Emerging opportunities for Ambient Intelligence in creativity support tools

Frederica Gonçalves[1], Eduardo Fermé[2] , João C. Ferreira[3]

[1]Madeira Interactive Technologies Institute/University of Madeira - Portugal
[2]University of Madeira/ NOVA LINCS - Portugal
[3]ISCTE - Instituto Universitário de Lisboa - Portugal
frederica.goncalves@m-iti.org; ferme@uma.pt;
joao.carlos.ferreira@iscte.pt

Abstract. The fundamental challenge in developing and evaluating creativity support tools is that we are not able to detect when a person is being creative. In this position paper we described our perspective of ambient intelligence in creativity support tools specially in the use of creative writing environments. Starting with the activity theory, we describe a simple analysis of writing sessions involving 100 students from a higher school, and recorded using a keystroke logging program called Inputlog and the program iTALC to support it. Specifically, we outline the writing activity goals and the interaction design goals.

Keywords: Future environments, Ambient Intelligence, Creativity Support Tools.

1 Introduction

Interactive technologies and new environments are used by a crowd of users with diverse characteristics, needs and requirements [1]. Humans are able to distinguish different scenes, objects or places with all their senses and also have the ability to recall those to spark creativity, e.g. while writing a text. Today, people can take small yet powerful computers anywhere at any time. The rapid adaptation of smart and ubiquitous or pervasive computing enable people to have access to information much faster that previous generations.

With the new trends in natural interaction between computer and human there is a challenge to empower users to harness and embrace their creativity through the use of creativity support tools [2]. Robison [3] defines creativity as the process of having original ideas that have value. Creativity it is also a complex and multifaceted phenomenon [4]. As stated by Shneiderman [5] creativity includes discovery or invention of a significant idea, pattern, method, or device that gains recognition from accepted leaders in a field. Creative workers use artificial stimuli as inspirational guides, e.g., listening to music while writing or looking at images while drawing. Indeed, well-designed creativity support tools can help users in generating multiple levels of creativity for example during the process of writing, particularly those tools that can also generate different

stimuli. Ambient intelligent environments can be characterized by their ubiquity, transparency and intelligence [6], and also eventually intelligent agents or algorithms creativity support tools, would help decisions that automatically serve a person or notify to make a decision or to carry out an action [7].

In this position paper we outline our perspective of ambient intelligence in creativity support tools, especially in the user interfaces to support creative writing. Based on activity theory we enhance the emerging opportunity to use ubiquitous or pervasive technology in a creative process. We present a study using different modalities - such as sound and smell - on a creative writing activity of 100 students in a high school[1]. In a between-subjects design we tried to discover patterns in the influence of smell and sound on the participants writing activity while using a word processor in different environments. These modalities were chosen because they do not distract the users' attention from the main creative task.

2 Background

Ambient Intelligence (AmI) is an emerging discipline that brings intelligence to our everyday environments and makes those environments sensitive to us [8]. It is a multidisciplinary paradigm that draws a new kind of relationship between humans, their environment and the technology [9]. Weiser [10] states that the computer of the 21th century should be invisible to its users, also it would be embedded in the environment. Such invisibility is related to the capacity of the technology to help users to reach their goals in a less obtrusive way. As stated by Hopper [11] applications can be made more responsive and useful by observing and reacting to the physical world and it is particularly attractive in a world of mobile devices and ubiquitous computers. The development of technologies including facial expression [12], emotion [13], speech [14], or gesture recognition, motion tracking [15], facilitate normal interactions with intelligent environments. Essentially, AmI systems should know when it is convenient to interrupt a user when to make a suggestion but also when it is more convenient to refrain from making a suggestion [8]. Our work revolves around creativity support tools and using different modalities, such as sound and smell in a creative writing process, to improve and formulate new guidelines for design for this type of user interfaces, as well as enhancing exploration of future environments.

Interaction with technology gives fresh possibilities to use it in a creative way while also leading to the evolution and sometimes to a transformation of that specific technology. Emerging computer-based tools can develop better and more creative solutions to the problems that we face in our day to day [16]. The success during software development, despite of being a conceptually complex, knowledge intensive and cognitive activity, depends on the creativity of software engineers [17]. There's an effort for developing creativity support tools, which enable us to explore, discover, imagine, innovate, compose and collaborate [18]. And also it is a challenge to construct information technologies that support creativity and the goal of developing new creativity supported tools can be obtained by building upon an adequate understanding of the creative process [5]. A creativity support tools is any tool that can be used by people in the open-

[1] Escola da APEL www.escola-apel.com

ended creation of new artifacts [19]. 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 [20]. Wang et al. [21] and Andolina et al. [22], targeted stimuli such as the visual stimuli, images and text, to support creativity, increasing both originality and diversity of ideas during brainstorming. Ohers researches [23] studied UI Zen-based themes, composed of sound and images to foster inspiration, focus and immersion on creative writing tasks.

The model of activity theory (Figure 1) was proposed by Engeström [24] that provides a number of constructs by focusing on activities as the unit of analysis, activities as goal-directed of intensive interaction of a subject with an object through the use of tools [25]. The illustration of these tools are forms of mental processes manifested in constructs whether physical or psychological. As stated by Appiah et al. [25] 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.

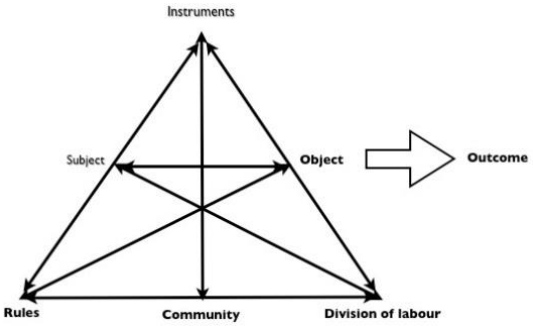

Figure 1 - Model example of human activity by Engeström (Engeström, 2000).

Human activity is executed in a hierarchy of three levels: activity-action-operation [26]. 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 [26]. The major key terms in activity theory include internalization, mediation, subject, object, tool, process (transformation), rules community, division of labor and outcomes [25]. As stated by Kuuti [27] activity theory provides a philosophical and cross disciplinary framework for studying different forms of human practices as development processes.

3 Study

The aim of the study, was to examine how students go through a creative process with computers in a special environment - using modalities such as sound and smell, and their interaction in a creative task. This study applies a between-subject design experience, and we focused on the creative task activity of 100 students. We used a creativity activity such a writing task, since they were students and during their school curriculum they have to write compositions in various disciplines as further evaluation. We recorded the writing sessions using a keystroke logging program called Inputlog [28] and

the program iTALC [29] to support the observations. Also to contribute towards understanding we applied activity theory [24] and semi-structured interviews.

3.1 Participants, conditions and task

The experiment was conducted in a classroom in the secondary high school, during two weeks, and we recruited a group of students. Our experimental design was based on a between-subjects design, in which seven 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.

This experience involved 100 students from the institution's population, aged between 15 and 19 years old (M=15.9; SD=0.94). There were 45 females and 55 males. All subjects were naïve to the experimental conditions. We lead one session per group of students, making up a total of seven sessions for the experience. The classroom was equipped with desks with integrated computers (Figure 1).

Figure 2 - One group of students performing the study in the moment of the experience.

The creative activity in this experiment included writing in four creative writing conditions. Microsoft Word was the word processor in this experiment. We chose this creative writing user interface because the participants were more familiar with it, has a large formatting options, the ability to change font-weight and many other things that allows users an essay and near-instant input.

Condition 1 (N=14). Our baseline (*session 1*) without any cues.
Condition 2 (N=22). We used two types of olfactory cues: an alerting smell (*session 2*) was achieved by the actual fragrance of hot coffee that was spread around the room in small cups, and relaxing smell (*session 3*)– for which we used a laurel fragrance.
Condition 3 (N=31). In this condition we used also two auditory cues: an alerting sound (*session 4*) - 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 5*), achieved using a natural soundtrack featuring water, birds and foliage.
Condition 4 (N=33). 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 6*), and the other group of students could had the relaxing fragrance and sound of nature (*session 7*).

Task. We presented a map to students and they had to choose two points. Students had to write a short story using the starting point as a map. Through their own imagination and creativity, they wrote a story of the path from point X to Y. They initiated their writing from their own ideas. The time limit was 15 minutes to complete the writing task.

3.2 Results

To study the activity system according to Engeström model [24], we randomly took one writing session as starting point. *Students initiate their writing as if they had their ideas already predefined. After a while, they were looking at the map while writing or staring vaguely at the horizon, pausing as if to think and then they started writing.* The action in this activity was a writing task using as instruments the software (Microsoft Word) in the computer for that purpose. One rule existed, students could not use the internet while writing. With a disturbance such as the absence of ideas and resulted in a pause while writing, made the object (in this case the student) activate a contradiction in the initially exposed rule. The outcome in this case, is the final draft of a short story.

It was also monitored this activity 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.

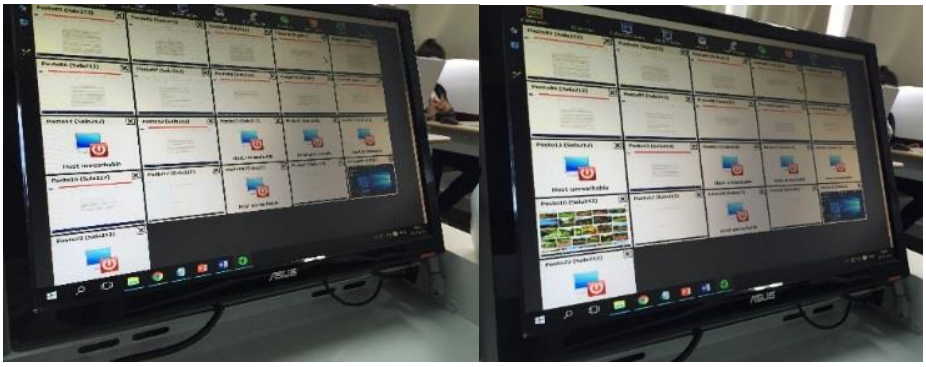

Figure 3 -Fragment of monitoring during the writing activity: example of the use of image search during the writing task.

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 1), the average time of pauses in each session while writing and the average of switches between mouse and keyboard in each session (Table 2).

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

Table 1 - Average time in each session on the writing activity using the keyboard

In Table 2 results shows that the average time on the writing activity using the keyboard in session 3 (Condition 2) had lower values than the other sessions, but results were not of statistical significance.

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

Table 2 - Average time pauses in each session while writing and average switches between mouse and keyboard.

Regarding the average switches between mouse and keyboard, results in Table 3 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 2 had changed fewer times between the keyboard and the mouse, as well participants in Session 5 and Session 7. 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 (Table 3) shows that the participants in the Condition 2 (Session 2 and 3) wrote an average more words, which contrasts with our baseline - Condition 1 (Session 1), and with Condition 3 (Sessions 4 and 5) and Condition 4 (Session 6 and 7).

	Condition 1	*Condition 2*		*Condition 3*		*Condition 4*	
	Session 1	**Session 2**	**Session 3**	**Session 4**	**Session 5**	**Session 6**	**Session 7**
Mean	230,10	412,60	210,10	258,40	273,70	279,20	277,10
Std. Error	39,383	30,768	24,897	32,245	41,226	30,234	17,669
Median	217,50	429,50	192,00	232,50	294,50	275,00	264,00
Std. Deviation	124,541	97,298	78,732	101,969	130,369	95,609	55,876
Minimum	87	211	124	136	54	117	201
Maximum	493	533	364	399	463	433	365

Table 3 - Statistical analysis for stories written in each condition.

Using Friedman's ANOVA approach to testing differences between each condition results were statically significant $Fr(6)=15.77$, $p<.05$. Therefore the non-parametric Wilcoxon test was applied to follow up this finding. For students in Condition 2 the results were significantly higher than students in Condition 1 (our baseline), ($T=1$, $z=-2.59$, $p<.05$, $r=-.43$). When comparing Condition 1 with Condition 3 and Condition 4, results were not statistically significant. In general, we observed that the participants were concentrated on the writing moment. Triangulating the results with semi-structured interviews it was clear that all participants felt somewhat creative during the experiment. In the semi-structured interview, 50% of students consider that they did feel more creative in Condition 1, 54.8% in the Condition 3 and 63,6% in the Condition 4. 72.7% of the students in the Condition 2 considered themselves more creative in this condition. One of the factors that are believed to play an important role in human creativity is our sensory richness. To improve and foster creative tasks, our study suggests that the combination of different modalities such as sound and smell, should increase research on the development of creativity support tools and environments.

4 Discussion

Cook et al. [8] suggest that ambient intelligence is maturing and the resulting technologies promise to revolutionize daily human life by making people's surroundings flexible and adaptive. In the field of ambient intelligence applied to education there are few studies referring to smart classrooms that use an interactive whiteboard that stores content in a database [30] or that employs different devices that recognize interactions such as gestures, motions and speech to capture information or focus attention on appropriate displays and material [31] but more research is needed in this field and creativity support tools especially with the rise of new technologies.

In this position paper we investigate how students go through a creative process with computers in a special environment (using olfactory and auditory cues), and their interaction in a creative task such as creative writing. Today technology is shifting the way people express themselves. The pervasiveness of new technologies in our day to day lives, especially digital interfaces, has increased our access to and interaction with the written word, resulting in both more reading and writing. Whether you’re script-writing a novel or creating a new story at school, sometimes writing might not be as easy as it seems. Chang et al. [32] refer that a good storyteller usually needs good inspiration during the story construction process. Other researchers [33] have studied the role of storytelling technologies to encourage collaboration and to reflect design suggestions made by children themselves. To improve and foster creative tasks, our study suggests that interactions with multisensory systems can have an important role in a creative process of users.

5 Conclusions

In this position paper we presented a study that addresses the use of different modalities such as sound and smell on the creative writing process of users to enhance their creative activity in four different conditions. This position paper was written with the intention to spark an initial discussion around ambient intelligence and creativity support tools with the simple focus of how to design new tools that involved multisensory interactions, and when to apply the multisensory stimulus in the user's creative process. New creativity support tools could provide ubiquitous solutions whereby new technologies can enhance the user's creative process.

Acknowledgements. We would like to thank the students who participated in this research, as well as the teachers and the institutional support from Escola da APEL. Thanks to ARDITI - Regional Agency for the Development of Research Technology and Innovation through the support provided by the M14-20 Project - 09-5369-FSE-000001- PhD Scholarship. E.F. was supported by FCT MCTES and NOVA LINCS UID/CEC/04516/2013.

References

[1] C. Stephanidis, "Design for all," in *The encyclopedia of Human Computer Interaction 2nd edition*, Interaction Design Foundation, 2015, pp. 2453-2550.

[2] E. a. L. C. Carrol, "Triangulating the personal creative experience: self-report, external judments and physiology.," *In Proceedings the Graphics Interface 2012 (GI'12). Canadian Information Processing Society, Toronto, Ont. Canada.*, pp. 53-60, Canada, 2012.

[3] K. Robinson, Out of our Minds, Learning to be Creative, Capstone Publishing Ltd., 2011.

[4] T. Ward, "Creative cognition as a window on creativity," *In Elsevier, Science Direct, Methods 42 (2007),* pp. 28-37, 2006.

[5] B. Shneiderman, "Accelerating Discovery and Innovation," *Communications of the ACM, 50, 12,* 2007.

[6] E. Aarts and S. Marzano, The new Everyday: Views on Ambient Intelligence, Rotterdam: 010 Publishers, 2003.

[7] M. Friedewald, O. Costa, Y. Punie, P. Alahuhta and S. Hienonen, "Perpectives of ambient intelligence in the home environment," *Elsevier: Telematics and Informatics,* pp. 221-238, 2005.

[8] D. Cook, J. Augusto and V. Jakkula, "Ambient Intelligence: Technologies, applications, and opportunities," *Elsevier: Pervasive and Mobile Computing,* pp. 277-298, 2009.

[9] M. Dibitonto, "New Challenges in HCI: Ambient Intelligence for Human Performance Improvement," 2011.

[10] M. Weiser, " The computer for the twenty-century," *Scentific American,* pp. 94-104, 1991.

[11] A. Hopper, "Satient Computing," University of Cambridge, 1999.

[12] M. Pantic, "Face for ambient Intelligence," in *Ambient Intelligence in Everyday Life*, springer, 2006, pp. 32-66.

[13] R. Nakatsu, "Integration of multimedia and art for new human-interaction communications," in *Proceedings of the Pacific Rim International Conference of Artificial Intelligence*, 2002.

[14] R. Xu, G. Mei, Z. Ren, C. Kwan, J. Aube, C. Rochet and V. Stanford, "Speaker identification and speech recognition using phased arrays," in *Ambient Intelligence in Everyday Life*, Springer, 2006, pp. 227-238.

[15] S. Ge, Y. Yang and T. Lee, "Hand gesture recognition and tracking based on distributed locally linear embedding," *Image and Vision Computing,* pp. 1607-1620, 2008.

[16] J. J. Elam and M. Mead, "Can Software Influence Creativity?," *Information Systems Research,* 1990.

[17] R. Hegde and G. Walia, "How to Enhance the Creativity of Software," in *Proceedings of the 26th IEEE International Conference on Software Engineering and Knowledge Engineering*, Vancouver, Canada, 2014.

[18] B. Shneiderman, "Leonardo's laptop: Human Needs and the New Computing Technologies," *MIT Press, Cambridge,* 2002.

[19] E. Cherry and 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.

[20] T. Selker, "Fostering motivation and creativity for computer users," *International Journal of Human-Computer Studies,* vol. 63, no. 4-5, pp. 410-421, 2005.

[21] H. Wang, S. Fussell and D. Cosley, "From diversity to creativity: Stimulating group brainstorming with cultural differences and conversationally-retrieved pictures.," in *InProc. CSCW. ACM*, 2011.

[22] S. Andolina, K. Klouche, D. Cabral, T. Ruotsalo and G. Jacucci, "InspirationWall: Supporting Idea Generation Through Automatic Information Exploration.," in *In Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition (C&C´15)* , New York, USA, 2015.

[23] F. Gonçalves, P. Campos, J. Hanna and S. Ashby, "You're the Voice: Evaluating User Interfaces for Encouraging Underserved Youths to express themselves through Creative Writing," in *C&C'15 Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition*, New York, USA, 2015.

[24] Y. Engeström, "Activity Theory as a framework for analyzing and redesigning work," *Ergonomics,* pp. 960-974, 2000.

[25] E. Appiah and J. Cronjé, "Exploring Information and Communication Theory in Graphic Design Education with Activiy Theory," *International Journal of COmputer Applications,* 2013.

[26] J. E. Bardram and A. Doryab, "Activity analysis: Applying activity theory to analyze complex work in hospitals," in *CSCW*, Hangzhou, China, 2011.

[27] K. Kuuti, "Acitivity theory as a potential framework for human-computer interaction research," *Context and consciousness,* pp. 17-44, 1996.

[28] InputLog, "InputLog," [Online]. Available: http://www.inputlog.net/.

[29] iTALC, "iTALC - Intelligent Teaching And Learning with Computers," [Online]. Available: http://italc.sourceforge.net/.

[30] Y. Shi, W. Xie, G. Xu, R. Shi, E. iChen, Y. Mao and F. Liu, "The smart classroom: Merging technologies for seamless tele-education," *IEEE Pervasive Computing ,* pp. 47-55, 2003.

[31] D. Franklin, "Cooperating with people: The intelligent classroom," *Proceedings of the National Conference on Artificial Intelligence,* pp. 555-560, 1998.

[32] Y. Chang, S. Chen and T. Li, "A Computer System Aiming to Stimulate Creativity for Narrative," *Proceedings in Creativity and Cognition ,* 2011.

[33] S. Benford and (Eds), "Designing Storytelling Technologies to Encourage Collaboration Between Young Children," *Proceedings of CHI2000,* 2000.