the subliminal condition was reported as the less enjoyed condition, participants previously self-reported that they felt more

animated during the subliminal task (see Table 5 “Enjoyment”). On the other hand, and while the *No Priming* condition revealed higher values of Immersion (see Table 5), minimizing the speed with which cues (subliminal or supraliminal) were presented, may help reduce the number of disruptions of participant’s workflow. Although the results are not statistically significant, they are important as part of the process.

8.6. Conclusion

In this study we presented a novel approach that addresses for the first time the study of priming (subliminal and supraliminal) in a creative task such as creative writing. Specifically, we highlight the value of interaction with implicit or explicit cues as an alternative to boost the creative process more effectively. Many techniques are sometimes used to boost the creativity while writing – our experiment used the fridge magnets as creative writing prompts.

Reflecting upon the state of the research, we see there are many aspects of this study that remain open for future investigation, such as our results about creativity and its metrics combined with priming. When using creative writing tools, it is important to measure creativity because metrics can lead us to the different impacts that these tools can have on diverse people. These types of features such as subliminal and supraliminal cues may be present within these tools as a way to trigger the writing process and also to intensify the creativity of writers. It is important to increase the research efforts on designing user interfaces that support creative writing and to develop novel tools that can be used by numerous users.

Finally, acknowledging the limitation of not considering the long-term usage of each condition, the present study found empirical support for using subliminal or supraliminal priming in creativity support tools. Also, our study can be replicated in different fields, combining several approaches that have the common objective of supporting human creativity.

CHAPTER 9

EXPLORING THE EFFECTS OF OLFACTORY AND AUDITORY CUES TO SUPPORT CREATIVE WRITING TASKS



Through the following publications:

Gonçalves, Cabral, D., Campos, P., "*Olfactory Cues and their Influence on the Self-Perception of Creativity*". Submitted.

Gonçalves, F., Cabral, D., Campos, P., Schöning, J., "*I Smell Creativity: Exploring The Effects Of Olfactory And Auditory Cues To Support Creative Writing Tasks*". Submitted to INTERACT 2017.

Gonçalves, F., Fermé, E., Ferreira, J. C., "*Emerging Opportunities for Ambient Intelligence in Creativity Support Tools*", (ISDA 2016), A.M. Madureira et al. (eds), Intelligent Systems Design and Applications, Springer International Publishing AG, 2017.

CHAPTER 9

EXPLORING THE EFFECTS OF OLFACTORY AND AUDITORY CUES TO SUPPORT CREATIVE WRITING TASKS

9.1. I SMELL CREATIVITY

Humans perceive different objects, scenes or places using all of their senses. Our sensory richness also plays an important role for creative activities. Humans also recall those sensory experiences in order to spark creativity, e.g. while writing a text. How can auditory and olfactory stimuli better support creative writing tasks? This paper presents a study with 100 students that explores the effect of auditory and olfactory cues and their combination during a creative writing exercise. Our results provide useful insights suggesting that olfactory cues have an important role in the creative process of users and also when this type of cues are combined with auditory cues. This type of modalities should gain more relevance on the development of creativity support tools and environments for supporting the creative writing process.

9.1.1. Introduction

Writing is one of the main forms of human artistic expression [10]. Creative writing can be a central component to a range of different industries (e.g. journalism, science fiction, advertisement, etc.) [8]. A writing activity itself often follows a similar process: a writer starts with a prewriting, finishes the first draft, revises the draft, and then edits and finishes a final version of the work [10]. Usually, writers try to obtain their creativity from a very wide range of sources ranging from memories of dreams or television news reports, in a way in which they can imagine new characters or situations that can be included in their writings [12].

There is a duality between technology and creativity itself, in the sense that they are both complex to create and to evolve. Creativity support tools help people engage creatively with the world [79], and some researchers claim [156] that it is a challenge for human-computer interaction researchers and user interface designers to construct information technologies that support creativity.

Robinson [63], argues that creativity involves putting your imagination to work. He also defines creativity as the process of having original ideas that have value. Nevertheless, to properly investigate creativity it is appropriate to adopt a variety of methods and perspectives to make it plausible and understanding. Creativity is a complex and multifaceted phenomenon [64]. Even with decades of creativity research, there is no single, agreed upon methodology for evaluating how well a creativity support tools to aid the creativity of its users [66]. Creativity includes discovery or invention of a significant idea, pattern, method, or device that gains recognition from accepted leaders in a field [157]. Creative workers use artificial stimuli as inspirational guides, e.g., listening to music while writing or looking at images while drawing. Certainly, well-designed creative writing tools can help users in generating multiple levels of creativity during the process of writing, particularly tools that can also generate different stimuli [158].

Olfactory cues are well known to have a strong emotional effect on arousal level and task on arousal level and task performance have also been suspected but remain poorly assessed in the literature [158]. Among other researchers, Seo [159] states that even though we often perceive odours in the presence of various background sounds, there is limited knowledge about the effects of background sound on odour perception. Spence [160], has studied the effect of background noise on the sensory-discriminative aspects of taste/flavour perception and on people's hedonic responses to food and beverage items. He highlights the impact of background music and/or soundscapes on food and beverage perception/consumption on people's sensory-discriminative and hedonic responses.

Therefore, this is the first study on the effects of different modalities (sound and smell) on the creative writing process. The core contribution of this research is a novel between-subjects study to discover patterns in the influence of smell and sound on the participants' creativity while using a word processor in different environments. The research described below makes two supporting contributions. First, we triangulate qualitative and quantitative data from different sources to assess creativity of users in

different writing conditions, giving us useful insights in order to develop a novel prototype for supporting the creative writing process. Second, although research on creativity has thus largely occurred within areas such as psychology and neuroscience and HCI, we believe other areas of computer science can also contribute to this domain.

9.1. 2 Perception of olfactory and auditory cues

Ho and Spence [161] investigate the differential effects of olfactory stimulation on dual-task performance under conditions of varying task difficulty. Their results provide the first empirical demonstration that olfactory stimulation can facilitate tactile performance, and highlight the potential modulatory role of task-difficulty in odour-induced task performance facilitation.

Some researchers, such as Xiang et al. [162] presented in their study a prototype system – Olfaction - that emits odour emoticons and it was applied in two contexts: online text chatting and voicemail receiving. Their results suggested that odour emoticons induced more chatting, and were easy to use, and helped participants to better perceive and convey emotions. Studies have been conducted with auditory cues in different areas such as consumer behaviours [163] and consumers' perception of food texture and quality [164].

Other studies were conducted to investigate the effect of visual cues on olfactory perception in humans [165]. Guest et al. [166] investigated whether similar auditory manipulations change people's perception of the roughness of abrasive surfaces and also, they replicated the rubbing-hands manipulation of previous experimenters while participants rated either the perceived roughness or wetness of their hands. In these experiments, it was possible to demonstrate that auditory frequency manipulations can have an influence on the perceived tactile roughness and moistness of surfaces.

9.1.3 User Study

We conducted a between-subjects experiment to investigate if olfactory or auditory cues affect peoples' creativity during a creative writing exercise. Since writing is part of everyday routine of our sample, the activity in this experiment involved writing a short story using Microsoft Word (MS Word) as the writing environment. We chose MS Word because the participants (high school students) were most familiar with.

Conditions

The creative activity in this experiment included writing in four creative writing conditions: Neutral Environment (no cues); Smell Environment (cues alert/relax), Sound Environment (cues alert/relax) and Smell + Sound Environment (both cues, sound/smell combined).

Neutral Environment. Our baseline (*session 1, N=14*) without any cues.

Sound Environment. In this condition we used two auditory cues: an alerting sound (*session 2, N= 17*) through which users might feel that they would be sitting in a cafe with the constant bustle of movement of people, machines and dishwashers, and a relaxing sound (*session 3, N=14*), achieved using a natural soundtrack featuring water, birds and foliage.

Smell Environment. We used two types of olfactory cues: an alerting smell (*session 6, N= 12*) which was achieved by the actual fragrance of hot coffee that was spread around the room, and a relaxing smell (*session 4, N=10*) for which we used a laurel fragrance.

Smell + Sound Environment. We used the combination of sound and smell in each condition – alert and relaxed. One group of students could have the smell of the real coffee and the sound of a café (*session 7, N=21*), and the other group of students could had the relaxing fragrance and sound of nature (*session 5, N=12*).

Smell Spread: Ten minutes before the session six and session seven started, we made coffee in the school's kitchen, and placed the coffee pot in the classroom, with doors and windows closed. To spread it we used a fan and small cups of coffee were placed next to each computer in case participants wanted to smell it more during the writing. In session four and session five we spread olfactory laurel fragrances using air fresheners' room spray by Air Wick⁸, that remains for up to one hour and is propelled by 100% filtered air. Participants were exposed to smell during the session. Sessions of the different olfactory cues were done on different days.

Since this was a study conducted in a school environment, including students that were minors of age, a protocol was setup between parents, school and researchers

⁸ <http://www.airwick.us/products/room-sprays/>

regarding all the data gathered, even if anonymous, in order not to raise any privacy or security issues.

Task

Students had to write a short story using the starting point as a map⁹ (Figure 61) that was presented in the classroom. They had to choose two points from the map, and through their own imagination and creativity they had to write a story about their path from point X to point Y. They had to initiate their writing from their own ideas. Participants were given 15 minutes as a time limit to complete the writing task in all conditions.



Figure. 61. Map used to trigger the writing task.

Participants

The study involved 100 students (45 female, 55 male), from the institution's population, aged between 15 and 19 years old ($M=15.9$; $SD=0.94$). They were recruited through the school's mailing list. All subjects were naïve to the experimental conditions. Everyone reported having a normal olfactory and auditory acuity.

Measures

We used the following measures for our experiment: Creative Behavior Inventory; Flow Theory dimensions and Self-assessments; Creativity Support Index and Post-experiment interviews.

We used a subset of thirty items from the original CBI [71] [72], particularly the specific examples of creative activities such as: literature, miscellaneous, performing

⁹ All rights reserved to <http://frommadeiratomars.com/pt/>

arts, science and music [69]. We classified subjects into two classes: subjects that had less than 30 points on the CBI as being *less creative*, and participants that had more than 30 points on the CBI as *highly creative* [66].

The Creativity Support Index (CSI) is a survey to assess a tool's creativity support which users provide ratings for six dimensions of creativity support: Enjoyment, Exploration, Expressiveness, Immersion, Results Worth Effort, and Collaboration [79].

We asked participants to self-rate their creativity [80], answering the question “*I consider myself a creative person*” ranking a seven-point Likert with the evidence scale for 1 (totally disagree) and 7 for (totally agree).

Another different approach to measuring creativity is the one of the Flow theory [152]. We were particularly interested in the following Flow Theory dimensions: concentration, sense of control, losing track of time, and loss of self-consciousness. Participants ranked a 7-point Likert scale based on questions such as: “*I felt very concentrated during this task*”; “*I was able to solve this task without any problem*”; “*I lost my attention during this task*”; “*I lost track of time during this task*”.

To access participants' mental well-being, they were asked to choose up to three adjectives from the following list: Surprised, Delighted, Laid back, Depressed, Pacific, Happy, Tired, Bored, Sad, Satisfied, Frustrated, Angry, Serious, Animated, Distressed, Creative, and Frightened.

Finally, we collected qualitative data from all users with a semi-structured interview with questions such as: “*Did you enjoyed to write in this condition and why?*”; “*This condition gave you more immersive and emotionally engaging experience and why?*”; “*This condition felt more natural to you to write and why?*”; “*In this condition you felt more creative and why?*”; “*Did you felt more relaxed and why?*”; “*Did you felt more stressed and why?*”; “*Is there any comment that you would like to add?*”, in order to know the participant's opinion about the whole experience.

Procedure

The experiment was conducted in a classroom in the secondary high school (Figure 2), during two weeks.



Fig. 62. Students from session 7, performing the study in the moment of the experience.

A preliminary evaluation was conducted with six participants to examine the feasibility and accuracy of the smell spread in the classroom. Three participants were in one classroom with the smell of coffee and the others were in a classroom with the smell of laurel. For this purpose, we used a simple creative writing technique [36] that participants were presented with an image. They were asked to write a simple story during ten minutes. Following, participants were asked whether they could smell the odour during the writing task. The smell was already spread into the classroom as previously mentioned (*see smell spread*). Since participants reported that they smelled the odour, it was considered that the study may be conducted according to the procedure.

Participants were brought to the classroom (Figure 62), previously prepared for the experiment. The experiment was conducted in a classroom equipped with computers on desks, and the time requirement for each session, including pre questionnaire, instructions, experiment and debriefing took over an hour.

When participants entered the classroom, they delivered the document with the experiment protocol and the authorization to participate, which was previous delivered to them. Before starting each session, it was asked if the smell bothered any of the participants.

First, participants were requested to fill the Creative Behaviour Inventory [31], and to self-rate their creativity [33]. After filling the inventory, the writing task was explained.

Then, when they finished the writing task, they had to fill the Creativity Support Index [3], together with the very short survey based on Flow Theory [35] and to select up to three adjectives from the list that was mentioned before. Lastly, we interviewed them.

9.1. 4 Results

To inquire the impact of olfactory and auditory cues on user's apparent and experienced creativity, we triangulated different data sources, such as behavioural data, users' verbal accounts during task execution, self-reports using psychometric scales of creativity and data from our exit interviews. We will refer to the creative writing conditions previously presented and shown in Table 20.

Table 19. Description of the creative writing conditions used.

Creative Writing Session	N
Baseline	14
Sound Alert	14
Sound Relax	17
Smell Relax	10
Smell + Sound Relax	12
Smell Alert	12
Smell + Sound Alert	21

Is our sample equally creative?

Participants self-rated their creativity ($M=4.85$; $SD= 1.17$) in a seven-point Likert Scale before starting the experience. Results are shown in Tables 21 and 22.

Table 20. Frequency and percentages "I consider myself a creative person".

Seven-point Likert scale	Frequency	Percent
1	0	0%
2	0	0%
3	11	11%
4	31	31%
5	32	32%
6	14	14%
7	12	12%
Total	100	100%

Table 21. Descriptive of self-assessment about creativity in each creative writing conditions.

Sessions	1	2	3	4	5	6	7
Mean	4.36	4.71	5.06	5.00	5.17	4.67	4.95
St. Deviation	.842	1.383	1.197	1.491	1.030	.888	1.244
Std. Error	.225	.370	.290	.471	.297	.256	.271
Minimum	3	3	3	3	3	3	3
Maximum	6	7	7	7	7	6	7

A chi-square test of independence was performed to examine the relation between students in each condition and their self-assessment of creativity. The relation between these variables was not significant, $X(24) = 17.992, p = .803$. This tells us that there is no statistically significant association between participants and their self-assessment of creativity; that is, students consider themselves creative persons.

Through Cronbach's alpha, the CBI inventory was found to be highly reliable (30 items; $\alpha = .84$). Regardless of the self-report scale in the 30-item CBI that could capture a creative accomplishment and activities in past behaviours, our results suggest in terms of past creative actions that 42 students had a more than 30 points on the CBI ("*highly creative*") and 58 students had less than 30 points on the CBI ("*less creative*"). We compared the gender of the subjects with their creative level of the self-report scale in CBI to see if there were any difference between genders. On average, female participants reported greater creativity in past activities ($M = 30.78; SD = 16.40$) than male participants ($M = 25.86; SD = 14.99$). This difference was not statistically significant ($t(98) = 1.57, p > .05$); however it did represent a small-sized effect $r = .13$.

We also compared the subjects in each condition (*session 1 to session 7*) and their creative level of the self-report scale in CBI. Some descriptive statistics are shown in Table 23.

Table 22. Average (SD) from CBI in each creative writing condition.

Sessions	1	2	3	4	5	6	7
M (SD)	20.64 (12.73)	20.01 (14.93)	23.71 (9.50)	38.20 (15.55)	35.58 (14.40)	33.83 (23.26)	29.48 (13.38)

A chi-square test of independence was performed to examine the relation between the participants in each condition and their results in CBI (creativity in past activities). The relation between these variables was not significant, $X(288) = 296.04, p = .360$. This tells us that there is no statistically significant association between participants and their creativity; that is, all groups were equally creative in past activities.

Did olfactory or auditory cues lead to increased flow?

To assess the participants' mental well-being, we asked them to select up to three adjectives from the following list: Surprised, Delighted, Laid back, Depressed, Pacific, Happy, Tired, Bored, Sad, Satisfied, Frustrated, Angry, Serious, Animated, Distressed, Creative and Frightened. Table 24 displays the percentages for each adjective, as selected by the participants on each creative writing environment.

We can see in Table 24 that Animated, Relaxed, Satisfied, Creative and Pacific were the most chosen adjectives.

A chi-square test of independence was performed to examine the relation between students and the adjectives selected in each creative writing condition. The relation between these variables was only significant for the adjective "Tired", $X(6) = 20.490$, $p = .002$. By looking at the data represented in Table 24, this tells us that there was a statistically significant association between participants and their state of mental well-being in session one (*baseline*), session six (*smell alert*) and session seven (*smell + sound relax*); that is, students felt somehow tired in these sessions.

Table 23. Results in percentages for the adjectives chosen by participants in each creative writing condition.

Adjectives/Sessions	1	2	3	4	5	6	7
Distressed	----	7.1	-----	-----	----	----	9.5
Animated	35.7	28.6	52.9	40.0	33.3	50.0	23.8
Satisfied	57.1	35.7	17.6	30.0	58.3	33.3	23.8
Bored	7.1	7.1	5.9	-----	----	----	4.8
Pacific	21.4	21.4	52.9	20.0	50.0	33.3	14.3
Relaxed	78.6	64.3	52.9	60.0	75.0	66.7	52.4
Creative	57.1	57.1	70.6	40.0	75.0	83.3	57.1
Astonished	21.4	7.1	17.6	-----	8.3	8.3	23.8
Serious	14.3	14.3	23.5	-----	----	----	14.3
Fear	----	7.1	-----	-----	----	----	----
Frustrated	----	14.3	-----	10.0	----	8.3	19
Happy	28.6	-----	29.4	20.0	16.7	8.3	28.6
Delighted	14.3	-----	-----	-----	----	8.3	4.8
Tired	7.1	-----	-----	-----	----	8.3	33.3
Angry	----	-----	10.0	-----	----	----	----
Sad	----	-----	10.0	-----	----	----	----
Depressed	----	-----	10.0	-----	----	----	----

Thus, when we asked about how they felt in the writing task, participants reported similar thoughts to the creative writing conditions in this case, e.g., "I did not have much creativity, so I felt tired of writing." [baseline, P12]; "I got tired of writing and imagining the end of the story I was writing (...)" [smell+sound relax, P10]; "I did not feel like writing and I had no ideas to write." [smell alert, P2].

Some statistical results are shown in Table 25, to test differences between each creative writing environment from the answers in the survey based on Flow Theory [35] dimensions and ranked by participants in a seven-point Likert scale.

Table 24. Average (SD) for Flow Dimensions in each creative writing condition.

	(i) Concentration	(ii) Sense of Control	(iii) Loss of self- consciousness	(iv) Lost Track of Time
session 1	4.64 (1.82)	5.00 (1.75)	5.79 (1.37)	3.79 (2.08)
session 2	5.50 (1.74)	5.42 (1.60)	5.78 (1.93)	2.71 (2.27)
session 3	4.47 (1.80)	5.11 (1.69)	4.65 (2.19)	3.35 (2.06)
session 4	4.00 (1.25)	4.90 (1.85)	4.60 (1.89)	3.50 (1.84)
session 5	5.25 (1.29)	5.91 (.99)	5.00 (1.70)	2.41 (1.68)
session 6	5.25 (1.95)	5.17 (1.67)	4.50 (2.28)	2.67 (2.23)
session 7	5.00 (1.81)	4.90 (1.73)	5.38 (1.69)	3.47 (2.16)

A Kruskal-Wallis test, showed that there was not a statistically significant difference in Concentration levels of participants' between the different creative writing conditions, $H(6) = 8.36, p = .213$ with a mean rank Concentration score of 46.21 for session 1 (baseline), 61.71 for session 2 (sound alert), 43.74 for session 3 (sound relax), 33.20 for session 4 (smell relax), 54.96 for session 5 (smell+sound relax), 57.88 for session 6 (smell alert) and 52.83 for session 7 (smell+sound alert). The Sense of Control level of participants' was not significantly affected by the different sessions, $H(6) = 3.192, p = .784$. Also the levels of Loss of Self-Consciousness, $H(6) = 7.724, p = .259$ and the levels of Lost of Track Tim, $H(6) = 6.391, p = .381$.

Yet, by looking at the Table 25, one can see that the *Lost Track of Time* dimension was not a significant issue for any of the environments we evaluated. The *Sense of Control*, *Loss of self-consciousness*, and *Concentration* dimensions, results were most consistent in all environments. Qualitative data revealed that students' in the Smell + Sound Environment (33.3%) felt more stressed and others claim that the noise interfered with their concentration. 7.1% of the users in the Neutral Environment felt stressed because they knew they were contributing to a study. In the Sound Environment 12.9% of the users felt more stressed as 18.8% in the Smell Environment. Participants in these environments felt pressure to write under a limited time, but both the smell of the coffee and the laurel relaxed them, and the same for the sound cues. For instance, e.g., "I felt stressed about knowing that I am contributing to an investigation." [baseline, P10]; "Yes, I felt stressed, because I had a time limit to finish." [sound relax,

P13]; "Yes, the fact of having a time limit left me stressed, but it did not stop me from expanding my imagination." [sound alert, P14]; "Yes a lot of pressure to write, however the smell of coffee allowed me to abstract a little." [smell alert, P2].

Did olfactory or auditory cues lead to increased output?

It was also monitored the activity of writing through the iTALC program, and one example of disturbance in this activity, was the use of image search when students stopped writing (Figure 2). When we interviewed them, enquiring why they did this search, students assumed they were out of ideas to write and wanted to find inspiration, or others said that they wanted to enrich their text with a more elaborate definitions.

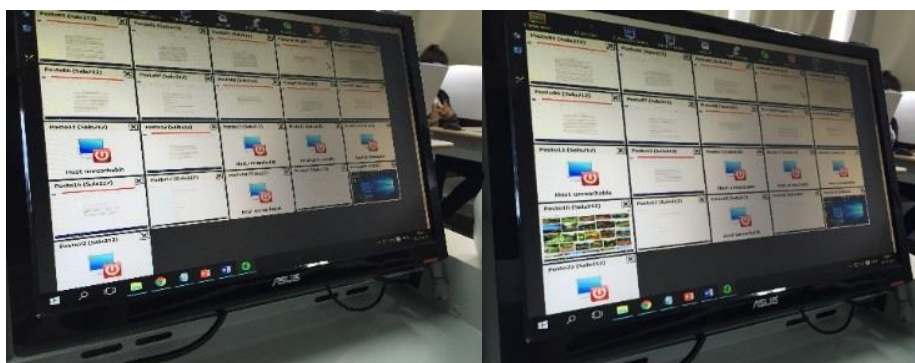


Figure 63 -Fragment of monitoring during the writing activity: example of the use of image search during the writing task.

Using the keystroke logging program called Inputlog, we had an overview of information such as the average time in each session on the writing activity using the keyboard (Table 25), the average time of pauses in each session while writing and the average of switches between mouse and keyboard in each session (Table 26).

Table 25 - Average time in each session on the writing activity using the keyboard

	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7
Mean (seconds)	00:12:03 (72,180)	00:11:44 (68,640)	00:12:28 (73,680)	00:10:53 (63,180)	00:12:19 (73,140)	00:12:02 (72,120)	00:11:27 (67,620)
Std. Deviation	0,00233	0,00260	0,00235	0,00305	0,00230	0,00298	0,00266

In Table 25 results shows that the average time on the writing activity using the keyboard in session 4 had lower values than the other sessions, but results were not of statistical significance.

Table 26 - Average time pauses in each session while writing and average switches between mouse and keyboard.

	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7
Mean (pauses)	00:06:16 (36,960)	00:04:19 (25,140)	00:04:10 (24,600)	00:04:48 (26,880)	00:03:55 (21,300)	00:04:33 (25,980)	00:04:45 (26,700)
Std. Deviation (pauses)	0,00287	0,00112	0,00107	0,00083	0,00125	0,00100	0,00104
Mean (switches)	33,714	26,118	18,429	23,500	19,154	10,333	28,476

Regarding the average switches between mouse and keyboard, results in Table 26 shows that the participants in Session 1 (baseline) had changed more often than the other participants in the other Conditions. From the results, we also noted that participants in Session 6 had changed fewer times between the keyboard and the mouse, as well participants in Session 3 and Session 5. Considering the average time pauses while writing, participants in Session 1 stopped more often than the others in each session, but results were not of statistical significance.

Regarding the stories written and the data dispersion, results showed (Table 27) that the participants in the session 4 (smell relax) wrote an average of 412.6 words ($SD=97.3$), which contrasts with other creative writing conditions.

Table 27. Average (SD) for words written in each creative writing condition.

Sessions	1	2	3	4	5	6	7
Words	267.0	246.0	269.5	412.6	270.1	213.8	300.7
Written	(132.1)	(90.23)	(105.7)	(97.3)	(90.0)	(79.7)	(79.6)

A Kruskal-Wallis test, showed that there was a statistically significant difference between the words written by the participants' and the different creative writing conditions, $H(6) = 20.449$, $p=.002$. Mann-Whitney tests were used to follow up this finding with a correction at a .0083 level of significance, but we did not find statistically differences between sessions.

Did olfactory or auditory cues lead to increased CSI?

We used the CSI [3] as a way of evaluating how well each environment (neutral, smell, sound or smell + sound) supported the creativity of the participants. 100 students generated an average overall CSI score as shown in Table 28 for creative writing task in each environment. Tables 29, 30 and 31 show the average factor counts, average factor score, and average weighted factor score for each of the six factors on the CSI in each environment session.

Table 28. Overall CSI Score in each condition.

<i>Overall CSI Score</i>	
session 1	M= 54.43; SD=15.77
session 2	M= 71.03; SD=21.09
session 3	M= 58.49; SD= 18.88
session 4	M= 51.37; SD= 17.30
session 5	M= 77.60; SD= 15.97
session 6	M= 74.03; SD=14.92
session 7	M= 51.73; SD= 21.89

Table 29. CSI Avg. Factor Counts (SD): Sum of Results of Two Questions by Factor.

<i>Sessions</i>	1	2	3	4	5	6	7
Results Worth	11.29	14.50	11.88	9.70	17.00	15.50	12.14
Effort	(2.76)	(5.27)	(4.40)	(4.92)	(2.31)	(3.24)	(5.00)
Exploration	10.71	13.40	11.47	10.50	15.10	13.60	10.86
	(2.43)	(5.27)	(3.79)	(3.60)	(3.78)	(3.41)	(4.29)
Enjoyment	10.36	14.70	12.06	9.80	15.30	15.30	6.38
	(4.57)	(4.45)	(4.58)	(4.78)	(3.97)	(4.16)	(5.69)
Expressiveness	9.64	12.90	11.35	10.90	15.30	13.70	11.43
	(4.67)	(5.32)	(4.34)	(4.25)	(3.13)	(3.23)	(4.61)
Immersion	11.86	17.30	11.35	8.80	15.40	16.70	11.19
	(5.67)	(3.06)	(3.89)	(3.68)	(4.50)	(4.16)	(6.03)
Collaboration	11.57	14.50	12.18	10.50	13.90	14.20	7.43
	(3.34)	(5.42)	(4.23)	(3.60)	(5.02)	(3.33)	(4.23)

Table 30. Avg. Factor Score (SD).

<i>Sessions</i>	1	2	3	4	5	6	7
Results Worth	2.14	2.40	1.94	2.70	2.40	2.60	2.24
Effort	(1.10)	(1.43)	(1.20)	(1.34)	(1.26)	(1.35)	(1.30)
Exploration	3.36	3.50	3.47	2.80	3.50	3.30	3.29
	(1.15)	(1.08)	(1.46)	(0.92)	(1.08)	(1.16)	(1.15)
Enjoyment	2.00	1.10	2.18	2.30	2.20	1.10	1.71
	(1.47)	(0.99)	(1.33)	(1.42)	(1.23)	(1.45)	(1.71)
Expressiveness	3.57	4.50	3.65	3.80	2.90	3.70	3.43
	(1.60)	(0.53)	(1.22)	(1.14)	(1.66)	(1.25)	(1.57)
Immersion	1.71	2.40	2.18	2.00	2.20	2.40	2.90
	(1.49)	(1.17)	(1.01)	(1.56)	(1.48)	(1.43)	(1.22)
Collaboration	2.21	1.10	1.59	1.40	1.80	1.90	1.43
	(1.89)	(1.66)	(1.62)	(1.35)	(1.23)	(1.79)	(1.63)

Table 31. Avg. Weighted (SD).

Sessions	1	2	3	4	5	6	7
Results Worth	24.71	31.00	25.00	28.80	42.00	40.10	28.81
Effort	(14.96)	(15.61)	(21.95)	(22.58)	(23.72)	(25.31)	(19.18)
Exploration	35.71	45.50	40.59	28.00	52.60	45.90	36.71
	(14.35)	(22.42)	(20.77)	(10.91)	(22.10)	(21.88)	(19.23)
Enjoyment	21.21	16.50	25.94	25.10	36.20	18.60	10.33
	(20.36)	(18.45)	(15.95)	(17.43)	(27.60)	(26.50)	(15.63)
Expressiveness	35.29	58.90	43.65	40.20	43.90	49.50	40.10
	(25.16)	(26.27)	(27.73)	(20.33)	(25.99)	(18.85)	(24.17)
Immersion	19.43	43.20	25.24	18.60	33.00	39.70	32.29
	(17.91)	(25.02)	(15.76)	(21.13)	(25.96)	(27.23)	(22.27)
Collaboration	26.93	18.00	15.06	13.40	25.10	28.30	8.95
	(23.07)	(31.45)	(13.81)	(14.52)	(19.89)	(26.60)	(11.42)

A Kruskal-Wallis test, showed that there was a statistically significant difference in CSI scores between the different creative writing conditions, $H(6) = 24.046, p = .01$ with a mean rank CSI score 39.21 for session 1 (baseline), 60.71 for session 2 (sound alert), 45.29 for session 3 (sound relax), 37.50 for session 4 (smell relax), 73.42 for session 5 (smell+sound relax), 70.46 for session 6 (smell alert) and 37.12 for session 7 (smell+sound alert). Mann-Whitney tests were used to follow up this finding. A correction was applied and so all effects are reported at a .0024 level of significance.

CSI scores in session 1 ($Mdn=50.17$) differ significantly from CSI scores in session 5 ($Mdn=81.33$), $U=25.5, p=.002, r=-.59$.

There was a statistically significant difference in CSI scores from students in session 4 ($Mdn=54.33$) and session 5 ($Mdn=81.33$) $U=12.0, p=.001, r=-.67$. Also, CSI scores from session 4 differ significantly from session 6 ($Mdn=77.17$), $U=12.0, p=.001, r=-.67$.

CSI scores in session 5 ($Mdn=81.33$) were statistically different from CSI scores in session 7 ($Mdn=50.33$), $U=41.5, p=.001, r=-.55$.

Finally, CSI scores in session 6 ($Mdn=77.17$), when compared with CSI scores in session 7 ($Mdn=50.33$), $U=42.5, p=.001, r=-.55$.

From the results, we can conclude that the combination of olfactory cues with auditory cues can significantly affect the level of support to the creative process of a digital creativity support tool, when compared to a condition that does not use any cue (olfactory or auditory). This holds true whether the cues are alerting or relaxing. Also,

this is verified when there are only smell cues (alert or relax) in the creative writing task. However, when using only auditory cues, the results do not show any evidence of increased creative process support.

Triangulating the results with semi-structured interviews allowed us to support some of these results and observations. Students were curious to know what the writing task was, since none of the users had ever taken an experiment such as this one. In general, we observed that the participants were concentrated on the writing moment. It was clear that all participants felt somewhat creative during the experiment.

In the semi-structured interview, participants showed mixed feelings about how they felt creative in the creative writing conditions. 50% of students consider that they did feel more creative in the Neutral environment, 54.8% in the Sound Environment and 63.6% in the Smell + Sound Environment. 72.7% of the students in the Smell Environment considered themselves more creative in this creative writing condition.

90.9% of the participants enjoyed to write in the Smell Environment, expressing reasons such as: *"It made me relax, without any pressure."*[smell_relax_P2]; *"(...) because we were very excited and happy"* [smell_relax_P5]; *"(...) because I think it helps to have more ideas"* [smell_relax_P5]; *"It was interesting - at first I was anguished and then more relaxed."*[smell_relax_P10]; *"it made me want to work."*[smell_relax_P7]; *"it allowed me to get immersed in the activity and be very creative. Although I did not have enough time to finish my story, I managed to create a creative and funny story, while not respecting some rules of grammar."*[smell_alert_P9]; *"as the smell of coffee is comforting and makes it easier to express my ideas."*[smell_alert_P7]; *"(...) because it allows a better flow of writing."*[smell_alert_P3]; *"I think that it stimulated my creativity, imposing it on the work"* [smell_alert_P8].

In the Neutral Environment 57.1% of participants enjoyed to write in this environment as much as the 57.6% users in the Smell + Sound Environment. 77.4% of students enjoyed to write in the Sound Environment, expressing *"(...) because I felt completely oblivious of what was happening around me and I was just concentrated on what I had to do."*[sound_relax_P11]; *"I was so focused writing that did not even notice the sounds around me."*[sound_relax_P12]; *"music gives a good environment for writing and is relaxing."*[sound_alert_P9]; *"(...) music has stimulated my creativity in writing"* [sound_alert_P3];

During the experience we could note that participants were anxious and curious to know what they were supposed to do. In a qualitative way, we could also observe them focused and in absolute concentration during the writing task in all conditions. According to the interviews, some participants were deeply involved in the creative writing task.

9.1.5 Discussion

This study aimed to explore which modalities, olfactory or auditory, were stronger triggers for creativity.

We could identify that most of the students considered themselves creative persons, even though more than half of them were not usually engaged with creative activities, as reported by the CBI. These results indicate that the study was not biased by a highly critical self-assessment.

As stated by Csikszentmihalyi [35], every flow activity, whether they involved competition or any dimension of experience, had in common the sense of discovery, the creative feeling of transporting the person into a new reality. By giving a “writing challenge” we could observe that students were immersed in the writing moment, and after they finished the activity, they felt creative, animated, relaxed and peaceful. This was especially evident during the smell and sound cues, and also during the combination of both (the smell + sound environment). From observation, in the Neutral Environment students were feeling more apathetic and they made more pauses in writing during the timeout. Although, through statistically analysis, we did not find significant results from the Flow Theory dimensions, from our qualitative data we could notice that sound cues could lead to lower levels of concentration. Also, we could notice that they felt a little pressure towards writing with a time limitation, and this was probably the reason for the inexistence of substantial results in the Flow dimensions.

Triangulating the qualitative data from semi-structured interviews and results, indicates that 72.7% of students said they felt more creative in the Smell Environment, in contrast to other conditions that had higher values (50% in Neutral, 54.8% in Sound and 63.6% in Smell + Sound Environment) as well as that 90.9 % of students enjoyed to write in the Smell environment and 77.4% in the Sound environment.

CSI did show significant difference through statistical analysis, confirming the benefit of olfactory and sound stimuli during a writing task.

The different results from our study show a strong influence of smell and sound cues during a creative writing task and with a highlight on olfactory cues. Therefore, answering our main research question “*Which modality, olfactory or auditory, sparks stronger triggers for creativity?*”. Such results become more relevant if we consider that previous research did not show any significant effect of odours on performance, as stated by Ho and Spence [17].

Our study suggests that olfactory cues should gain more relevance on the development of creativity support tools and environments. Novel smell dispensers, like regular portable media devices, as well as rich and immersive multimodal work environments could improve and foster creative tasks.

9.1.6 Conclusion

Creative writing is a constant activity in many sectors and professions in the modern world. Because of today’s diversity of possible technological ways to write, designing a creative writing user interface is hard work. Sometimes it is difficult to find a tool that keeps users focused whilst eliminating some of the hard work. In this study, we presented a study that addresses the use of different modalities such as smell and sound on the creative writing process of users to enhance creativity.

In the between-subject study we tested the influence of smell and sound on the participant’s creativity in a writing task measured by the Creativity Support Index. We have created two types of auditory and olfactory cues each: an alerting smell was created using the actual fragrance of hot coffee that was spread around the room in small cups. Regarding the alerting sound, users might feel that they would be sitting in a cafe with the constant bustle of movement of people, machines and dishwashers. As for a relaxing scent, we used the fragrance of laurel, and the sound mode used was a natural soundtrack with water, birds and foliage.

We investigated which cue could promote higher levels of creativity and mental well-being – as measured by a survey based on the dimensions of Flow Theory.

We compared four different environments (neutral, smell, sound and smell + sound) using MS Word as a word processor. From a creative perspective, and triangulating qualitative and the statistical results, it is suggested that users considered to feel more

expressive and more creative during the writing task, especially in the Smell Environment.

We found out that participants considered that the smell allowed them more creative times, thus being one of the decisive factors to abstract and to become concentrated. Our results provide interesting information regarding the smell and sound cues modalities. At the same time, for the combination of smell and sound in each category, in semi-structured interviews participants gave particular emphasis to these conditions in the creative moment of the writing task.

A significant problem faced by interaction designers that are involved in multisensory interaction is the timing of each multisensory interaction (*when* to apply the multisensory stimulus). Writing prompts – among other techniques such as using images like a map – are sometimes used to kick start the creative process, when writing. In this research we highlight the value of smell and sound cues as an alternative, more powerful means to kick-start that same process more effectively.

There are many aspects of this study that remain open for future investigation such as our results about creativity combined with different modalities. Measuring creativity is an important approach that will lead us to different impacts of specific creative writing tools. These tools can have features to increase the creativity of writers and also contribute to unblock writer's block. In future work, we think it is important to intensify the research on designing user interfaces that support creative writing and build novel tools that can be used by several people.

9.2. CREASENSESES

Olfactory cues are strong triggers of memories, thoughts and creativity. Different scents can create sensitive environments that foster creative tasks. In this study, we present a study that includes olfactory cues, representing different types of sensitive environments such as “food” (using the odor of coffee and oranges) and “ambience” (perfume and laurel fragrances) in a within-subject design. Our aim was to obtain a deeper understanding over which olfactory cues promote higher levels of creativity, as self-perceived, during the specific process of creative writing. We discuss the results and the potential implications for the design of new creative writing support tools. This study was evaluated using the Creativity Support Index (CSI) and self-assessments. Some participants reported that specific scents – perfume and laurel fragrances – made it more difficult to have new ideas for their writing. Others expressed genuine interest in the oranges (fruit) olfactory cue, which presented the highest, more positive results.

9.2.1 Introduction

Creativity can be fostered by our senses [167], and by the surroundings [168]. Audio and visual cues have been used as stimuli for inspiration, e.g., listening music while writing or looking at images while drawing. Olfactory cues can be strong triggers of memories, emotions [169], [170] and, therefore, of creativity, but they remain poorly assessed [158], [171]. In this study, we explore how different scents can influence a creative writing task, considering that writing is one of the main artistic expressions of humans [10] [12]. We selected olfactory cues that most people are used to, in their daily life and applied them to a creative writing task. We decided to focus on two main categories of scents: “food” and “ambience”, and selected two specific scents per group, “coffee”/“orange” for “food”, and “perfume”/“laurel” for “ambience”.

Some researchers provided results from the first empirical demonstration that olfactory stimulation can facilitate tactile performance, and highlight the potential modulatory role of task-difficulty in odor-induced task performance facilitation [161]. Others [162], presented a prototype system – Olfaction - that emits odor emoticons and it was applied in two contexts: online text chatting and voicemail receiving. Their results suggested that odor emoticons induced more chatting, and were easy to use, and helped participants to better perceive and convey emotions. Studies have been conducted with auditory cues in different areas such as consumer behavior [163] and consumers’ perception of food texture and quality [164]. Demattè et al. [165] investigate the effect of visual cues on olfactory perception in humans and others such as Guest et al. [166] have investigated whether similar auditory manipulations change people’s perception of the roughness of abrasive surfaces and they replicated the rubbing-hands manipulation of previous experimenters while participants rated either the perceived roughness or wetness of their hands. In these experiments, it was possible to demonstrate that auditory frequency manipulations can have on the perceived tactile roughness and moistness of surfaces.

We contribute with a within-subject study where participants wrote a slogan using a text processor while experiencing the different scents. Our approach was measured using the Creativity Support Index (CSI) [79] and self-assessments [69].

9.2.2 User Study

We conducted a within-subject experiment to investigate whether olfactory cues influence people’s creativity and mental well-being during a creative process. The

experiment was conducted during one week. As a prerequisite, the participants had to have a prior writing skills and a basic amount of computer and Internet experience, since our questionnaires are all online. The creative activity in this experiment included writing a Slogan (a sentence) in a text processor. We chose Microsoft Word as a text processor because of its familiarity. The conditions were: *No Odor*; and Odor as *Food* and Odor as *Ambience*. To reduce bias, the order of the conditions was counterbalanced and randomly assigned.

No Scent. Our baseline. A word processor without any explicit scent in the control room.

Food. In this condition, we used two types of olfactory cues: coffee and orange.

Ambience. We used the fragrance of perfume (fragrance fruity fresh, including mint, lavender, citronella and limonene) and laurel (with a touch of floral fragrance and dew).

Scent's spread: Five minutes before the session when the olfactory cues were used, the respective scent was placed in different airtight sacks to ensure that it was evenly propagated and maintained. We used a fan to remove all traces of the scent before starting a new experiment. Participants were exposed to the scent during each session and if they wanted to smell it more, they could use the airtight sacks for that.

Task

Participants were challenged to write a slogan under a maximum of five minutes' using the addressing tool. To initiate their writing challenge, we defined five different objects of a similar degree of complexity. Participants were presented with one of five objects they often use in their daily routine: a ballpoint pen, a mobile phone, a post-it, a USB pen drive and a power bank. Participants were free to finish the task whenever they wanted, under the 5-minute limit.

Participants

Participants had a mean of ages of 31.3 ($SD = 8.6$). The percentage of females was 85.7%. All reported having a normal or corrected visual acuity and sensitivity to odors. All subjects were naïve to the experimental conditions.

14.3% of participants reported to write about three hours per day. 42.9% of participants said they write at least one hour per day and 42.9% said that they write

at least two per day. Most of the participants considered themselves creative persons ($M= 7.29$; $SD=0.95$).

Measures

Before they started the experience, participants were asked to fill a very short survey to collect some demographic data (gender, age, profession, and how often they write) and self-assessments about their creativity (“*Do you consider yourself a creative person?*”) [80] in a ten-point Likert scale survey. They were also asked about their past creative behavior and activities by filling a 30-item survey based on the Creative Behavior Inventory [71], which captures creative accomplishments and activities in past behaviors. We classified subjects that had less than 30 points on the CBI as being *less creative*, and participants that had more than 30 points on the CBI as *highly creative* [172].

At the end of each session, participants were asked to fill out the first part of the Creativity Support Index and a Likert scale (ten-point) survey about their perception of how the whole experience made them feel based on Flow Theory dimensions and rating their creativity in each condition after writing. We asked them also to select up to three adjectives from the following list: Surprised, Delighted, Laid back, Depressed, Passive, Happy, Tired, Bored, Sad, Satisfied, Frustrated, Angry, Serious, Animated, Distressed, Creative and Frightened. Finally, after finishing all conditions they fill out the paired-comparison part of Creativity Support Index and they were interviewed. We collected qualitative data with a semi-structured interview with questions such as: “*Did you enjoy to write in this condition and why?*”; “*In this condition did you feel more creative and why?*” to understand a bit better the participant’s opinion about the whole experience.

Procedure

A preliminary evaluation was conducted with 2 participants to examine the feasibility and accuracy of the scent spread in the classroom. They were asked to write a simple story during ten minutes. After that, participants were asked whether they could smell the scent during the writing task. The scent was already spread into the research laboratory as previously mentioned. Since participants reported that they smelled the scent, we considered that the study could be conducted according to the procedure.

Participants were brought into the research laboratory (Figure 64), previously prepared for the experiment.

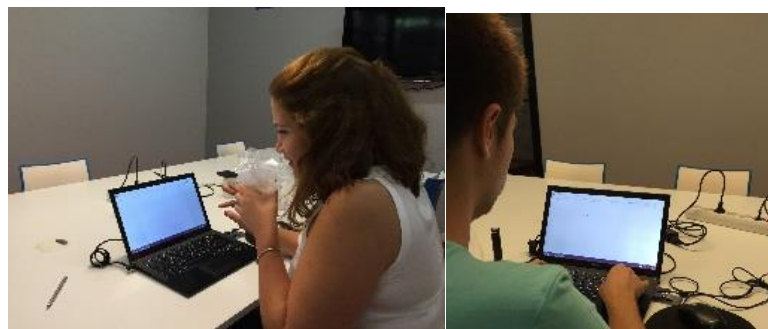


Figure 64 - Participants performing the study in the research laboratory, in conditions odor: ambience, and no odor.

We used one laptop computer with a screen size of 13.3 inches and a display resolution of 1920x1080 pixels.

After filling in the demographic data and the CBI inventory, the writing task was explained. When participants finished writing, they responded to the first part of the CSI survey and the survey about their perception and rated their creativity in each condition. Finally, when they finished all conditions they filled out the paired-comparison part of the CSI and were interviewed.

The total time per subject – including instructions, experiment, breaks and debriefing – took over forty minutes. Subjects could take breaks (five minutes) between each environment conditions.

9.2.3 Findings

We analyzed the results from a perspective that triangulates the data from the survey, self-assessments of creativity, interviews and the slogans themselves. We also discuss the particularities of each scent to elucidate the potential design qualities of single scents.

Our results from the CBI suggest that our sample was likely composed by creative persons in terms of past creative actions. *Six* out of seven participants had more than 30 points on the CBI and only *one* participant had less than 30 point on the CBI.

Since we used repeated measurements, we applied Friedman's ANOVA to test between each condition based on the answers from the survey about Flow Theory dimensions [152]: *(i)* intense and focused concentration on the present moment, *(ii)* sense of personal control or agency over the situation or activity, *(iii)* loss of reflective self-consciousness, and *(iv)* distortion of temporal experience; these were ranked by

participants in a ten-point Likert scale. Through Cronbach’s alpha, the survey based on Flow Theory’s dimensions [152] was found to be reliable ($\alpha = .77$). Some statistical results are shown in Figure 65. In the Orange condition, participants exhibited a higher level of Flow values. However, using Friedman’s ANOVA, the participants’ mental well-being – their “flow”, was not statistically significant ($F(4) = 3.42, p > .05$).

Statistics					
	NoOdorFlow	CoffeeFlow	OrangeFlow	PerfumeFlow	FragranceFlow
Mean	5,7857	6,2857	6,8571	5,8214	6,2143
Std. Error of Mean	,35114	,56544	,76543	,49315	,66240
Median	6,0000	6,7500	7,7500	5,0000	5,0000
Std. Deviation	,92903	1,49603	2,02514	1,30475	1,75255

Figure 65 - Statistics for Flow Dimensions.

In the semi-structured interview, all participants considered that they did feel more creative in the Orange condition expressing, e.g. “it was a natural odor” [P4, P7, food]; “because it made me feel happy” [P6, food]. Others considered that the Coffee odor was a smell of “day-to-day”, being more familiar and connected to work activity: “The smell of a coffee is linked to my daily work routine” [P4, food]; “the coffee did not make any difference to my creativity in writing, because it is a familiar scent to me” [P6, food]; “The coffee smell was a neutral smell from me, because I’m used to it in my day at work” [P7, food].

85.7% of participants chose the adjective Creative in the Orange Condition while only 14.3% in the No Odor Condition and 42.9% in Coffee condition. 57.1% of participants chose the same adjective (Creative) in Perfume and Fragrance conditions. In the No Odor condition, participants felt more passive (71.4%) in contrast to 14.3% in Orange, Perfume and Fragrance conditions, while 42.9% chose this adjective in the Coffee condition. The adjective Relaxed was chosen by 57.1% of participants in No Odor and Coffee conditions while 14.3% chose in Fragrance condition, 28.6% in Perfume condition and 42.9% in Orange condition. Most adjectives selected in the Food (Coffee and Orange) and Ambience (Perfume and Fragrance) conditions indicates a positive mental well-being. In the No Odor condition, 42.9% of participants chose adjectives such as Serious or Bored (28.6%). During the experiment, we observed that the participants stopped the writing task and they were thinking and smelling the environment in the room before they started the writing challenge. They were curious to know what they were supposed to do and what scent came next. It was clear that all participants felt somewhat creative during the experiment. Triangulating the results with semi-structured interviews allowed us to support some of these results and observations. 71.4% of participants considered that olfactory cues in the Perfume

and Laurel Fragrance conditions gave them a “writer’s block” and it was more difficult to find ideas for their writing: “It was a less natural smell, the perfume and fragrance (...) more industrialized, gave me blocks when writing.” [P2, ambience]; “I was out of ideas in both conditions” [P4, ambience]; “I did not feel immersed in the activity with the smell of the perfume” [P6, ambience]; “the laurel fragrance and the perfume are relaxing but in the long term I did not like them” [P7, ambience]. After the experiment, participants self-rated their creativity in each condition. In the *Coffee* and *Orange* conditions, participants self-rated their creativity higher than in the *No Odor*, *Perfume* and *Fragrance* Conditions (Figure 66). However, using Friedman’s ANOVA, this difference was not found to be statistically significant ($F(4) = 1.42, p > .05$).

	NoOdor	Coffee	Orange	Perfume	Fragrance
Mean	5,4286	6,7143	6,5714	6,2857	6,0000
Std. Error of Mean	,81232	,64418	,92214	,83707	1,00000
Median	5,0000	7,0000	8,0000	7,0000	6,0000
Std. Deviation	2,14920	1,70434	2,43975	2,21467	2,64575

Figure 66 - Statistics for "How do you rate your creativity in this condition?"

The analysis of the Creativity Support Index (CSI) scores through repeated measures ANOVA (normality checked with Shapiro-Wilk test) did not show significance difference, $F(1.57, 9.42) = 1.42, p > .05$, among the five conditions but all fragrances present higher values when compared to the baseline, particularly the ones related to “Food”, as shown in Table 32.

Table 32 - Overall CSI Means.

Overall CSI Means (SD); N=7		
No Scent		55,76 (21,14)
Food	Coffee	67,76 (13,33)
	Orange	66,19 (14,52)
Ambience	Perfume	61,81 (12,39)
	Laurel	59,57 (16,68)

Despite the fact that the experimenter said it would not be necessary to connect the smell in the displayed object to the writing challenge (the advertising slogan), participants in the *Coffee* condition (two out of seven participants) wrote: “Your pen constantly fails and smears all documents? We have the solution for you: the Caféneta - for consistent writing and even flavored coffee! Try it!” [P1, food]; “If you’re down on productivity, wake up! Get energized with the pen” [P3, food]. While in the *Orange* condition they (four out of seven participants) expressed genuine connections to this

type of smell, e.g., “(...) *We have the solution: A mobile battery, lightweight, compact and available in several colors. And the funny thing is that each color is associated with a fruit! Try it.... your purse is always fragrant... and your mobile phone is always charged!*” [P1, food]; “*Recharge your batteries with vitamin!*” [P2, food]; “*Fill your life with the exotic power of our products, fill your life with Power Bank.*” [P6, food]; “*Do you consider vitamin C to be a fundamental ingredient in your daily life? Well if not, you should. Have you wondered your electronics could use the same type of vitamin? Would you carry it in your pocket? Of course not, you haven’t had that chance, well now you do! ChargeMe is available in our stores across the city. Lightweight, compact, and easy to handle, buy your ChargeMe right away, and feed your electronics!*” [P7, food]. Participants, (four out of seven participants) identified the sense of *Perfume Condition* in their writing, e.g., “(...) *try our post-its! They are customizable, from color to shape, without forgetting that you can give them your favorite scent!*” [P1, ambience]; “(...) *find your inspiration in the smells of nature.*” [P2, ambience]; “*When you can’t cover up the scent of your responsibilities, freshen up with Post-it notes.*” [P3, ambience]; “*Make your life a scent that you will never forget and use our notepad.*” [P6, ambience]. Finally, in the *Fragrance Condition* participants (four out of seven) wrote: “*Connect with the environment.*” [P2, ambience]; “*If you need to clear up your troubles, freshen your day with the iPhone.*” [P3, ambience]; “*Clean your life and your thoughts, use smartphones to give your brain liberty for the pleasures of life*” [P6, ambience]; “*Looking for the latest tool to help you document your memories? Try the new phone X. It’s breezy, light and convenient to carry with you. It stores your images, and it’s perfect to use as your personal camera. Plus, you can talk to people who are not there with you, with its special 4G connection. Trust me, this phone should be yours! Bring back the nature with X as your company!*” [P7, ambience].

In semi-structured interviews, we asked participants’ to categorize the olfactory cues into two categories: alert and relaxed [160]. Table 33 shows self-perceptions to the categories for each odor.

Table 33 - Categorization of each odor through self-perceptions.

	No Scent (%)	Coffee (%)	Orange (%)	Perfume (%)	Fragrance (%)
Relaxed	-----	42.9	85.7	14.3	42.9
Alert	-----	57.1	14.3	85.7	57.1

While olfactory cues such as Orange and Perfume are evident to participants in each category they belong, 85.7% of participants considered the Orange cue can give a

relaxed feeling, and 85.7% of participants considered the Perfume can give them an alert feeling. The other two olfactory cues – Coffee and Fragrance – were considered almost as equivalent. One participant commented that the smells can also be distracting: *“I believe that the smells are distracting. They can be used for inspiration to arise naturally and not consciously.”* (P5). Another participant considered that olfactory cues can be messy: *“The smell can become confusing because it uses many memories and it would take a lot to write about. The smell can disturb.”* (P7).

9.2.4 Discussion

The high percentage of participants that have chosen the “Creative” adjective, combined with the high CSI overall scores during the fragrance conditions show that olfactory cues can influence creativity, something also suggested by the analysis of the produced slogans. In addition, we observed that “food” fragrances present higher values when compared to “ambience” fragrances. However, we did not find particular influence if we classify the fragrances as Relax or Alert. The Orange condition was the olfactory cue that better raised the users’ creativity. Also, triangulating data from their *flow* state with interviews one can see that the Orange condition was the one that users felt that better fostered their creativity. To improve and to foster creative tasks, our study suggests that olfactory cues should be used in the development of creativity support tools and environments.

9.3 Conclusion

In this study, we compared four different olfactory cues in two categories (Food – Coffee/Orange; Ambience – Perfume/Fragrance) using MS Word as a word processor. From a creative perspective, and triangulating qualitative and statistical results, users considered themselves to feel more creative during the writing task. Assuming that creativity is often conducted through digital tools, these have the potential to either inhibit or promote states of flow. Understanding this dimension could lead to better systems and novel environments, in the future. A significant problem faced by interaction designers who are involved in multisensory interaction is when to apply the multisensory stimulus. Writing prompts are sometimes used to stimulate the creative process, when writing. In this research, we highlight the value of olfactory interaction as a powerful means of encouraging that same process.



PART III
REFLECTIONS

CHAPTER 10

CONCLUSIONS AND FUTURE WORK



"Creativity is the Greatest Gift of human intelligence"
Ken Robinson

CHAPTER 10

CONCLUSIONS AND FUTURE WORK

10. 1. Conclusions

The main conclusions of this work are structured along the three main techniques we employed and evaluated in a creative task context: (i) the “mild” place illusion as a new paradigm for VR interfaces targeted at improving creativity; (ii) the subliminal approach, where we highlight the value of interaction with implicit cues as an alternative to boost the creative process more effectively; and (iii) the use of different modalities such as smell and sound on the creative writing process of users to enhance creativity.

Firstly, we showed that for creative tasks such as creative writing, new product ideation, and brainstorming, a “just-enough” amount of place illusion leads to a greater self-perception of creativity, as opposed to a “full-level” of place illusion. It was clear that most of our subjects felt somewhat empowered and creative during the experiment, especially when they were in the Mild PI condition. Generating multiple possible solutions by reading the text to trigger their creativity and afterwards using the brainstorming technique to generate ideas was a good way to ensure that we would not be restricting the creativity of participants, giving them freedom to write through their own (previously-generated) ideas. Results show that participants in “Mild” PI wrote more words than No PI or “Full” PI, without spending a lot of time. Triangulating these results with interviews, we can assume that they were more focused on the task itself and felt more creative.

Secondly, we presented a novel approach that addresses for the first time the study of priming (subliminal and supraliminal) in a creative task such as creative writing. Specifically, we highlight the value of interaction with implicit or explicit cues as an alternative to boost the creative process more effectively. Acknowledging the limitation of not considering the long-term usage of each condition, our study found empirical support for using subliminal or supraliminal priming in creativity support tools. Also, our study can be replicated in different fields, combining several approaches that have the common objective of supporting human creativity. Results showed that participants in the subliminal condition experienced more loss of self-consciousness when compared to the control condition, with statistical difference. We found no other significant differences in individuals but eye-tracking data and post-experiment verbal accounts revealed subtle differences regarding the impact of the cues on the self-perception of creativity. Some participants considered that the cues did influence their thoughts and consequently their writing, others considered that they were in their implicit memory and used them in later conditions.

Finally, we addressed the role of multi sensory stimulus and how they could improve the current state of the art in creativity support tools. We presented a study that addresses the use of different modalities such as smell and sound on the creative writing process of users to enhance creativity. In the between-subject study we tested the influence of smell and sound on the participant's creativity in a writing task measured by the Creativity Support Index. We created two types of auditory and olfactory cues each: an alerting smell was created using the actual fragrance of hot coffee that was spread around the room in small cups. From a creative perspective, and triangulating qualitative and the statistical results, it is suggested that users considered to feel more expressive and more creative during the writing task, especially in the Smell Environment. We found out that participants considered that the smell allowed them more creative times, thus being one of the decisive factors to abstract and to become concentrated. Our results provide interesting information regarding the smell and sound cues modalities. At the same time, for the combination of smell and sound in each category, in semi-structured interviews participants gave particular emphasis to these conditions in the creative moment of the writing task.

10.2. Future Work

One of the most important long-term prospects of our studies resides in the assessment of different VR qualities (e.g. Place Illusion) and its impact on user's creativity. Studying these qualities will enable VR designers to come up with more

engaging environments to support creative activities. VR has been employed in so many domains (health, entertainment, military) and there is ample room for improvement of current creativity support tools using VR. However, this improvement should be properly informed by focused studies such as the one we presented, especially because emotion, flow and mood play an important role in human creativity, and they can be negatively impacted by improper VR settings.

Similarly, there is ample room for improving future work along the lines of the subtle computing using nudging, or implicit cues, as a trigger to creativity. In fact, the power of the automatic mind can be used to harness the creative power in users, by at the very least subconsciously influencing their lines of thought. Further exploring how this could be achieved, in a user interface setting, is future work worth pursuing. The advantage is clear: less cognitive load resulting from using the automatic mind. However, we are still far from being certain of the effects subliminal priming brings to the creative process: more experimentation is needed, in various forms.

Finally, and regarding the multi sensory approach to creative tools: There are many aspects of our study that remain open for future investigation such as our results about creativity combined with different modalities. Measuring creativity is an important approach that will lead us to different impacts of specific creative writing tools. Future tools can have features to increase the creativity of writers and also contribute to unblocking writer's block. In future work, we think it is important to intensify the research on designing user interfaces that support creative writing and build novel tools that can be used by several people. Assuming that creativity is often conducted through digital tools, these have the potential to either inhibit or promote states of flow. Understanding this dimension could lead to better systems and novel environments, in the future. A significant problem faced by interaction designers who are involved in multisensory interaction is when to apply the multisensory stimulus. Research about proper timing of these stimulus should also be part of future work.

APPENDIX

A - Example of the questionnaire for each dimension for creative writing

SERENDIPITY	HAVEN	EVOLUTION	SHUFFLE
<ul style="list-style-type: none">• How mobile is this tool?• Can the tool be used anywhere, on the move?• Would you say that this tool helps you write better?• When you get a new idea, how fast is to write it done using this tool?	<ul style="list-style-type: none">• How immersed in your writing did you feel when using this tool?• How bored did you feel when writing with this tool?• How inspired do you feel when writing with this tool?• Can you think clearly when writing with this tool?	<ul style="list-style-type: none">• If you were to write a new story, how would this tool help the flow of new ideas?• Do you see this tool as an alternative that allows you to write better?• Would you agree that writing with this tool might produce different story results?• What was your progress in terms of writing, when you used this tool?	<ul style="list-style-type: none">• If you were given several topics to write about, would this tool help you prioritize them?• Is the tool versatile enough to adapt to your writing habits?• Could you see yourself developing new kinds of writing with this tool?• Did you find this tool flexible enough to meet your needs?

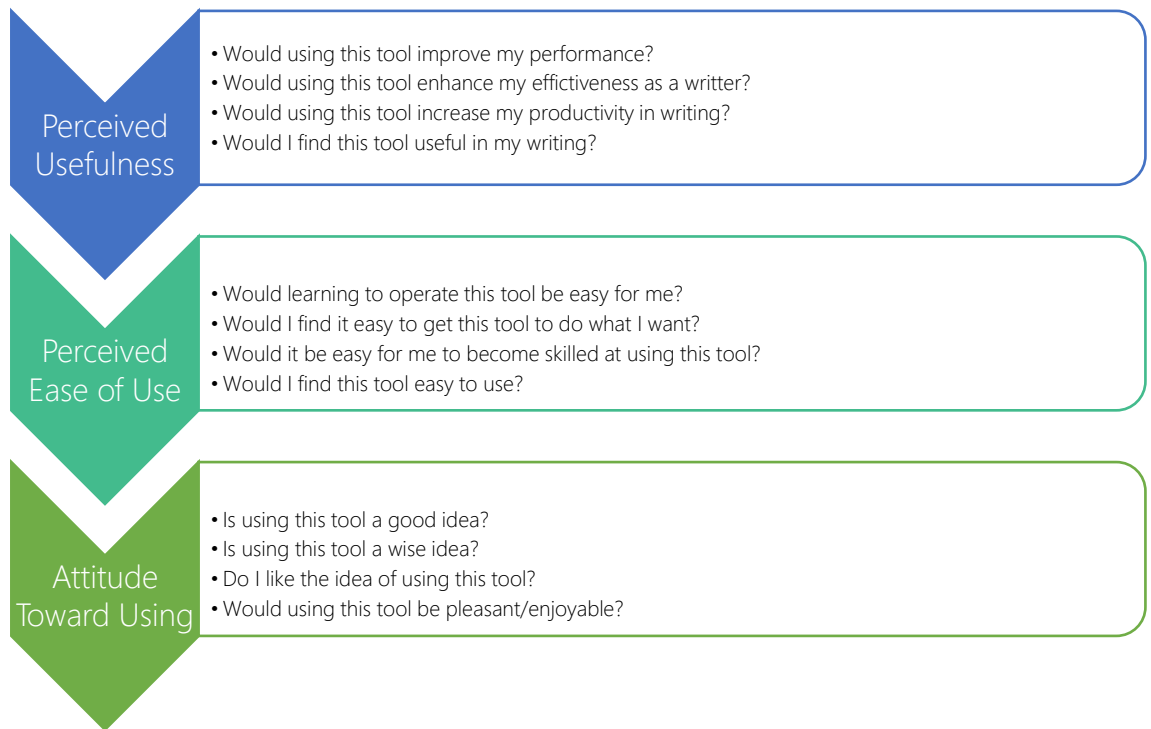
After using the tool, would like to answer the following questionnaire. *

Evidence for scale: 1 not really, 7 yes, very much

	1	2	3	4	5	6	7
How mobile is this tool?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
How immersed in your writing did you feel when using this tool?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If you were to write a new story, how would this tool help the flow of new ideas?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If you were given several topics to write about, would this tool help you prioritize them?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Can the tool be used anywhere, on the move?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
How bored did you feel when writing with this tool?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Do you see this tool as an alternative that allows you to write better?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Is the tool versatile enough to adapt to your writing habits?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Would you say that this tool helps you write better?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	1	2	3	4	5	6	7
How inspired do you feel when writing with this tool?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Would you agree that writing with this tool might produce different story results?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Could you see yourself developing new kinds of writing with this tool?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When you get a new idea, how fast is to write it done using this tool?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Can you think clearly when writing with this tool?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
What was your progress in terms of writing, when you used this tool?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Did you find this tool flexible enough to meet your needs?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

B - Example of the questionnaire for TAM dimensions



Evidence for scale: 1 (not useful / disagree) | 4 (neutral) | 7 (very useful / agree)

	1	2	3	4	5	6	7
Would using this tool improve my performance?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Would learning to operate this tool be easy for me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Is using this tool a good idea?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Would using this tool enhance my effectiveness as a writer?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Would I find it easy to get this tool to do what I want?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Is using this tool a wise idea?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Would using this tool increase my productivity in writing?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Would it be easy for me to become skilled at using this tool?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Do I like the idea of using this tool?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	1	2	3	4	5	6	7
Would I find this tool useful in my writing?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Would I find this tool easy to use?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Would using this tool be pleasant/enjoyable?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

C - Example of the Creative Behavior Inventory

	Never (0)	Once (1)	Twice (2)	3-4 times	5-6 times	More than 6 times
Wrote a short story	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prepared an original floral arrangement	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Started but did not finish a novel	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Applied math in an original way to solve a practical problem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wrote an original computer program	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kept a sketch book	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wrote and completed a novel	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Worked as an editor for a school or university literary publication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Developed an experimental design	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Had a piece of literature (poem, short story, etc.) published	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Never (0)	Once (1)	Twice (2)	3-4 times	5-6 times	More than 6 times
Had a piece of literature published	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Had an original music published or publicity performed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wrote clever or humorous letters	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wrote something humorous such as jokes, limericks, satire, etc.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wrote the lyrics to a song	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Designed and made your own greeting card	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Planned and kept a garden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wrote clever or humorous e-mails	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Made cartoons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Participated in a craft workshop, club or similar organization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Painted an original picture	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wrote music for one instrument	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Put on a radio show	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Won an award for scientific project or paper	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wrote music for several instruments	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Choreographed a dance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Participated in a writer's workshop, club or similar organization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Entered a contest as a musician	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Took and developed your own photographs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wrote poems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

D- Example of the list of adjectives used to access participants mental well-being

Adjectives that best define how it felt to use the tool? *

Select 1-3 from the following list

- Animated
- Creative
- Distressed
- Fear
- Serious
- Angry
- Satisfied
- Frustrated
- Sad
- Astonished
- Depressed
- Bored
- Tired
- Happy
- Delighted
- Pacific
- Relaxed

E- Example of the Flow Theory dimensions survey

Choose from the following scale: *

1 represents the lowest value (I Tottally Disagree) and 7 represents the highest value (I Tottally Agree)

	1	2	3	4	5	6	7
I felt very concentrated during this challenge	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was able to solve this challenge without any problem?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I lost my attention during this challenge	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I lost track of time during this challenge	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

F - Example of the Creativity Support Index survey

Choose from the following scale: *

0 represents the lowest value (Highly Disagree) and 10 represents the highest value (Highly Agree)

	0	1	2	3	4	5	6	7	8	9	10
I was satisfied with what I got out of the system or tool.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was easy for me to explore many different ideas, options, designs, or outcomes, using this system or tool.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The system or tool allowed other people to work with me easily.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would be happy to use this system or tool on a regular basis.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was able to be very creative while doing the activity inside this system or tool.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My attention was fully tuned to the activity, and I forgot about the system or tool that I was using.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I enjoyed using this system or tool.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The system or tool was helpful in allowing me to track different ideas, outcomes, or possibilities.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	0	1	2	3	4	5	6	7	8	9	10
What I was able to produce was worth the effort I Had to exert to produce it.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The system or tool allowed me to be very expressive.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was really easy to share ideas and designs with other people inside this system or tool.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I became so absorbed in the activity that I forgot about the system or tool that I was using.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

CSI - 1/15

When doing this task, it's most important that I'm able to....*

- Explore many different ideas, outcomes, or possibilities
- Work with other people

CSI 2/15

When doing this task, it's most important that I'm able to....*

- Be creative and expressive
- Produce results that are worth the effort I put in

G - Example of the Perceptual Effects survey

Choose from the following scale:

1 represents the lowest value (I Totally Disagree) and 7 represents the highest value (I Totally Agree)

	1	2	3	4	5	6	7
I sometimes felt as if I was actually writing at the environment's real location.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sometimes I felt that the environment was providing me inspiration.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
At some moments I felt that the environment was influencing my thoughts.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It sometimes seemed as if the creativity I was feeling came from somewhere between my mind and the environment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It sometimes seemed as I had more creativity than ever.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The flow of my writing was caused by environment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It felt as if the writing was drifting towards a very good way.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

REFERENCES

- [1] J. Dyson e R. Uhlig, *The History of Great Inventions*, Carroll & Graf Publishers, 2001.
- [2] B. Archer, "The Nature of Research," *Co-Design*, 1995, pp. 6-13.
- [3] P. J. Stappers, "Doing design as a part of doing research," em *Design Research Now*, Switzerland, Michel, R., Birkhäuser, Basel, 2007, pp. 81-91.
- [4] J. Frens, *Designing for Rich Interaction: Integrating Form, Interaction, and Function*, The Netherlands: Doctoral Dissertation, Eindhoven University of Technology, 2006.
- [5] A. L. Vera, *Co-designing interactive spaces for and wiht designers: supporting mood-board making*, Finland, 2009.
- [6] S. March e G. Smith, "Design and Natural Science Research on Information Technology," em *Decision Support Systems*, 1995, pp. 251-266.
- [7] P. Campos, "Designing for Workstyle Transitions: Interaction Design Tools for Software Engineering," Funchal, Portugal, 2006.
- [8] D. Morley, *The Cambridge Introduction to Creative Writing*, Cambridge: Cambridge University Press, 2007.
- [9] J. H. G. Kroll, *Research Methods in Creative Writing*, Palgrave Macmillan, 2013.
- [10] J. Kroll e G. Harper, *Research Methods in Creative Writing*, Palgrave Macmillan, 2013.
- [11] M. Weiss, "Overcoming Writer's Block", Pennsylvania, 2010.
- [12] D. G. Myers, *The Elephants Teach: Creative Writing since 1880.*, Chicago: University of Chicago Press, 2006.
- [13] T. Tharp, *The Creative Habit: Learn It and Use It for Life*, Simon & Schuster, 2006.
- [14] F. Gonçalves, P. Campos, J. Hanna e S. Ashby, "You're the Voice: Evaluating User Interfaces for Encouraging Underserved Youths to express themselves through Creative Writing," *Creative & Cognition June 22-25, Glasgow, United Kingdom*, 2015.
- [15] D. McVey, "Why all writing is creative writing," *Innovations in Education and Teaching International* , vol. 45, n° 3, pp. 280-289, 2008.
- [16] R. Sternberg, S. B. Kaufman, J. Kaufman e (eds.), *The Psychology of Creative Writing*, Cambridge University Press, 2009.
- [17] J. J. Elam e M. Mead, "Can Software Influence Creativity?," *Information Systems Research*, pp. 1-22, 1990.

- [18] E. a. L. C. Carrol, "Triangulating the personal creative experience: self-report, external judgments and physiology.," *In Proceedings the Graphics Interface 2012 (GI'12)*. Canadian Information Processing Society, Toronto, Ont. Canada., pp. 53-60, Canada, 2012.
- [19] R. Hegde e G. Walia, "How to Enhance the Creativity of Software," em *Proceedings of the 26th IEEE International Conference on Software Engineering and Knowledge Engineering*, Vancouver, Canada, 2014.
- [20] B. Shneiderman, "Leonardo's laptop: Human Needs and the New Computing Technologies," *MIT Press, Cambridge*, 2002.
- [21] S. Joy e K. Breed, "Innovation Motivation, Divergent Thinking, and Creative Story Writing: Convergence and Divergence Across the Torrance Tests and TAT," *Imagination, Cognition and Personality*, vol. 32, n° 2, pp. 179-195, 2012.
- [22] T. Selker, "Fostering motivation and creativity for computer users," *International Journal of Human-Computer Studies*, vol. 63, n° 4-5, pp. 410-421, 2005.
- [23] B. Shneiderman, "Creating Creativity: User Interfaces for Supporting Innovation," em *ACM Transactions on Computer-Human Interaction*, Vol. 7, N.º 1, 2000, pp. 114-138.
- [24] H. Wang, S. Fussell e D. Cosley, "From diversity to creativity: Stimulating group brainstorming with cultural differences and conversationally-retrieved pictures.," em *InProc. CSCW. ACM*, 2011.
- [25] S. Andolina, K. Klouche, D. Cabral, T. Ruotsalo e G. Jacucci, "InspirationWall: Supporting Idea Generation Through Automatic Information Exploration.," em *In Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition (C&C'15)*, New York, USA, 2015.
- [26] F. Gonçalves, P. Campos, J. Hanna e S. Ashby, "You're the Voice: Evaluating User Interfaces for Encouraging Underserved Youths to express themselves through Creative Writing," em *C&C'15 Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition*, New York, USA, 2015.
- [27] A. M. Magnifico, "'Getting other's perspectives': a case study of creative writing environments and mentorship.," in *In Proceedings of the 9th International Conference of the Learning Sciences - Volume 1 (ICLS'10)*, 2010, pp. 1151-1157.
- [28] A. Yannopoulos, "DirectorNotation: Artistic and technological system for professional film directing," *J. Comput. Cult. Herit.*, 6, 1, , p. Article 2, 2013.
- [29] U. Farooq, J. Carrol e C. Ganoë, "Supporting creativity with awareness in distributed collaboration," *In Proceedings of the 2007 International ACM conference on supporting group work (GROUP'07)*, pp. 31-40, ACM, New York, NY, USA, 2007.
- [30] D. Grammenos, "Stupidity, ignorance and nonsense as tools for creative thinking.," *ACM interactions* 21, 5 (September), pp. 54-59, 2014.
- [31] G. Oestreicher-Singer e L. Zalmanson, "Content or community? A digital business strategy for content providers in the social age," *MIS Q.* 37, 2,, pp. 591-616, 2013.
- [32] M. D. A. Goulet, "Focus group on computer tools used for professional writing and preliminary evaluation of LinguisTech.," em *In Proceedings of the Second Workshop on Computational Linguistics and Writing (CLW 2012): Linguistic and Cognitive Aspects of Document Creation and Document Engineering (EACL 2012)*, Stroudsburg, PA, USA, Linguistics, Association for Computational, 2012, pp. 39-47.
- [33] T. Coughlan e P. Johnson, "Understanding productive, structural and longitudinal interactions in the design of tools for creative activities.," *In Proceedings of the seventh ACM conference on Creativity and cognition (C&C'09)*, pp. 155-164, ACM, New York, NY, USA., 2009.
- [34] K. F. M. a. B. M. Wiesner, "Unleashing creative writers: situated engagement with mobile narratives.," *In Proceedings of the 21st Annual Conference of the Australian Computer-Human Interaction Special Interest Group: Design: Open 24/7 (OZCHI'09)*, pp. 373-376, ACM, New York, NY, USA, 2009.

- [35] M. Bernstein, G. Little, R. Miller, B. Hartman, M. Ackerman, D. Karger, D. Crowell e K. Panovich, "Soylent: a word processor with a crowd inside.," In *Proceedings of the 23rd Annual ACM symposium on User Interface Software and Technology (UIST'10)*, pp. 313-322, ACM, New York, NY, USA, 2010.
- [36] J. Robertson e K. Nicholson, "Adventure Author: a learning environment to support creative design," In *Proceedings of the 6th international conference on Interaction design and children (IDC'07)*, pp. 37-44, ACM, New York, NY, USA., 2007.
- [37] M. Jones, M. Kisthardt e M. Cooper, "Interdisciplinary teaching: introductory programming via creative writing," In *Proceedings of the 42nd ACM technical symposium on Computer science education (SIGCSE'11)*, pp. 523-528, ACM, New York, NY, USA., 2011.
- [38] A. Steidle e I. Weirth, "Freedom from constraints: Darkness and dim illumination promote creativity," *Journal of Environmental Psychology, Vol. 35, Sep.*, pp. 67-80, 2013.
- [39] C. Shah, K. Erhard, H. Ortheil, E. Kaza, C. Kessler e M. Lotze, "Neural Correlates of Creative Writing: An fMRI Study," *Human Brain Mapping*, 2011.
- [40] H. C. M. Christiaans, "Creativity as a Design Criterion," *Creativity Research Journal*, vol. 14, n° 1, pp. 41-54, 2002.
- [41] B. Schneiderman, "Accelerating Discovery and Innovation," *Communications of the ACM*, 50, 12, 2007.
- [42] Y. Engeström, "Activity Theory as a framework for analyzing and redesigning work," *Ergonomics*, pp. 960-974, 2000.
- [43] J. E. Bardram e A. Doryab, "Activity analysis: Applying activity theory to analyze complex work in hospitals," em *CSCW*, Hangzhou, China, 2011.
- [44] D. Cook, J. Augusto e V. Jakkula, "Ambient Intelligence: Technologies, applications, and opportunities," *Elsevier: Pervasive and Mobile Computing*, pp. 277-298, 2009.
- [45] V. Kaptelinin e B. A. Nardi, *Acting with Technology: Activity Theory and Interaction Design*, The MIT Press, 2009.
- [46] A. Leontev, *Activity, Consciousness, and Personality*, Prentice-Hall, 1978.
- [47] L. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes*, Harvard University Press, 1978.
- [48] V. Kaptelinin, *The encyclopedia of Human Computer Interaction 2nd Edition*, Interaction Design Foundation, 2015.
- [49] E. Appiah e J. Cronjé, "Exploring Information and Communication Theory in Graphic Design Education with Activity Theory," *International Journal of Computer Applications*, 2013.
- [50] C. Bazerman, "Cyborgs in Action," em *Context and Consciousness: Activity Theory and Human-Computer Interaction -*, Regents of the University of California on behalf of the Laboratory of Comparative Human Cognition, 1998, pp. 73-75.
- [51] L. Bannon e S. Bodker, "Beyond the Interface: Encountering Artifacts in Use.," em *Designing Interaction: Psychology at the Human-Computer Interface*, Cambridge University Press, 1991, pp. 227-253.
- [52] S. Card, T. Moran e A. Newell, *The Psychology of Human-Computer Interaction*, Lawrence Erlbaum Associates, 1983.
- [53] V. Kaptelinin e B. Nardi, *Acting with technology - Activity Theory and Interaction Design*, MIT Press, 2006.
- [54] K. Kuutti, "Activity theory as a potential framework for human-computer interaction research," *Context and consciousness*, pp. 17-44, 1996.
- [55] J. Rasmussen, A. Pejtersen e L. Goodstein, *Cognitive Systems Engineering*, New York: Wiley, 1994.

- [56] P. Campos, T. Clemmensen, J. Abdelnour-Nocera, D. Katre, A. Lopes e R. (Ørnrngreen, Human Work Interaction Design. Work Analysis and HCI, Springer , 2012.
- [57] T. Clemmensen, "A Human Work Interaction Design (HWID) case study in e-Government and Public Information Systems," *International Journal of Public Information Systems*, vol. 3, 2011.
- [58] R. Ørnrngreen, A. Mark Pejtersen e T. Clemmensen, "Themes in Human Work Interaction Design," *IFIP*, vol. 272; pp. 33-46, Springer., 2008.
- [59] F. Gonçalves, P. Campos e T. Clemmensen, "Human Work Interaction Design: An Overview," em *Human Work Interaction Design - Work Analysis and Interaction Design Methods for Pervasive and Smart Workplaces*, Springer, 2015, pp. 3-19.
- [60] F. Gonçalves, T. Clemmensen, P. Campos e J. Molka-Danielsen, "'Drifting towards a new HCI field: A Review of 10 Years of HWID Research'," 2017.
- [61] T. Clemmensen, "The form of HWID theory," em *Workshop INTERACT - Human Work Interaction Design (HWID): Design for Challenging Work Environments*, Bamberg, Germany, 2015.
- [62] Y. Rogers, *Secrets of Creative People*, Yvonne Rogers, 2014.
- [63] K. Robinson, *Out of our Minds, Learning to be Creative*, Capstone Publishing Ltd., 2011.
- [64] T. Ward, "Creative cognition as a window on creativity," *In Elsevier, Science Direct, Methods 42 (2007)*, pp. 28-37, 2006.
- [65] P. R. J. Silva, "A Methodology to Evaluate Creative Design Methods: A study with BadIdeas Method.," *OZCHI 2010, November, Brisbane, Australia*, 2010.
- [66] E. Carrol e C. Latulipe, "Triangulating the personal creative experience: self-report, external judgments and physiology.," *In Proceedings the Graphics Interface 2012 (GI'12). Canadian Information Processing Society, Toronto, Ont. Canada.*, pp. 53-60, Canada, 2012.
- [67] P. Silva e J. Read, "A Methodology to Evaluate Creative Design Methods: A study with BadIdeas Method.," *OZCHI 2010, November, Brisbane, Australia*, 2010.
- [68] D. Hocevar, "The Development of the Creative Behavior Inventory," *Annual Meeting of the Rocky Mountain Psychological Association*, 1979.
- [69] P. Silvia, B. Wigert, R. Reiter-Palmon e J. Kaufman, "Assessing Creativity With Self-Report Scales : A Review and Empirical Evaluation," *Psychology Faculty Publications*, 2012.
- [70] D. Hocevar, "Intelligence, divergent thinking, and creativity," *Intelligence*, pp. 25-40, 1980.
- [71] D. Hocevar, "The Development of the Creative Behavior Inventory," em *Annual Meeting of the Rocky Mountain Psychological Association*, 1979.
- [72] D. Hocevar, "Measurement of creativity: Review and critique," *Journal of Personality Assessment*, vol. 45, n° 5, pp. 450-463, 1981.
- [73] M. Csikszentmihalyi, *Flow: The Psychology of Optimal Experience*, New York: Harper Perennial, 1991.
- [74] B. Cramond, J. Mathews-Morgan, D. Bandalos e L. Zuo, "A report on the 40-year follow-up of the Torrance Tests of Creative Thinking: Alive and well in the 21st century," *Gifted Child Quarterly*, vol. 49, pp. 283-291, 2005.
- [75] T. Amabile, "Creativity in Context," *Westview Press*, 1996.
- [76] T. Amabile, P. Goldfarb e S. Brackfield, "Social Influences or creativity: Evaluation, coaction and surveillance," *Creativity Research Journal*, vol. 3, n° 1, pp. 6-21, 1990.
- [77] A. E. R. J. JSTOR, Torrance, E.P. Torrance Tests of Creative Thinking: Norms - Technical Manual, 95pp.; Thinking Creatively with Words, Test Booklets and Manuals, Form A, 62pp., 1998.

- [78] L. Almeida, L. Prieto e M. O. E. F. C. Ferrando, "Torrance Test of Creative Thinking: The question of its construct validity," *In Elsevier, Thinking Skills and Creativity* 3, vol. 3, n° 1, pp. 53-58, 2008.
- [79] E. Cherry e C. Latulipe, "Quantifying the Creative Support of Digital Tools through the Creativity Support Index," *ACM Transactions on Computer-Human Interaction, Vol. 21, N.º 4, Article 21*, 2014.
- [80] R. Wiseman, C. Watt e K. Gilhooly, "Creativity and ease of ambiguous figural reversal," *British Journal of Psychology*, vol. 102, pp. 615-622, 2011.
- [81] S. Joy e K. Breed, "Innovation Motivation, Divergent Thinking, and Creative Story Writing: Convergence and Divergence across the Torrance Tests and TAT.," *Imagination, Cognition and Personality, Vol. 32 (2)*, pp. 179-195, 2012.
- [82] InputLog, "InputLog," [Online]. Available: <http://www.inputlog.net/>.
- [83] L. K. N. M. K. B. S. N. N. V. C. P. G. F. C. M. F. P. Guzman, "Yarn: a Product for Unraveling Stories.," *In NordiCHI'14 Industrial Program, Helsinki*, 2014.
- [84] L. Guzman, N. Kannan, K. Mendonza, S. Buenafe, N. Nunes, V. Nisi, P. Campos, F. Gonçalves, M. Campos e P. Freitas, "Yarn: a Product for Unraveling Stories.," *In NordiCHI'14 Industrial Program, Helsinki*, 2014.
- [85] M. Morris e A. Dillon, "How User Perceptions Influence Software Use.," *IEEE Software*, 14 (4), pp. 58-65, 1997.
- [86] Scrivener. [Online]. Available: <https://www.literatureandlatte.com/scrivener.php>.
- [87] OmmWriter. [Online]. Available: <http://www.ommwriter.com>.
- [88] Ulysses. [Online]. Available: <http://www.ulyssesapp.com>.
- [89] D. Hocevar, "Measurment of creativity: Review and critique," *Journal of Personality Assessment*, vol. 45, n° 5, pp. 450-463, 1981.
- [90] I. S, "IBM SPSS Statistics," [Online]. Available: <http://www-01.ibm.com/software/analytics/spss/>. [Acedido em 2016].
- [91] H. Cooligan, *Research Methods and Statistics in Psychology*, New York: Routledge, 2013.
- [92] L. Almeida, L. Prieto, M. Ferrando, E. Oliveira e C. Ferrándiz, "Torrance Test of Creative Thinking: The question of its construct validity," *In Elsevier, Thinking Skills and Creativity* 3, pp. 53-58, 2008.
- [93] D. Norman e S. Draper, *User Centered Design, Nem Perspectives on Human-Computer Interaction*, L. Erlbaum Associates Inc. , 1986.
- [94] D. Norman, *Things That Make Us SMART, Defending Human Attribute in the Age of the Machine*, New York: Basic Books, 1993.
- [95] M. Rose, "Writer's Block: The Cognitive Dimension. *Studies in Writing & Rhetoric*", Southern Illinois University Press: Carbondale, 1984.
- [96] W. Digest, *The Writer's Guide to Creativity*, F+W Media Inc., 2011.
- [97] E. Estellés-Arolas e González-Landrón-De-Guevara, ""Towards an integrated crowdsourcing definition", *J.Inf. Sci.*, Vols. %1 de %2v. 38, n. 2, pp. 189-200, 2012.
- [98] J. Howe, *Crowdsourcing: Why the Power of the Crowd is Driving the Future of Business*, New Work, USA: Crown Publishing Group, 2008.
- [99] D. C. Brabham, ""Crowdsourcing as a Model for Problem Solving: An Introduction and Cases", *Convergence: The International Journal of Research into New Media Technologies*, Vols. %1 de %214,1, pp. 75-90, 2008.
- [100] F. Kleemann, G. Vob e K. Reider, ""Un(der)paid Innovators: The Commercial Utilization of Consumer Work through crowdsourcing", *Science, Technology & Innovation Studies*, Vols. %1 de %2vol.4, n.1, pp. 5-26, 2008.
- [101] M. Baas, C. De Dreu e B. Nijstad, ""A Meta-Analysis of 25 Years of Mood-Creativity Research: Hedonic Tone, Activation, or Regulatory Focus?," *Psychological Bulletin*, Vols. %1 de %2vol. 134, n.6, pp. 779-806, 2008.

- [102] A. Rooij e S. Jones, "Mood and Creativity: An Appraisal Tendency Perspective," em *9th ACM Conference on Creativity & Cognition*, Sydney, Australia, 2013.
- [103] C. K. W. De Dreu, M. Baas e B. Nijstad, "Hedonic Tone and Activation Level in the Mood-Creativity Link: Toward a Dual Pathway to Creativity Model," *Journal of Personality and Social Psychology*, Vols. %1 de %2vol.94, n.5, pp. 739-756, 2008.
- [104] Z. Ivcevic, M. Brackett e J. Mayer, "Emotional Intelligence and Emotional Creativity," *Journal of Personality*, Vols. %1 de %2vol. 2, n. 75, pp. 200-236, 2007.
- [105] R. Friedman e J. Forster, "The Effects of Promotion and Prevention Cues on Creativity," *Journal of Personality and Social Psychology*, Vols. %1 de %2vol. 81, n.6, pp. 1001-1013, 2001.
- [106] N. E. H. Kaya, "Relationships between color and emotion: a study of college students," *College Student Journal*, Vols. %1 de %2vol. 38, n.3, pp. 396-405, 2004.
- [107] N. Kaya e H. Epps, "Color-emotion associations: Past experience and personal preference," em *Color and Paints, Interim Meeting of the International Color Association*, Porto Alegre, 2004.
- [108] J. Goethe, *Theory of Colours*, London: MIT Press, 1970.
- [109] A. Field, *Discovering Statistics Using SPSS*, London : SAGE Publications Ltd, 2009.
- [110] Y. Rogers, *Secrets of Creative People*, Yvonne Rogers, 2014.
- [111] B. Shneiderman, "Creativity Support Tools: Accelerating Discovery and Innovation," *Communications of the ACM*, vol. 50, n° 12, pp. 20-32, 2007.
- [112] M. Boden, *The Creative Mind: Myths and Mechanisms*, George Weidenfield and Nicolson Ltd, 1990.
- [113] A. Pasztor, G. Molnar e B. Csapo, "Technology-based assessment of creativity in educational context: the case of divergent thinking and its relation to mathematical achievement," *Elsevier - Thinking Skills and Creativity*, vol. 18, p. 32.42, 2015.
- [114] M. D. Mumford e S. B. Gustafson, "Creativity syndrome: Integration, application, and innovation.," *Psychological Bulletin*, vol. 103 (1), pp. 27-43, 1988.
- [115] M. Csikszentmihalyi, *Creativity: flow and the psychology of discovery and invention*, Harper Perennial, 1971.
- [116] A. Jonathan, R. A. Plucker e B. & G. T. Dow, "Why Isn't Creativity More Important to Educational Psychologists? Potentials, Pitfalls, and Future Directions in Creativity Research," *Educational Psychologist*, vol. 39, n° 2, 2004.
- [117] H. Geschka, G. Schaudé e H. Schlicksupp, "Modern Techniques for Solving Problems," *International Studies of Management & Organization*, vol. 6, n° 4, pp. 45-63, 1973.
- [118] R. Stenberg e Ed., *Handbook of Creativity*, Cambridge: Cambridge University Press, 1999.
- [119] M. Slater, "Place Illusion and Plausibility Can Lead to Realistic Behaviour in Immersive Virtual Environments," *Philos Trans R Soc Lond B Biol Sci* 364: 1535, pp. 3549-3557, 2009.
- [120] M. Botvinick e J. Cohen, "Rubber Hands "feel" touch that eyes see," *Nature*, vol. 391, p. 756, 1998.
- [121] E. L. Waterworth e J. A. Waterworth, "The Illusion of Being Creative," *Being There: Concepts, effects and measurement of user presence in synthetic environments*, 2003.
- [122] J. Waterworth, "Creativity and Sensation: The Case of Synaesthetic Media," *Leonardo*, vol. 30 (4), pp. 327-330, 1997.
- [123] E. Waterworth, *Perceptually-Seductive Technology - Designing computer support for everyday creativity*, Sweden: Umea University, 2001.
- [124] E. Waterworth, M. Häggkvist, K. Jalkanen, S. Olsson, J. Waterworth e H. Wimelius, "The Exploratorium: An Environment to Explore Your Feelings," *PsychNology Journal*, Vols. %1 de %21, 3, pp. 189-201, 2003.

- [125] M. Slater, D. Perez-Marcos, H. Ehrsson e M. SanchezVives, "Towards a igital body: the virtual arm illusion," em *Frontiers in Human Neuroscience*, 2008.
- [126] V. B. J. Abbot e E. Smith, "Human memory search as a random walk in a semantic network," *NIPS Proceedings, Advances in Neural Information Processing Systems 25* , 2012.
- [127] L. Candy e Z. Bilda, "Undestanding and Evaluating Creativity," em *C&C'07*, Washington, USA, 2007.
- [128] T. Hewett, M. Czerwinski, M. Terry, J. Nunamaker, L. Candy, B. Kules e E. Sylvan, "Creativity Support Tool Evaluation Methods and Metrics," em *NSF Workshop Report Creativity Support Tools* , 2005.
- [129] N. Bonnardel e F. Zenasni, "The Impact of Technology on Creativity in Design: An Enhancement?," *Creativity and Innovation Management*, vol. 19, n° 2, pp. 180-191, 2010.
- [130] N. LeBoutillier e D. Marks, "Mental imagery and creativity: A meta-analytic review study," *British Journal of Psychology*, vol. 94, pp. 29-44, 2003.
- [131] R. J. Sternberg, "The Assessment of Creativity: An Investment-Based Approach," *Creativity Research Journal*, 24 (1), pp. 3-12, 2012.
- [132] M. Sanchez-Vives e M. Slater, "From presence to consciousness through virtual reality," *Nat Rev Neurosci.* , vol. 6, n° 4, pp. 332-339, 2005.
- [133] P. Turner e S. Turner, "Place, sense of place, and presence," *Presence: Teleoperators and Virtual Environments*, vol. 15, n° 2, pp. 204-217, 2006.
- [134] R. Boice, "The neglected third factor in writing: Productivity.," *College Composition and Communication*, vol. 36, n° 4, pp. 472-480, 1985.
- [135] R. DeHaan, "Teaching creativity and inventive problem solving in science.," *CBE-Life Science Education*, vol. 8, n° 3, pp. 172-181, 2009.
- [136] M. Rose, "Writer's Block: The Cognitive Dimension. Studies in Writing & Rhetoric," Southern Illinois University Press, Carbondale, 1984.
- [137] P. Huston, "Resolving writer's block.," *Canadian Family Physician*, vol. 44, p. 92, 1998.
- [138] S. Ellis, "Story-writing, planning and creativity," *Reading*, vol. 37, n° 1, pp. 27-31, 2003.
- [139] C. W. T. U. D.-F. W. Tool, "<http://www.calmlywriter.com/>," [Online].
- [140] F. Campos, F. Aguiar e P. Campos, "Delineato: Designing Distraction-Free GUIs.," *World Academy of Science*, vol. 8, n° 4, pp. 685-689, 2015.
- [141] D. Kahneman, *Thinking, fast and slow.*, 2011.
- [142] G. Fitzsimons e T. Chartrand, "Automatic effects of brand exposure on motivated behavior: how apple makes you "think different.,"" *Journal of consumer*, vol. 35, n° 1, pp. 21-35, 2008.
- [143] S. Lewis, M. Dontcheva e E. Gerber, "Affective computational priming and creativity.," *In Proceedings of the SIGCHI Conference on Human in Computing Systems ACM*, pp. 735-744, 2011.
- [144] N. Andreasen, "A journey into chaos: Creativity and the unconscious.," *Mens sana monographs*, vol. 9, n° 1, p. 42, 2011.
- [145] S. Ritter, R. V. Baaren e A. Dijksterhuis, "Creativity: The role of unconscious processes in idea generation and idea selection.," *Thinking skills and creativity*, vol. 7, n° 1, pp. 21-27, 2012.
- [146] R. Zajonc, "Attitudinal effects of mere exposure," *Journal of personality and social psychology*, vol. 9, n° 2, p. 2, 1968.
- [147] J. Légal, J. Chappé e V. Coiffard, "Don't you know that you want to trust me? Subliminal goal priming and persuasion.," *Journal of Experimental Social Psychology*, vol. 48, n° 1, pp. 358-360, 2012.

- [148] T. M. Amabile, "Motivation and creativity: Effects of motivational orientation on creative writers.," *Journal of personality and social psychology*, vol. 48, n° 2, p. 393, 1985.
- [149] A. Barbot e S. Koudier, "Longer is not better: nonconscious overstimulation reverses priming influences under interocular suppression," *Attention, Perception, & Psychophysics*, vol. 74, n° 1, pp. 174-184, 2012.
- [150] "Writers Digest," [Online]. Available: <http://www.writersdigest.com/qp7-migration-books/writing-better-lyrics-excerpt>.
- [151] "Tobiipro," [Online]. Available: <http://www.tobiipro.com/product-listing/tobii-pro-x2-30/>.
- [152] M. Csikszentmihalyi, *Flow: The Psychologic of Optimal Experience*, New York: Harper Perennial, 1991.
- [153] M. A. Boden, *Dimensions of Creativity*, MIT Press, 1994.
- [154] B. Shneiderman, "Accelerating Discovery and Innovation," *Communications of the ACM*, 50, 12, 2007.
- [155] M. Csikszentmihalyi, *Creativity: Flow and the Psychology of Discovery and Invention*, Harper Perennial, 1997.
- [156] B. Shneiderman, "Creating Creativity: User Interfaces for Supporting Innovation," em *ACM Transactions on Computer-Human Interaction*, Vol. 7, N.º 1, 2000, pp. 114-138.
- [157] B. Shneiderman, "Accelerating Discovery and Innovation," *Communications of the ACM*, 50, 12, 2007.
- [158] J. Millot, G. Brand e N. Morand, "Effects of ambient odors on reaction time in humans.," *Neurosci*, vol. 322, n° 2, pp. 79-82, 2002.
- [159] H. Seo, V. Gudziol, A. Hähner e H. T., "Background sound modulates the performance of odor discrimination task.," *Exp Brain Res.*, vol. 212, n° 2, 2011.
- [160] C. Spence, "Auditory contributions to flavour perception and feeding behaviour," *Elsevier, Physiology & Behavior*, vol. 107, n° 4, pp. 505-515, 2012.
- [161] C. Ho e C. Spence, "Olfactory facilitation of dual-task performance," *Neuroscience Letters, Elsevier*, 2005.
- [162] W. Xiang, S. Chen, L. Sun, S. Cheng e V. Bove, "Odor emoticon," *International Journal of Human-Computer Studies*, pp. 52-61, 2016.
- [163] M. Zampini e C. Spence, "The Role Of Auditory Cues In Modulating The Perceived Crispness And Staleness Of Potato Chips," *Journal of Sensory Studies*, pp. 347-363, 2005.
- [164] H. Seo e T. Hummel, "Influence of Auditory Cues on Chemosensory Perception," em *The Chemical Sensory Informatics of Food: Measurement, Analysis, Integration*, American Chemical Society, 2015, p. 41-56.
- [165] L. Demattè, D. Sanabria e C. Spence, "Olfactory Discrimination: When Vision Matters?," *Chem. Senses* 34, pp. 103-109, 2009.
- [166] S. Guest, C. Catmur, D. Lloyd e S. C., "Audiotactile interactions in roughness perception," *Experimental Brain Research*, pp. 161-171, September 2002.
- [167] D. Knafo, "The senses grow skilled in their craving: thoughts on creativity and addiction.," *Psychoanal Rev.*, vol. 95, n° 4, pp. 571-595, 2008.
- [168] M. Csikszentmihalyi, *Creativity: the psychology of discovery and invention*, Harper Perennial Modern Classics, 2013.
- [169] R. S. Herz, J. Eliassen, S. Beland e T. Souza, "Neuroimaging evidence for the emotional potency of odor-evoked memory.," *Neuropsychologia*, vol. 42, n° 3, pp. 371-378, 2004.
- [170] R. Sullivan, D. Wilson, N. Ravel e A.-M. Mouly, "Olfactory memory networks: from emotional learning to social behaviors," *Frontiers in Behavioral Neuroscience*, pp. 9-36, 2015.

- [171] M. Obrist, C. Velasco, C. Vi, N. Ranasinghe, A. Israr, A. Cheok, C. Spence e P. Gopalakrishnakone, "Sensing the future of HCI: touch, taste, and smell user interfaces.," *Interactions*, pp. 40-49, August 2016.
- [172] E. a. L. C. Carrol, "Triangulating the personal creative experience: self-report, external judgments and physiology.," *In Proceedings the Graphics Interface 2012 (GI'12). Canadian Information Processing Society, Toronto, Ont. Canada.*, pp. 53-60, Canada, 2012.
- [173] K. Nakjb, "La rédactologie: domaine, méthode et compétences," *ASp*, Vols. %1 de %237-38, pp. 15-26, 202.
- [174] H. Christiaans, "Creativity as a Design Criterion," *Creativity Reserach Journal* 14(1), pp. 41-54, 2002.

