Entertainment Computing 1 (2010) 125–137

Contents lists available at ScienceDirect

Entertainment Computing

journal homepage: ees.elsevier.com/entcom

How to behave as Alice in Wonderland–about boredom and curiosity

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ARTICLE INFO

Article history:
Received 31 July 2010
Accepted 6 September 2010

Keywords:
Affective computing
Boredom
Cultural computing
Curiosity
Emotion
Exploration
Mixed reality
Persuasion
Un-consciousness
User experience

ABSTRACT

In the context of cultural computing, we created a mixed reality environment that influences user affect and evokes predefined user behaviour. The theoretical challenge is applying persuasive design to virtual and augmented reality. Based on begin of the story 'Alice's in adventures in Wonderland' users play the role of the character Alice in a park scene (the first stage out of a total of six). The mixed reality environment ALICE is designed for users to experience the same sequence of emotional and behavioural states as Alice did in her quest through surreal locations and events. This particular study addresses the sequential arousal and interdependencies of two drives: boredom and curiosity. Based on literature, we introduce general design guidelines for arousing boredom and explain how boredom can result in curiosity. We report on the design and redesign of the park environment with the entrance to the rabbit hole. In an experiment effectively arousing boredom can be demonstrated. Based on the experimental results we redesigned the park environment. In a second experiment effectively arousing curiosity was shown so that the particular sequence of events (e.g. appearance of the 'White rabbit' robot) had a significant positive influence on the arousal of curiosity and on triggering and guiding intended user behaviour.

1. Introduction

Based on advanced entertainment technology a new paradigm for Human Computer Interaction (HCI) is emerging [48]: Cultural computing [56,75]. The term 'cultural computing' was coined by Naoko Tosa [73,77]. This new paradigm finds its roots in a combination of entertainment and Kansei mediation, a rich multimedia framework for both conscious and unconscious communication through emotions [48,71,72], moods, feelings, perceptions and experiences [65]. Cultural computing acknowledges the values and attributes of a cultural region [55] and uses these in interactive systems the user can engage with [76]. This is done in such a way that the experience through the interaction touches on unconscious core aspects of his/her own culture [56,58,59,74]. It is a design challenge that focuses primarily on a new kind of unconscious user experience as a possible mean for social transformation [61,63]. Through designing specifically for such kind of user experiences, cultural computing stimulates amongst others behavioural changes and self reflection by means of entertainment technology in a broad sense [47]. This article focuses in particular on the design of a part of the mixed reality installation, called ALICE [3]. We call this type of interactive installation 'mixed 'reality' [45] because this ALICE installation covers the whole virtuality continuum from augmented reality to augmented virtuality; for more technical details see somewhere else [7,29]. The main research challenge for this kind of mixed reality installations is the design of an environment that elicits, triggers and guides certain user behaviour based on a given narrative [17]. In our case this narrative was chosen from the book 'Alice's adventures in Wonderland' [16] because this narrative survived already for a long time and is still actual [15]. The selected parts of this narrative are recreated in six interactive stages, together forming our mixed reality environment ALICE.

In the first stage boredom and curiosity function as drives for mental and physical exploration, luring the character 'Alice' from a park environment into the rabbit hole (this article). In the second stage Alice falls down the rabbit hole. This fall seems so slow that Alice engages in a conversation with herself, disputing the relationship of herself within the space of earth. This stage questions the Western interpretation of time and space as fixed linear concepts [25], and the experience of microgravity for spatial perception [67]. In the third stage, Alice physically grows and shrinks as a result of eating a cake and drinking from a bottle located in a room she finds herself in. This stage questions the concept of environmental space and body size. After shrinking to the size of grass, Alice swims through her own pool of tears (stage four). During

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1875-9521/$ - see front matter
doi:10.1016/j.entcom.2010.09.003

her swim, she talks to a mouse that swims with her. This experience represents genesis and evolution. In the fifth stage, Alice discusses her own identity with a caterpillar [38]. The emotions and events in the previous stages brought Alice into a state of confusion and made her question reality [13], becoming open for persuasion [24]. The caterpillar challenges Alice to reflect on her self-concept, which is essential for transformation [11,19]. Finally, in the sixth stage Alice talks to the Cheshire cat about logical reasoning. For a more detailed explanation about the reasons for choosing this particular narrative with these six stages and for getting a more detailed overview over the whole installation we have to refer to already published articles about this project [7,29,56].

This kind of mixed reality installation can be related to the perspective of persuasive technology as introduced by Fogg [24] because we want to elicit and guide predetermined user behaviour through adequately designed affordances [68]. Fogg coined the term 'captology' as an overlapping area between persuasion and computing technology, affecting user intention and behaviour. He differentiates between two levels of persuasion. The first is "the overall persuasive intent of a product" on a macro-level. The second involves parts of these products such as dialogue boxes that "incorporate smaller persuasive elements to achieve a different overall goal" on a micro level (pp. 17f). The persuasion all happens on a conscious level, at least Fogg does not mention the aspect of sub- or un-consciousness. Cultural computing broadens the perspective of persuasive technology by not only addressing user intention and behaviour, but also emotions and cultural values [75]. Cultural computing does not only address the established conscious communication, but works also specifically through the sub- and unconscious [48,60,61].

In sociology, Johnson [36] identifies the micro (individual actions or interactional systems), meso (organizational systems) and macro-level (societal systems). When drawing the analogy between persuasive technology and sociology, a similar structure can be identified. The micro level would then remain on the level of interactional systems such as dialogue boxes, tangible interaction objects or other human-system interaction elements. This level influences single actions. The meso level would incorporate Fogg's macro-level of products, as a set of interactional aspects forming organizational systems. As such, the meso level affects user behaviour and intentions as outlined by Fogg. The macro-level is then the societal systems level in the form of cultural computing, addressing cultural values and affecting among others the self-concept. This macro-level analogy is also supported by a description of modern societies "characterized by increasing levels of reflexivity or self-reflection and the development of procedures for deliberate implementation of change" ([36] p. 489). In the context of his article cultural computing can thus be seen as a macro-level implementation of persuasive technology for mixed reality environments.

This article focuses entirely on the first stage in which Alice is lured into the rabbit hole after a sequence of events and emotional states. According to the narrative at first Alice was sitting in the park and felt very tired of having nothing to do, thus s/he was bored. After the White Rabbit ran by her with his unusual appearance and in a hurry to get somewhere, Alice was 'burning with curiosity' and ran after the rabbit [16]. Both boredom and curiosity are powerful drives, not only in Western society, and the focus of our research is to offer the user a chance to experience and engage in the same sequence of emotional states as Alice. We explore how behavioural aspects can influence user affect and decision making. We design for experience, to guide user behaviour by arousing a specific emotion whilst trying to avoid explicit instructions, signs or orders whenever possible. In this project we follow the general design approach of triangulation: a mix of different research and design activities [57]; a particular application of this approach – although in a quite different domain – is provided elsewhere [2]. This article reports on the optimisation and [re]design of part of a mixed reality installation based on literature research and two empirical studies addressing boredom and curiosity.

2. Boredom and curiosity

2.1. Emotions

First, we will explain the nature of emotions [33], and in particular boredom and curiosity [9]. From a broad perspective, emotions can be classified as an affective state together with moods, sentiments and personality traits [23,26]. It seems widely accepted that humans use emotions to guide reasoning and decision making [46]; one can consider for instance intuition and gut feeling [62]. But the influence of emotions goes beyond intuition [12,51]. Literature reports interplay between emotions, memory, rational thinking, decision-making and behaviour [18,20,31,32,40,66]. Within this perspective we try to trigger user behaviour through inducing user affect [50].

2.1.1. Boredom

To begin with, we would like to clarify a common misconception: boredom is *not* characterised by a state of low arousal like sleepiness. On the contrary, a bored human being is agitated and restless; she can even be emotionally upset. Berlyne [8] discusses the causes of boredom and states that a lack of arousal potential (sensory deprivation) or predictable signals (monotony) both lead to boredom. So monotony can lead to boredom, however Ulich [78] rightfully points out that monotony and boredom are not the same. Monotony, he argues, is the result of always doing the same things, whereas boredom is a result from not having enough possibilities to be active. Rauterberg [54] is fully in line with Berlyne and Ulich by adding that monotony is a result of a learning process that turns repeated activities into automated processes, thereby decreasing the possibilities to be active given a fixed environmental complexity. Glicksohn [27] and Rauterberg [54] found that an overload of stimuli can actually have similar effects as sensory deprivation.

Berlyne [8] identified several variables that can affect arousal and thus have to be reckoned with in order to arouse boredom. Firstly, he points out the *intensive variables*, which define the intensity of a stimulus (e.g. size, chromatic colours and high-pitched sounds). Secondly the *affective variables*, or emotional stimuli: human beings tend to search for emotional experiences and excitement. Thirdly, he categorized stimuli that are for instance surprising, incongruous, strange or complex as the *collative variables.*

Another area regarding boredom is the phenomenon of waiting. Waiting mainly results in uncertainty and anger and the experience of the wait is influenced by its commonness, duration, degree of occupied time and the users' expectation [43,70]. And finally, "[boredom] comes about whenever, from the relative emptiness of content of a tract of time, we grow attentive to the passage of the time itself" ([34] p. 626). The development and validation of a measuring scale for boredom resulted in four factors ([53]): (1) lack of meaningful involvement, (2) lack of mental involvement, (3) lack of physical involvement, and (4) slowness of time.

2.1.2. Curiosity

Curiosity is a state in which one's interest is heightened, leading to exploration; a vital motivation in learning and knowledge gathering. Berlyne [9] differentiates between two types of state curiosity. The first is *epistemic curiosity* and is a result of intellectual uncertainty, it drives people to *specific exploration* (e.g. to acquire knowledge by asking questions). *Perceptual* curiosity on the other hand, is aroused by new or unusual stimuli, motivating *diversive exploration* (e.g. attentive listening) [30]. To arouse one's curiosity an increase in arousal is desired, compared to one's general state of arousal. Remember that boredom too, works through a state of high arousal and can thus induce perceptual (or *diversive*) curiosity [21]. As for epistemic (i.e. specific) curiosity, Berlyne found that the collative variables (incongruity, surprise, complexity, novelty, and so on) arouse curiosity, while the amount and intensity of the arousal potential influence curiosity according the Wundt curve.

2.2. Design guidelines for arousing boredom and curiosity

Based on the results of our literature search, we introduce the following design guidelines (DG*x*) for arousing boredom:

- DG1: Induce sensory deprivation by reducing external stimuli to a minimum.
- DG2: Create monotony, by using highly predictive repetitive stimuli.
- DG3: Prevent drowsiness by using stimuli with high intensity.
- DG4: Do not satisfy the need for excitement; rather use the user's expectation to create an anti-climax.
- DG5: Avoid any novelties, changes and surprises; everything should seem in place and make sense.
- DG6: Do not mention a wait on forehand, nor explain the length and reason of it.
- DG7: Emphasize the passage of time during a wait.

All guidelines can positively influence the arousal of boredom, but some cannot coexist together. One purpose of this research is to identify the best method (i.e. combination of design guidelines) for inducing boredom. Guidelines DG1 'sensory deprivation' and DG3 'prevent drowsiness' are contradictory for instance. Guideline DG1 'sensory deprivation' might lead to boredom but has the risk of resulting in drowsiness instead. Guideline DG3 'prevent drowsiness' on the other hand, is likely to prevent drowsiness by applying high intensity stimuli but might not arouse boredom. When DG3 'prevent drowsiness' is combined with DG2 'create monotony' for instance (a set of two guidelines that does not contradict each other), the induced monotony could lead to boredom and still prevent the arousal of drowsiness. In the first experiment described below, several combinations of guidelines are tested. The guidelines for arousing diversive curiosity are the very same guidelines that induce boredom, since boredom eventually leads to curiosity. Specific curiosity on the other hand, is triggered by elements that oppose to these 'boredom' guidelines:

- *DG8:* Use novelties, changes and surprises; the use of incongruous and complex elements should make things seem out of place (*collative variables*)

When aiming to bring people in the highest state of curiosity, the use of these collative variables from DG8 'surprise' should be timed at the peak of the diversive curiosity that results from DG1 'sensory deprivation' to DG7 'passage of time', increasing this state with specific curiosity. The schematic overview of Arnone and Small [5] visualises how both diversive (or perceptual) and specific (or epistemic) curiosity are aroused and related to each other: (1) trait curiosity is a pre-deposition for specific and diversive curiosity, and (2) specific curiosity is the reaction to a particular stimulus coming from state curiosity, and (3) diversive curiosity is the reaction to boredom coming from state curiosity (see Fig. 1).

3. Design

3.1. Objective

The objective is to design a setting of affordances in which interactive (reactive and dependant on user behaviour) and behavioural (independent and autonomous) aspects of this setting induce predefined user affect to induce the intended behaviour. More specifically, we aimed for the following scenario:

After the user entered the park environment (stage-1) unaccompanied, either the absence or predictability of incoming stimuli results in boredom. As a result, diversive curiosity is aroused. At that time, an extraordinary White Rabbit enters the scene, triggering specific curiosity as well. Before the user gets the chance to take a good look at the rabbit, the rabbit quickly proceeds to the rabbit hole. The user is left with unanswered questions and unsatisfied curiosity, evoking exploratory behaviour. Therefore s/he is ready and willing to follow the rabbit into the rabbit hole finding an empty chair-lift awaiting him/her. After taking place, this chair-lift will take him/her down the rabbit hole to the next stage in the underworld.

3.2. Design of the park environment

Stage 1 is a simulated 12 m (long) by 5 m (wide) by 3 m (height) 'park environment' with artificial grass and a 360 degree surround canvas print, illuminated from the back. The 360 degree surround picture of this park was taken at a possible original place near

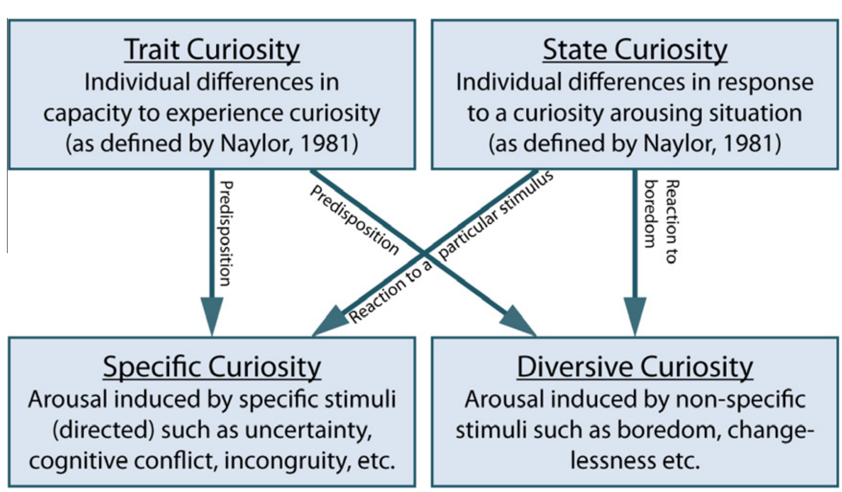

Fig. 1. Multifaceted nature of curiosity (with permission taken from [5]).

Oxford, UK. A tree trunk with a computer on top is set up for data input by the test subjects. Located in the back is a small entrance to a rabbit hole made of paper-maché (see Fig. 7 right). Inside the entrance is an electronic chair, a chair-lift running on a monorail to take the user on a journey down the rabbit hole (stage 2). For security reasons an automatic triggered gate separates the entrance from the 4 m (deep) hole. To sit down in this chair will be the end goal of the experience in the park environment (stage-1).

Boredom is triggered through giving the user instructions, based on the guidelines for arousing boredom. Since boredom results in diversive curiosity, the latter is aroused after some time. To arouse specific curiosity as well, we designed 'The White Rabbit' according to the collative properties (incongruity, surprise, complexity, novelty, and so on): neither a rabbit nor a talking person will surprise anyone. But combine the two and you get a strange and novel situation provoking a cognitive conflict, Alice's drive to follow the White Rabbit into the rabbit hole.

This White Rabbit is made of carbon fibre in combination with an epoxy paste, the strong but lightweight shell is painted white and assembled on top of a radio-controlled vehicle platform (see Fig. 2; we used the Wheely King 4x4 toy by HPI Racing). The rabbit's head is connected to the body via a rigid spring, causing the head to shake a little if an abrupt movement occurs. The pink-eyed rabbit wears a jacket with a collar and a scarf and holds a golden pocket watch in his paw. The rabbit is equipped with a hidden walkie-talkie connected to a small battery-powered speaker, enabling him to 'talk' to the environment. The look of a rabbit combined with human attributes and items, makes the White Rabbit a surprising and incongruent manifestation. The design of the setting is tested first in an empirical study on inducing and arousing boredom.

4. Experiment-I: boredom

4.1. Research questions

The scope of this experiment is to identify the best method for inducing and arousing boredom in the context of our 'park environment' (stage-1). Therefore we had the following two research questions:

Question 1: What is the most effective method for triggering boredom?

Fig. 2. The 'White Rabbit' robot in the park environment surrounded by a 360 degree canvas print of a real park scene nearby Oxford (UK) with backlighting.

Question 2: What is the required time to get someone in the state of boredom?

4.2. Test design and sample

The first independent variable (factor 'arousal method') exists of four test conditions for arousing boredom, based upon the design guidelines DGx described above:

- Method 1. *Highly repetitive stimuli* (DG2, DG4, DG6). Monotone and predictive stimuli combined with not satisfying the need for excitement and not mentioning the length of the wait. To achieve this, a short and monotone monologue on the importance of healthy food is played. This monologue was taken from a spoken book sample on the internet. This recording is repeated over and over again via hidden surround loudspeakers.
- Method 2. *Awareness of time passing* (DG2, DG3, DG4, DG6, DG7). Monotone and predictive stimuli combined with high intensity stimuli to prevent drowsiness. Need for excitement is not satisfied by the stimuli. The length of the wait is not mentioned on forehand, it is even emphasized by raising attention to the passage of time. To do so, a clock is displayed on the computer screen, accompanied by a loud and high pitched ticking. This should make the user aware of the elapsing time; counting seconds, minutes, and so on.
- Method 3. *Absence of arousal stimuli* (DG1, DG4, DG6). Arousal stimuli are decreased to a minimum. Placed in darkness, test participants are neither able to see the rich visual environment nor the rabbit hole. The need for excitement is not satisfied, nor is the length of the wait mentioned on forehand.
- Method 4. *Control group* (DG4, DG5, DG6). Participants are placed in the illuminated stage, nothing is added or adjusted, nothing happens over time. Thereby the need for excitement is not satisfied and the length of the wait is not mentioned.

The second independent variable (factor 'duration') is the influence of time on boredom arousal. We measured this by placing the participants in the park environment that was adapted to one of the aforementioned arousal methods for a predefined period of 10, 20 or 30 min. Since there was no pre-knowledge on the desired length of the wait for arousing boredom, these values were taken by common sense reasoning. Participants could only participate once (a between subject test design), because the wait duration should not be expected.

The third independent variable (factor 'before–after') is a within subject variable that determines measurements *before* and *after* each test condition. Dependant attitude measures were gathered with a questionnaire before and after the experiment, by means of eight variables (see next section). This led to a three ('duration') by four ('arousal method') by two ('before–after') factorial between and within-subject test design.

The study population consisted of 24 participants selected with a stratified random selection method out of a pool of students. Participants with prior knowledge of the ALICE project were omitted from the sample. Two tests were interrupted due to safety reasons, because the test subjects attempted to climb over the security gate inside the entrance to the rabbit hole. These data were omitted from the analysis. This lead to a sample of 22 participants between the age of 17 and 26 years old, of which 14 males and 8 females, all either college or university students. Gender and age were randomly divided over the groups.

4.3. Measurement and apparatus

The emotional state of participants was measured by applying two questionnaires [44]. The 'List of Adjectives' (LoA) [35], measuring seven selected affective states related to boredom: activeness, inactiveness (or lifelessness), extroversion, introversion, cheerfulness, agitation and dreaminess. Since the LoA is a German questionnaire and not all participants speak fluent German, the items were translated to Dutch by a Dutch German teacher [1] (see Appendix A for the items and the translations). The LoA is designed for the use in experiments with multiple measurements, specifically when the measurements are repeated in less than two hours time. It consists of 15 categories, or emotional states, each containing 4–16 synonym adjectives describing these emotional states. Participants have to answer in forced choice 'applicable' or 'not applicable' to all adjectives; thereby grading the experienced level of each separate emotional state. Measured levels of these states can be interpreted as an indication of the level of boredom.

The second questionnaire, the Melbourne Curiosity Inventory (MCI, [49], specifically measures 'state curiosity'. The MCI is test of 20 items each a 4-point Likert scale containing questions on epistemic (specific) and perceptual (diversive) state curiosity. The MCI also includes a trait curiosity test, which is omitted from this experiment since we are only interested in a change in state curiosity. In a critical review [10] curiosity tests including the MCI are considered to be limited and narrow, mainly due to the lack of measurements of other, possibly correlated states. To address and overcome this problem we use additionally the LoA questionnaire. Boyle does also consider the MCI to be the main curiosity test together with the State-Trait Curiosity Inventory [69]. The MCI is an English questionnaire and since the population exists of students who all speak fluent English, there was no need to translate these questions to Dutch. However, a Dutch translation of less common words and expressions was visible in a table next to the questions.

To monitor user behaviour and [non-]verbal reactions, video and audio recordings were made. Three aspects were monitored in particular: the time before the test subject (a) start to walk around, (b) enter the entrance to the rabbit hole, and/or (c) walk out of the park scene to contact the experimenter (i.e. 'to give up and stop the experiment'). In addition, a step counter was attached to the test subject's belt as an indicator of physical exploration over the entire test. Also, video recordings have been analysed to count the amount of steps per minute.

4.4. Procedure

Test subjects ($N = 24$; 2 drop outs resulted in $N = 22$) entered the stage individually through the entrance door of the whole test environment; via written instructions they were asked to switch off their mobile phone and to follow the instructions on the computer screen later on. The experimental setup includes the 'park environment', the entrance to the rabbit hole and a tree trunk; the ceiling monitoring camera is in the middle and the observation room is hidden from the test subjects' view by additional curtains (see Fig. 3). Video recordings were made, and the test subjects were free to leave the 'park environment' at any time if they wanted to. There was no indication of how much time the experiment would take. But if a test subject asked, the experimenter would mention an indication of approximately 30 min. Test subjects were not aware of the whereabouts of the experimenter or the rabbit robot.

The experiments lasted for exactly 10, 20 or 30 min for each of the four test conditions (i.e. methods to arouse boredom); before and after each session the questionnaires were acquired from the test subjects. During the experiment and depending on the arousal method, the computer display would either go black or display an analogue clock and the audio output ('tick tick') was automatically enabled. The test subject was unable to control the computer since this functionality was disabled by disconnecting the USB cable of the keyboard and mouse from backstage.

During the experiment, all remarks and questions directed towards the experimenter were recorded but neglected. In case test subjects would walk out of the stage and try to contact the experimenter, they were told "Everything that happens is supposed to happen the way it does, so please go back to the park environment." In the analysis a distinction was made between participants walking out believing something was not working correctly (e.g. because the computer screen went black and keyboard controls were disabled), and participants walking out because they wanted to give up.

4.5. Results

The binary (0, 1) answers per LoA item were summed up per scale and divided by the number of items belonging to the scale, resulting in a value between 0 and 1 for every measured affective state. The MCI exists of twenty 4 point Likert scale items. The item values ranging from 0 to 3 were summed up and divided by the highest possible total value, thereby converting curiosity to a value between 0 and 1 as well. The 0.01 and 0.05 confidence levels were used as alpha-error significances.

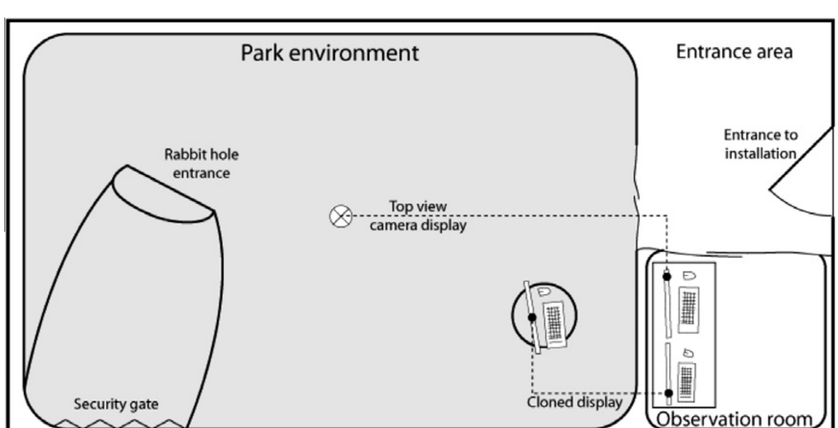

Fig. 3. Boredom experimental setup as schematic top down view (floor plan of stage-1).

Overall, *user affect* (difference before–after) increased significantly for *inactiveness* with +0.147, $F(1,10) = 9.216$, $p < 0.05$ (before: MEAN = 0.185, SD = 0.212; after: MEAN = 0.321, SD = 0.247; $N = 22$). *Extroversion* decreased significantly with −0.214, $F(1,10) = 7013$, $p < 0.05$ (before: MEAN = 0.630, SD = 0.326; after: MEAN = 0.435, SD = 0.294; $N = 22$). *Introversion* increased significantly with +0.151, $F(1,10) = 10.182$, $p < 0.01$ (before: MEAN = 0.301, SD = 0.258; after: MEAN = 0.460, SD = 0.216; $N = 22$). And *cheerfulness* decreased significantly with −0.269, $F(1,10) = 12.906$, $p < .01$ (before: MEAN = 0.645, SD = 0.303; after: MEAN = 0.384, SD = 0.340; $N = 22$) (see Table 1 and Fig. 4). In a short informal interview afterwards, test subjects generally reported to feel bored and occasionally disappointed that nothing had happened, in contradiction to their expectations.

With regard to the four arousal methods, no significant difference in the change of user affect was found (see Fig. 5). The 'duration of the wait' had an significant effect on *activeness* ($p < 0.05$) with an increase of +0.159 for the 10 min wait (before: MEAN = 0.523, SD = 0.353; after: MEAN = 0.682, SD = 0.322), a decrease of -0.398 for the 20 min wait (before: MEAN = 0.602, SD = 0.266; after: MEAN = 0.205, SD = 0.180), and a decrease of −0.182 for the 30 min wait (before: MEAN = 0.568, SD = 0.297; after: MEAN = 0.386, SD = 0.342) (see Fig. 5 left). The *duration* also had a significant effect on *inactiveness* ($p < 0.05$) with a decrease of −0.087 for the 10 min wait (before: MEAN = 0.327, SD = 0.256; after: MEAN = 0.240, SD = 0.231), an increase of +0.327 for the 20 min wait (before: MEAN = 0.067, SD = 0.087; after:+0.394, SD = 0.241), and an increase of +0.202 for the 30 min wait (before: MEAN = 0.144, SD = 0.175; after: MEAN = 0.346, SD = 0.286) (see Fig. 5 right).

The total amount of steps shows no correlation with a change in *user affect*. It proved to be a poor indicator of exploration, since one can also explore in other ways that are not expressed in steps (e.g. mental exploration Rauterberg [54] or crouching in the rabbit hole, etc.). As for the time measurements, i.e. 'starting to walk around' ($N = 22$, MEAN = 162s, SD = 206s), 'entering the rabbit hole' ($N = 16$, MEAN = 213s, SD = 245s), and 'walking out of the park environment to contact the experimenter' (i.e. 'close to giving up') ($N = 7$, MEAN = 605s, SD = 263s) (see Fig. 6); none showed a significant correlation with a change in *user affect*.

4.6. Discussion of experiment-I

Overall, a significant rise of inactiveness and introversion is observed, accompanied by a decrease of extroversion and cheerfulness. Additionally, most participants reported to feel bored of having nothing to do. These are clear indications that boredom was triggered. Based on the literature we expected a rise in curiosity when boredom was induced. However this rise did not occur, or at least could not be measured. We attribute this to the already high curiosity value measured before and at begin of the experiment (0.733 out of a maximum of 1.000). This initial value is most likely such high as a result of (a) curiosity due to high expectations about the type of experiment in general, and (b) filling in the questionnaires in the visually stimulating park environment. The only significant difference between the *durations* is found in *activity* and *inactivity* measures.

The outcome of our first experiment shows that the largest difference is between the 10 and 20 min wait. When comparing the overall change in user affect with the lack of differences between the durations, we conclude that introversion, extroversion and cheerfulness were already affected to the maximum before the 10 min interval. This is also supported by the average time before test subjects walked out (approx. 10 min, see Fig. 6), which is a last

Table 1
MANOVA of the boredom experiment-I with LoA and MCI scales as dependent variables and 'before – after', 'arousal method' and 'duration' as independent variables ($N = 22$) [* significant at the .05 level; ** significant at the .01 level].

Source	Scale	Type III Sum of Squares	df	Mean Square	F	Sig.	
Before–after	Activeness (LoA)	.202	1	.202	3.747	.082	
	Inactiveness (LoA)	.224	1	.224	9.216	.013	*
	Extroversion (LoA)	.472	1	.472	7.013	.024	*
	Introversion (LoA)	.235	1	.235	10.182	.010	**
	Cheerfulness (LoA)	.744	1	.744	12.906	.005	**
	Agitation (LoA)	.001	1	.001	0.027	.872	
	Dreaminess (LoA)	.060	1	.060	1.041	.332	
	Curiosity (MCI)	.000	1	.000	0.003	.954	
Before–after * arousal method	Activeness (LoA)	.079	3	.026	0.491	.696	
	Inactiveness (LoA)	.122	3	.041	1.675	.235	
	Extroversion (LoA)	.084	3	.028	0.415	.746	
	Introversion (LoA)	.032	3	.011	0.461	.715	
	Cheerfulness (LoA)	.065	3	.022	0.376	.773	
	Agitation (LoA)	.038	3	.013	0.478	.705	
	Dreaminess (LoA)	.101	3	.034	0.585	.638	
	Curiosity (MCI)	.980	3	.327	2.802	.095	
Before–after * duration	Activeness (LoA)	.628	2	.314	5.822	.021	*
	Inactiveness (LoA)	.355	2	.178	7.322	.011	*
	Extroversion (LoA)	.007	2	.004	0.053	.948	
	Introversion (LoA)	.080	2	.040	1.737	.225	
	Cheerfulness (LoA)	.149	2	.075	1.293	.317	
	Agitation (LoA)	.019	2	.009	0.357	.709	
	Dreaminess (LoA)	.077	2	.039	0.670	.533	
	Curiosity (MCI)	.205	2	.102	0.878	.445	
Before–after * arousal method * duration	Activeness (LoA)	.194	6	.032	0.598	.727	
	Inactiveness (LoA)	.123	6	.020	0.843	.564	
	Extroversion (LoA)	.246	6	.041	0.610	.719	
	Introversion (LoA)	.401	6	.067	2.899	.066	
	Cheerfulness (LoA)	.242	6	.040	0.700	.657	
	Agitation (LoA)	.197	6	.033	1.248	.360	
	Dreaminess (LoA)	.161	6	.027	0.465	.820	
	Curiosity (MCI)	.592	6	.011	0.847	.563	

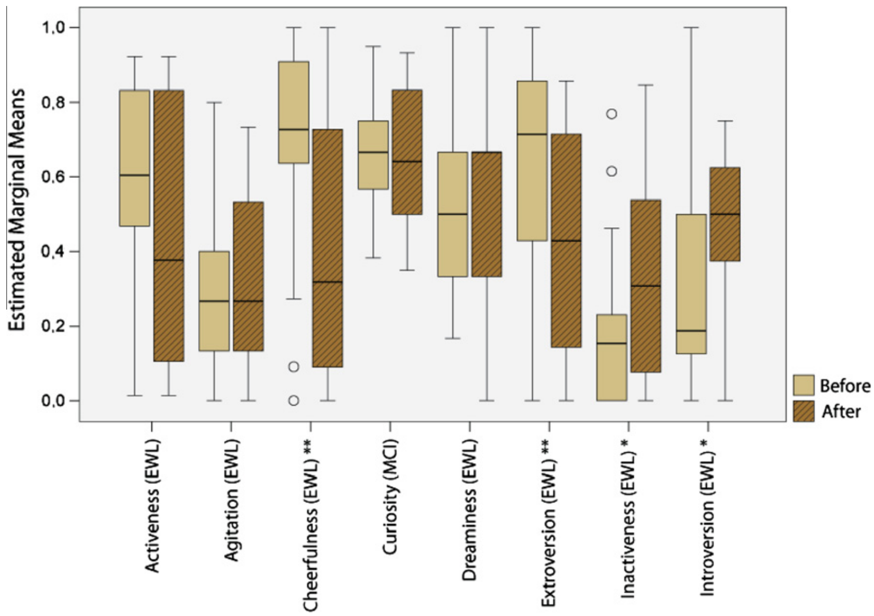

Fig. 4. Boxplot of overall changes of user affect in the boredom experiment-I measured with LoA (=EWL) and MCI questionnaires [* = significant at .05 level; ** = significant at .01 level].

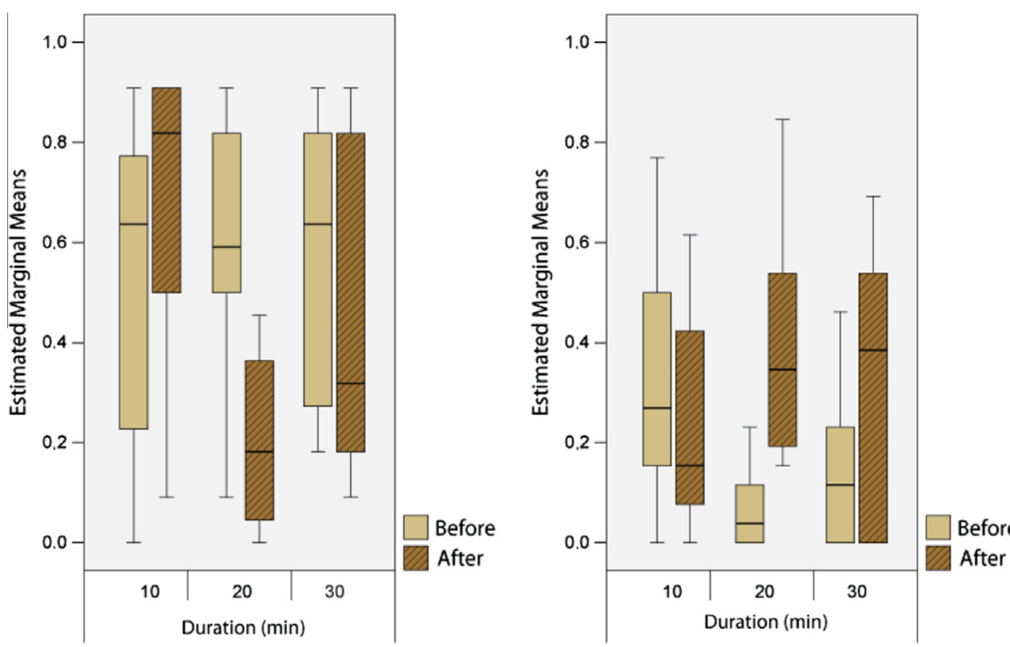

Fig. 5. Boxplot of *activeness* of the boredom experiment-I depending on duration of wait (left); boxplot of *inactiveness* depending on duration of wait (right).

resort for participants who feel bored and restless. In other words: user affect seems already be influenced to the maximum possible value of this situation during the first 10-min interval.

The lack of differences measured between the arousal methods can have several reasons. To begin with, the number of participants (4×6 subjects per condition = 24 test subjects in total) could be too small to measure the effect (insufficient test power). Secondly, the difference in effects of the arousal methods could not differ much, indicating all approaches are evenly effective. Or finally, a possible influence of the wait duration could mask differences between the conditions.

The fact that even the control group showed no difference might be due to the fact that even this group complied with two of the guidelines for arousing boredom. It is likely that significant differences would have been observed if the control group would have been given a task to occupy the waiting time. All aspects considered, the required time to get someone in the park environment in the state of boredom is likely to equal less than or around 10 min. Although a shorter time period might also be effective, our results show that a maximum of 10-min wait had the desired effect.

As for exploratory behaviour, the results were quite unexpected. For instance one participant attempted to climb over the security gate and down a pitch dark rabbit hole after 9 min whereas another test subject simply laid down on the grass. This indicated that participants undertake a wide range of unpredict-

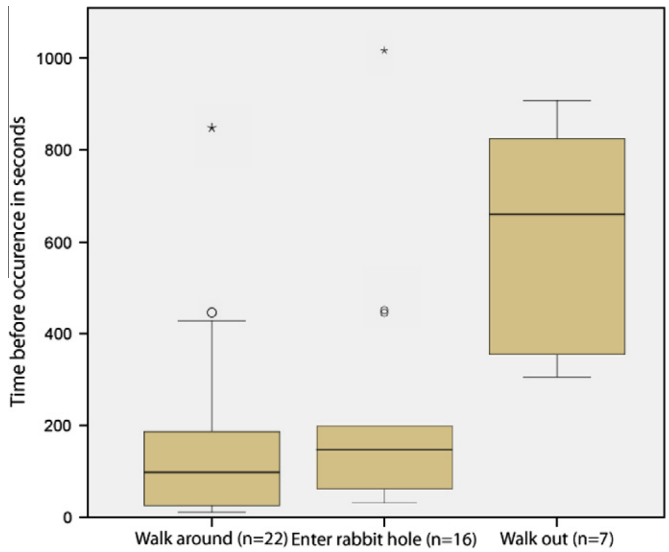

Fig. 6. Boxplot of *time measurement of noteworthy aspects* related to test subjects' physical exploration of the test environment.

able activities as a result of waiting. To limit this variety, either the possibilities would have to be limited physically or participants would have to be kept busy with a sufficiently boring repetitive task rather than a behaviourally unconstrained passive wait.

5. Redesign of stage 1

Based on the discussion of the results and outcomes of experiment-I, we redesigned the stage so that boredom could be aroused in a better way and participants would be prepared for the experience of being 'lured' into the rabbit hole by the White Rabbit.

The first modification was limiting unpredictable exploratory behaviour of participants by giving them a simple repetitive and occupying task. This would restrict them from satisfying their need for new incoming stimuli ahead of time (i.e. explore the environment before the White Rabbit enters the stage). "Boredom was accomplished by having the subjects perform monotonous tasks for an extended period of time" ([79]). We discussed to take simple math exercises, adding and subtracting random numbers between 1 and 10. This task would occupy the participants while it was still predictable enough to arouse boredom and evoke a need for new stimuli. The exercises were given via the computer for duration of 10 min. However, additional pilot tests showed that some participants presumed to be participating in a concentration exercise and therefore tried not to be distracted by the White Rabbit. Moreover, some test subjects tried to do it as fast as possible, which did not quite contribute to the increase of boredom. Consequently, the occupying task was changed: participants were supplied with a big pile of paper and via the computer they were instructed to fold sheets of paper one by one and then put them in an empty box. The futility of their effort was emphasized by stating that neither the amount of folded sheets, nor the method or duration of folding would be measured.

The second major modification was in the form of a curtain in the middle of the park environment that split the whole park scene of stage-1 into two separate parts, with a small gate (see Fig. 7 left) to the second part with the entrance to the rabbit hole (see Fig. 7 right). This additional gate will be closed by a small additional curtain until the rabbit appears. In the first place, this was done to limit the physical exploration by taking the rabbit hole out of sight. Secondly, this actually more closely resembled the original narrative, in which Alice had to crawl under the hedge to see the rabbit hole.

The third modification was a curtain placed inside the rabbit hole to hide the rabbit after entering this entrance area; this way leaving an illuminated empty chair to be the only item left. Finally, two infrared cameras were added to the stage, to monitor participants who entered the rabbit hole. These cameras were also used to provide visual feedback for the remote control of the 'White Rabbit' robot.

6. Experiment-II: curiosity

6.1. Research questions

This experiment was set up to test whether the design of the park environment and the given task indeed arouses sufficient curiosity and triggers the user to enter the rabbit hole at the desired point in time (see e.g. [4]. Therefore the research questions were formulated as follows:

Question 3: Does the proposed sequence of events significantly arouse state curiosity?

Question 4: Does the proposed sequence of events trigger the desired user behaviour (i.e. to enter the rabbit hole and sit down in the chair after maximal 10 min wait)?

6.2. Test design and sample

The only test condition was the same for all participants and designed to measure the intended behavioural effects. Located in the redesigned park environment (stage-1), we tried to arouse curiosity in two ways. Firstly, boredom was elicited during a maximum of 10-min wait to arouse perceptual (diversive) curiosity. As explained in the previous section, participants were instructed to

Fig. 7. The big curtain in the middle of the park environment with the additional gate to the second part (left); the close-up view on the entrance to the rabbit hole from the additional gate [under the 'hedge'] (right).

perform an obviously futile task of folding paper in an arbitrary manner. Secondly, after the wait the White Rabbit's emergence, appearance and behaviour were aimed to arouse epistemic (specific) curiosity as well. This is in line with guideline DG8. The test subjects were 5 males and 4 females ($N = 9$; aged 19–52; diverse educational background).

6.3. Measurement and apparatus

The experiment took place in the redesigned stage-1 as described in the previous section (see schematic overview of the setup Fig. 7). Again, the LoA and MCI questionnaires were applied before and after. Also, the time spent before participants entered the entrance of the rabbit hole was measured. Video recordings with all cameras have been made.

6.4. Procedure

Participants were tested one at a time and asked to read a written description similar to the boredom experiment on forehand. After a participant entered the park scene and completed the questionnaire, the paper folding instruction appeared on the computer screen. If the participant would stop folding paper, for instance to go through the curtain gateway in the middle of the park environment (Fig. 7), nothing would change or happen.

After ten minutes the 'White Rabbit' was steered into the stage. The rabbit would then 'run' around, say "Oh my dear, my dear, I shall be late" and disappear in the rabbit hole. If after 30 s the rabbit was not followed by the participant, he would try another run with intensified panicking behaviour. A maximum of three runs concluding with the rabbit literally asking the user to follow him, ensured that the participant would follow the rabbit to its hole (Fig. 8 visualizes the rabbit's behaviour).

After the test subject followed the rabbit into the entrance for the rabbit hole, s/he was expected to sit down in the chair. If s/he did not, s/he was given the time for exploration before the experimenter would politely ask him/her to take a seat via a loudspeaker inside the hidden rabbit. When the test subject sat down in the chair-lift, the experiment was finished and a questionnaire was acquired once again. The best way to measure the emotional states of the test subjects would be to measure at the beginning, before rabbit appears and at the end. To avoid the obtrusive artificial interruption in the middle, we skipped this measuring part, being well aware that this is a trade-off between measurement accuracy and unobtrusiveness to maximise ecological validity of the whole user experience. The test subject's reaction to the appearance of the rabbit was of particular interest to us. If the test subject had entered the entrance of the rabbit hole before the 'White Rabbit' appeared, the same procedure was followed. Test subjects prematurely suspending the paper folding task have therefore never seen the 'White Rabbit'.

6.5. Results

The test subjects entering the rabbit hole (RH) were categorized by amount of rabbit appearances (RA). Total number of test subjects (N) decreases when RA increases since the participants who already entered RH never experienced the other RA (see Table 2). Two participants entered RH before the rabbit appeared (RA = 0, $N = 2$), six test subjects entered at the first appearance (RA = 1, $N = 6$), none entered RH after the second appearance (RA = 2, $N = 0$) and the reluctant test subject from the last condition had even to be explicitly asked to follow the rabbit (RA = 3, $N = 1$).

The White Rabbit's luring effect was tested with the odds ratio in a two by two tabular risk estimate. The odds ratio of test subjects entering the rabbit hole for number of rabbit appearances ('no rabbit appearance' – '2 out of 9' / 'at first rabbit appearance' – '6 out of 7') is .048 (or 1:21) with a 95% confidence interval from .003 to .665 (see Table 2). This indicates a significant influence of the rabbit appearance on the number of test subjects lured into the rabbit hole. After entering the rabbit hole, 7 out of 9 test subjects took place in the chair lift. The other two test subjects waited in front of the chair, later reporting they were aware they should sit in the chair but were afraid to do so. After the experimenter's verbal request to take place in the chair via the loudspeaker in the rabbit, they both did so after all.

The LoA and MCI questionnaires showed significant results for *activeness*, with an increase of +0.273, $F(1,8) = 8981$, $p < .05$ (before: MEAN = 0.323, SD = 0.371; after: MEAN = 0.597, SD = 0.359; $N = 9$). *Extroversion* decreased with −0.174, $F(1,8) = 14.152$, $p < .01$ (before: MEAN = 0.523, SD = 0.236; after: MEAN = 0.349, SD = 0.216; $N = 9$). *Agitation* increased with +0.178, $F(1,8) = 9.237$, $p < .05$ (before: MEAN = 0.156, SD = 0.172; after: MEAN = 0.333, SD = 0.301; $N = 9$). Finally, *curiosity* increased with +0.141, $F(1,8) = 7.039$,

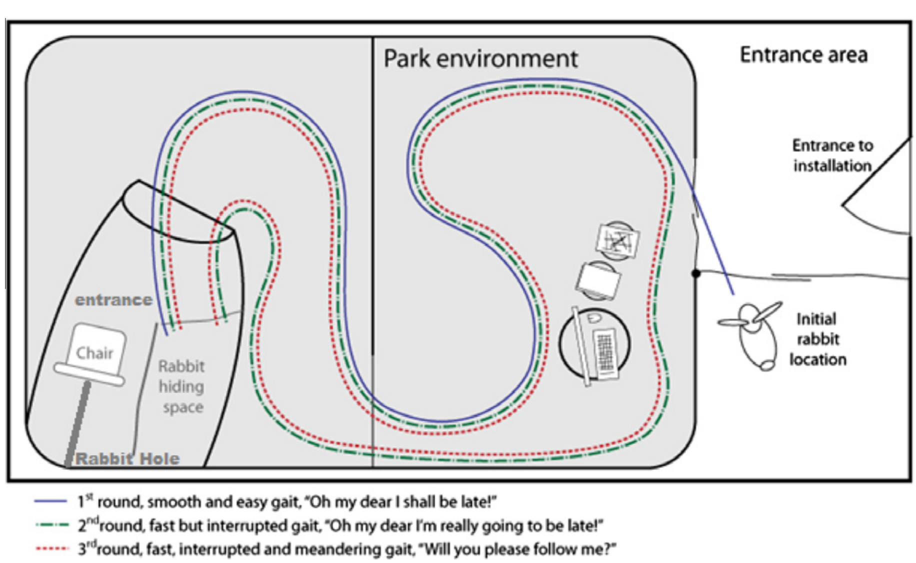

Fig. 8. Incremental behavior of the 'White Rabbit'.

Table 2
Number of test subjects entering the rabbit hole with or even without the appearance of the rabbit.

Number of rabbit appearances to lure subjects into the rabbit hole (RA)	Number of test subjects entering the rabbit hole (RH)	Total number of test subjects in this condition (*N*)
0	2	9
1	6	7
2	0	1
3	1	1

$p = .029$ (before: MEAN = 0.607, SD = 0.141; after: MEAN = 0.748, SD = 0.106; $N = 9$) (see Table 3 and Fig. 9).

7. Discussion of experiment-II

It is hard to measure the level of boredom and its influence on curiosity by means of a questionnaire only acquired afterwards, since the experience of following the rabbit probably accounts for a decrease of boredom during the whole experience. However, the significant rise in agitation points in a direction of boredom, since agitation is also characterized by restlessness. This rise differs from the findings of our boredom experiment-I where no significant change in agitation was measured. Perhaps this difference indicates a powerful influence of the paper folding task on the level of agitation, since this task might not only trigger the feeling that one is wasting his/her time but also his/her energy on such a simple and useless task.

The effect of an extreme arousal level was clearly visible in the case of the female test subject who did not follow the rabbit. As a result of the paper folding task, she reported to feel angry, scared and lonely and not interested in the rabbit and its destination at all. This affective state, also measured in her questionnaire, resulted in not taking place in the chair until she was explicitly asked to do so. This arousal of anxiety is in line with what research already suggested [22]. As for the participants who entered the entrance of the rabbit hole before the rabbit had appeared, their curiosity level had increased quite a lot as a result of boredom. The fact that they abandoned the paper folding task ahead of time could be an indication of high boredom or curiosity proneness, apparently arousing curiosity to the level of neglecting the instructions on the screen. Although they never saw the White Rabbit appearing, their sequence of affective states was actually as intended.

The important results related to the research questions are the fact that the appearance and behaviour of the White Rabbit proved to positively influence the chance of people entering the rabbit hole and the fact that this sequence of events significantly arouses curiosity. We cannot claim that the user's behaviour was indeed (partly) triggered by the heightened curiosity, but research of others shows that this correlation seems likely [5].

Table 3
MANOVA of the boredom experiment with LoA and MCI scales as dependent variables and 'before–after' as independent variable ($N = 9$); [* significant at the .05 level ** significant at the .01 level].

Source	Scale	Type III Sum of Squares	df	Mean Square	F	Sig.	
Before–After	Activeness	.336	1	.336	8.918	.017	*
	Inactiveness	.002	1	.002	.037	.852	
	Extroversion	.137	1	.137	14.152	.006	**
	Introversion	.014	1	.014	.525	.489	
	Cheerfulness	.122	1	.122	2.108	.185	
	Agitation	.142	1	.142	9.237	.016	*
	Dreaminess	.025	1	.025	.705	.425	
	Curiosity	.090	1	.090	7.039	.029	*

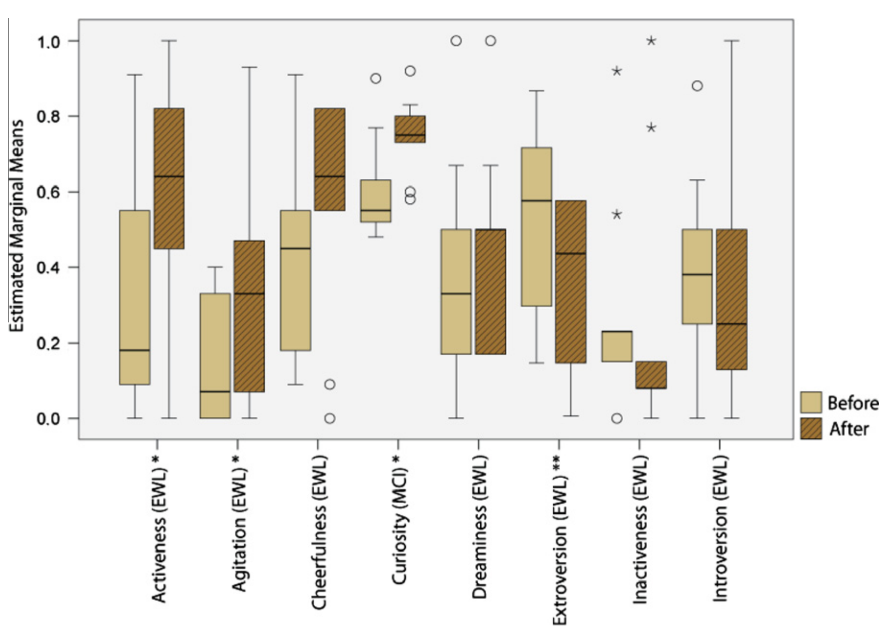

Fig. 9. Change of user affect in the curiosity experiment ($N = 9$).

8. General discussion and conclusions

Boredom and curiosity are important and probably universal drives [8,41]. From the perspective of sociology, we designed a mixed reality environment (stage-1) as part of the ALICE installation that has to induce and arouse boredom and curiosity. We were able to research the interactive and behavioural aspects by using various approaches to design for this experience. This environment was developed through an iterative design process in which the adaptations were based on outcomes of experiments and reflections on experiences. Our investigation seems to be the first study in which boredom is deliberately aroused in order to effectively guide user behaviour. The second experiment shows that the design of the environment accounts for a rise in curiosity and influences user behaviour as intended. Additionally, there are strong indications that this is preceded by a state of boredom. Thereby we showed that designing for experience can affect users and thereby user behaviour. Kashdan and Steger [37] could already provide support for curiosity as an ingredient in the individual development of well-being and meaning of life.

Our guidelines, design decisions and practical experiences can be of use in developing human–computer interactions that reckon with cultural values and affective drives. This study shows how to arouse a mental state in people that drives and guides them in behaviour such as neglecting given tasks, physical exploration and search for knowledge. It can be expected that similar research with more participants would lead to the discovery and exploration of additional, more subtle phenomena. Base on the results of our two empirical studies, the test power given by a group of 10 to 15 participants per test condition should be sufficient for measuring relevant significant differences in user affect. However this still might not lead to noticeable differences between several arousal methods. Future work could include more effective guidance of explorative behaviour through arousing emotions. Also, a detailed study on the effect of individual arousal stimuli (i.e. appearance, behaviour, timing, interaction and so forth) would be helpful. In future such studies we envision the use of continuous emotion recognition methods as described by others [6,14,52] in addition to questionnaires, because this would probably provide more detailed input for specific affordances control. Moreover, this would enable an installation that is able to adjust its actions on the individual user's affective state and personality traits such as boredom and curiosity proneness in real time (see e.g. [39]).

The aim of cultural computing to design for individual and maybe social transformation can evoke questions on the ethics thereof. We cannot deny the increasing influence that technology has on our lives. We have to be aware that everything that we interact with affects our actions, feelings, beliefs and even our identity. The question is how to act upon this growing awareness. [64] discerns three options: (1) ignore it, (2) fight it, or (3) avail ourselves of it. By involving in social and cultural computing research, we chose the latter. Our lives can be enriched by the environment we find ourselves in and by how we interact with it. There are promising advantages of the technological evolution, like how the mobile phone and internet brought people closer together. But there are also dangers, for instance how people can get socially isolated because of this very technology that is intended to bring us closer together [42]. Therefore, we consider it unacceptable to choose for the option to ignore technological advancements. After all, who would want to live in a world where everything is designed to minimize the way it can move, surprise or help people?

Choosing to avail ourselves of it, does not mean that we should rush into designing products that influence us in whatever way we choose. This choice to deliberately design for individual and social transformation, implies that we have to consider by what means we would do this. In our opinion, design for individual and social transformation should be approached with a humble attitude. This attitude should be reflected in the design of intelligent products and environments through inviting behaviours rather than forcing users to behave in that way. This freedom of control implies that products can inspire users to behave in a certain way, but should still allow for other ways of interaction. This way, users can go along with the designers' intention and stand open for transformation, but also have the freedom to choose otherwise. This is the way how we approached the design of the park environment of stage-1 in this project. We subtly guide users in their behaviour and decision making, while respecting the users' freedom of choice by leaving other options open as well. At the end, probably all societies run on two cultural pathways: (1) one emphasizes individuation and independence, preferred in the West; (2) while the other focus on social cohesion based on group membership and interdependence, preferred in the East [28]. To find a sustainable balance between both pathways seems to be a relevant challenge for future research in cultural computing.

Acknowledgements

Our thanks go to the many participants, who were willing to take part in this study. We also like to express our gratitude towards Sjriek Alers, Dima Aliakseyeu, Christoph Seyferth, Dirk van de Mortel, Geert van den Boomen and Arrens van Herwijnen for their cooperation in designing the first stage, and to all other team members who are involved in this project. A full list of team members can be found at http://www.alice.id.tue.nl. We are also very grateful for the sponsorship and support of the Department of Industrial Design and Electrical Engineering of the Eindhoven University of Technology, and the Microsoft Research Laboratory in Cambridge, UK.

Appendix A

Dutch translation of six scales of the LoA questionnaireItems from six scales of the short version of the 'List of Adjectives' (LoA) questionnaire [35], translated to Dutch (English only for categories) [1].

German	Dutch
Aktiviertheit	Actiefheid (activeness)
Tatkräftig	Daadkrachtig
Unermüdlich	Onvermoeibaar
Eifrig	IJverig
Arbeitslustig	Werklustig
Arbeitsam	Werkzaam
Betriebsam	Bedrijvig
Aktiv	Actief
Tüchtig	Bekwaam
Energisch	Energiek
Geschäftig	Nijver
Arbeitsfähig	In staat om te werken
Desaktiviertheit	Energieloosheid (inactiveness)
Nachlässig	Nalatig
Temperamentlos	Temperamentloos
Teilnahmslos	Onverschillig
Energielos	Energieloos
Kraftlos	Krachteloos
Faul	Lui
Träge	Traag

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Appendix A (*continued*)

German	Dutch
Aktiviertheit	Actiefheid (activeness)
Denkfaul	Traagdenkend
Schwerfällig	Sloom
Geistesabwesend	Afwezig
Lahm	Lam
Einschläfernd	In slap vallend
Lasch	Laks
Extravertiertheit	Extrovertheid (extroversion)
Gesprächig	Spraakzaam
Anhänglich	Aanhankelijk
Gesellig	Gezellig
Offen	Open
Zutraulich	Vertrouwelijk
Menschenfreundlich	Menslievend
Kontaktfreudig	Toegankelijk
Introvertiertheit	Introvertheid (introversion)
Einsilbig	Weinig spraakzaam
Ungesellig	Eenzelvig
Einsiedlerisch	Kluizenaarsachtig
Wortkarg	Zwijgzaam
Abgesondert	Afgezonderd
Verschlossen	Gesloten
Abgekapselt	Ingekapseld
Menschenscheu	Mensenschuw
German	Dutch
Gehobene Stimmung	Vrolijkheid (cheerfulness)
Froh	Vrolijk
Glücklich	Gelukkig
Ausgezeichnet	Uitstekend
Angenehm	Aangenaam
Befriedigt	Bevredigd
Heiter	Blijmoedig
Beschwingt	Zwierig
Lustig	Opgewekt
Frohgemut	Welgemoed
Freudig	Blij
Gutgelaunt	Goedgehumeurd
Erregtheit	Agitatie (agitation)
Ruhelos	Rusteloos
Aufgeregt	Zenuwachtig
Zappelig	Woelig
Unausgeglichen	Onevenwichtig
Zerfahren	Verstrooid
Erregt	Opgewonden
Unberechenbar	Onberekenbaar
Rastlos	Onvermoeid
Fahrig	Onevenwichtig
Unstetig	Onrustig
Kribbelig	Kribbig
Reizbar	Prikkelbaar
Durchgedreht	Doorgeslagen
Nervös	Nerveus
Verkrampft	Verkrampt
Verträumtheit	Dromerig (dreaminess)
Tiefsinnig	Diepzinnig
Gedankenvoll	In gedachten verzonken

Appendix A (*continued*)

German	Dutch
Aktiviertheit	Actiefheid (activeness)
Gedankenverloren	Peinzend
Besinnlich	Nadenkend
Verträumt	Dromerig
Träumerisch	Mijmerend

References

[1] J. Aart van, *Escaping reality - The creation of an affective experience.* Unpublished Semester report, Department of Industrial Design, Eindhoven University of Technology, Eindhoven, 2008.

[2] D. Abrazhevich, P. Markopoulos, M. Rauterberg, Designing internet-based payment systems-guidelines and empirical basis, Human Computer Interaction 24 (4) (2009) 408–443.

[3] ALICE, Project ALICE: not just another interactive installation. Retrieved July 22, 2010, <http://www.alice.id.tue.nl/>., 2010.

[4] M.P. Arnone, Using instructional design strategies to foster curiosity, *ERIC Digest,* Education Resources Information Center, vol. ED479842 (2008) pp. 1-4.

[5] M. P. Arnone, R.V. Small, Arousing and sustaining curiosity: lessons from the ARCS model, *ERIC Digest*, Education Resources Information Center, vol. ED383285 (1995) pp. 1-17.

[6] E. Barakova, T. Lauren, Expressing and interpreting emotional movements in social games with robots. *Personal and Ubiquitous Computing, online*(16 January 2010), 2010.

[7] C. Bartneck, J. Hu, B.I. Salem, R. Cristescu, G.W.M. Rauterberg, Applying virtual and augmented reality in cultural computing, International Journal of Virtual Reality 7 (2) (2008) 11–18.

[8] D.E. Berlyne, Conflict arousal, and curiosity, McGraw-Hill, New York, 1960.

[9] D.E. Berlyne, Curiosity and exploration, Science 153 (3731) (1966) 25–33.

[10] G.J. Boyle, Critical review of state-trait curiosity test development, Motivation and Emotion 7 (4) (1983) 377–397.

[11] G.M. Breakwell, Coping with threatened identities, Methuen, London, 1986.

[12] T. Brosch, G. Pourtois, D. Sander, The perception and categorisation of emotional stimuli: a review, Cognition and Emotion 24 (3) (2010) 377–400.

[13] J. Bruner, The narrative construction of reality, Critical Inquiry 18 (1) (1991) 1–21.

[14] M. Buchanan, Behavioural science. Secret signals, Nature 457 (7229) (2009) 528–530.

[15] T. Burton, Alice in Wonderland [Cinema], Walt Disney Pictures, US, 2010. In R. D. Zanuck (Producer).

[16] L. Carroll, Alice's adventures in wonderland, Macmillan, London, 1865.

[17] M. Cavazza, O. Martin, F. Charles, S.J. Mead, X. Marichal, Interacting with virtual agents in mixed reality interactive storytelling, in: T. Rist, R. Aylett, D. Ballin, J. Rickel (Eds.), Intelligent Virtual Agents, vol. 2792, Springer, Berlin, Heidelberg, New York, 2003, pp. 231–235. Lecture Notes in Artificial Intelligence.

[18] G.L. Clore, A. Ortony, Cognition in emotion: always, sometimes, or never?, in: L. Nadel, R. Lane, G.L. Ahern (Eds.), The Cognitive neuroscience of emotion, Oxford University Press, New York, 2000, pp. 24–61.

[19] P. Cranton, Teaching for transformation, in: J. Ross-Gordon (Ed.), Contemporary view points on teaching adults effectively, vol. 93, Wiley Periodicals, Inc., 2002, pp. 63–71. New Directions for Adult and Continuing Education.

[20] A.R. Damasio, Descartes'error: emotion, reason and the human brain, Gosset/ Putnam Press, New York, 1994.

[21] H.I. Day, The measurement of specific curiosity, in: H.I. Day, D.E. Berlyne, D.E. Hunt (Eds.), Intrinsic motivation: a new direction in education, Ontario Institute for Studies in Education, Ontario, 1971, pp. 77–97.

[22] H.I. Day, Curiosity and the interested explorer, Performance and Instruction 21 (1982) 19–22.

[23] P.M.A. Desmet, Designing emotions, Delft University of Technology, Delft, 2002.

[24] B.J. Fogg, Persuasive technology: using computers to change what we think and do, Morgan Kaufmann Publishers, San Fransisco, CA, 2003.

[25] P. Fraisse, Perception and estimation of time, Annual Review of Psychology 35 (1984) 1–36.

[26] N.H. Frijda, The Emotions, Cambridge University Press, Cambridge, 1986.

[27] J. Glicksohn, Subjective time estimation in altered sensory environments, Environment and Behavior 24 (5) (1992) 634–652.

[28] P.M. Greenfield, H. Keller, A. Fuligni, A. Maynard, Cultural pathways through universal development, Annual Review of Psychology 54 (2003) 461–490.

[29] J. Hu, C. Bartneck, B. Salem, M. Rauterberg, ALICE's adventures in cultural computing, International Journal of Arts and Technology 1 (1) (2008) 102–118.

[30] C. Hutt, Specific and diversive exploration, in: H.W. Reese, L.P. Lipsitt (Eds.), Advances in child development and behavior, vol. 5, Elsevier, Amsterdam, 1970, pp. 119–177.

[31] A.M. Isen, M. Lewis, J.M. Haviland, Positive affect and decision making, in: Handbook of Emotions, Guilford Press, New York, 1993, pp. 261–278.
[32] A.M. Isen, M. Lewis, J.M. Haviland, Positive affect and decision making, in: Handbook of Emotions, Guilford Press, New York, 1993, pp. 261–278.
[33] W. James, What is an emotion?, Mind 9 (34) (1884) 188–205
[34] W. James, The principles of psychology, vol. 1, Macmillan & Co., London, 1890.
[35] W. Janke, G. Debus, Die Eigenschaftswörterliste EWL, Hogrefe, Göttingen, Toronto, Zürich, 1978.
[36] D.P. Johnson, Contemporary sociological theory: an integrated multi-level approach, Springer, New York, 2008.
[37] T.B. Kashdan, M.F. Steger, Curiosity and pathways to well-being and meaning of life: traits, states, and everyday behaviors, Motivation and Emotion 31 (2007) 159–173.
[38] T. Kooijmans, M. Rauterberg, Cultural computing and the self concept: towards unconscious metamorphosis, in: L. Ma, R. Nakatsu, M. Rauterberg (Eds.), Entertainment Computing - ICEC2007, vol. 4740, Springer, Berlin, Heidelberg, New York, 2007, pp. 171–181. Lecture Notes in Computer Science.
[39] G. v. Lankveld, P. Spronck, J. Herik, M. Rauterberg, Incongruity-based adaptive game balancing, in: J.v.d. Herik, P. Spronck (Eds.), Proceedings of ACG 2009, vol. 6048, Springer, Berlin, Heidelberg, New York, 2010, pp. 208–220. Lecture Notes in Computer Science.
[40] J. LeDoux, The Emotional Brain, Simon & Schuster, New York, 1996.
[41] G. Loewenstein, The psychology of curiosity: a review and reinterpretation, Psychological Review 116 (1) (1994) 75–98.
[42] G. Lugano, Digital community design: exploring the role of mobile social software in the process of digital convergence Jyvaskyla Studies in Computing, Vol. 114, University of Jyvaskyla, Jyvaskyla, 2010.
[43] D.H. Maister, The psychology of waiting lines, in: J.D. Czepiel, M.R. Solomon, C.F. Surprenant (Eds.), The service encounter, Lexington Books, Lexington, MA, 1985, pp. 113–123.
[44] I.B. Mauss, M.D. Robinson, Measures of emotion: a review, Cognition and Emotion 23 (2) (2009) 209–237.
[45] P. Milgram, A. F. Kishino. Taxonomy of mixed reality visual displays. *IEICE Transactions on Information and Systems, E77-D*(12), (1994) 1321-1329.
[46] A. Moors, Theories of emotion causation: a review, Cognition and Emotion 23 (4) (2009) 625–662.
[47] R. Nakatsu, M. Rauterberg, Entertainment computing: inaugural editorial, Entertainment computing 1 (1) (2009) 1–7.
[48] R. Nakatsu, M. Rauterberg, B. Salem, Forms and theories of communication: from multimedia to Kansei mediation, Multimedia Systems 11 (3) (2006) 304–312.
[49] F.D. Naylor, A state-trait curiosity inventory, Australian Psychologist 16 (2) (1981) 172–183.
[50] A. Ortony, D.A. Norman, W. Revelle, Affect and proto-affect in effective functioning, in: J.M. Fellous, M.A. Arbib (Eds.), Who needs emotions: the brain meets the machine, Oxford University Press, New York, 2005, pp. 173–202.
[51] M. Pasch, N. Bianchi-Berthouze, B.v. Dijk, A. Nijholt, Movement-based sports video games: investigating motivation and gaming experience, Entertainment Computing 1 (2) (2009) 49–61.
[52] A. Pentland, Honest signals: how they shape our world, MIT Press, Boston, 2008.
[53] M.G. Ragheb, S.P. Merydith, Development and validation of a multidimensional scale measurting free time boredom, Leisure Studies 20 (1) (2001) 41–59.
[54] M. Rauterberg, About a framework for information and information processing of learning systems, in: E.D. Falkenberg, W. Hesse, A. Olivé (Eds.), Information system concepts: towards a consolidation of views, Chapman&Hall, London, 1995, pp. 54–69.
[55] M. Rauterberg, Enjoyment and entertainment in East and West, in: M. Rauterberg (Ed.), Entertainment Computing - ICEC 2004, vol. 3166, Springer, Berlin, Heidelberg, New York, 2004, pp. 176–181. Lecture Notes in Computer Science.
[56] M. Rauterberg, From personal to cultural computing: how to assess a cultural experience, in: G. Kempter, P.v. Hellberg (Eds.), UDayIV–Information nutzbar machen, Pabst Science Publisher, Lengerich, 2006, pp. 13–21.
[57] M. Rauterberg, HCI as an engineering discipline: to be or not to be!?, African Journal of Information and Communication Technology 2 (4) (2006) 163–184
[58] M. Rauterberg, Usability in the future–explicit and implicit effects in cultural computing, in: A.M. Heinecke, H. Paul (Eds.), Mensch und Computer im Strukturwandel, Oldenbourg, München, 2006, pp. 29–36.
[59] M. Rauterberg, Ambient culture: a possible future for entertainment computing, in: A. Lugmayr, P. Golebiowski (Eds.), Interactive TV: a shared experience–Adjunct Proceedings of EuroITV 2007. TICSP series #35, Tampere International Center for Signal Processing, Tampere, Finland, 2007, pp. 37–39.
[60] M. Rauterberg, Hypercomputation, unconsciousness and entertainment technology, in: P. Markopoulos, B.d. Ruyter, W. IJsselstein, R. Duncan (Eds.), Proceedings of Fun and Games 2008 Second International Conference, vol. 5279, Springer, Berlin, Heidelberg, New York, 2008, pp. 11–20. Lecture Notes in Computer Science.
[61] M. Rauterberg, Entertainment computing, social transformation and the quantum field, in: A. Nijholt, D. Reidsma, H. Hondorp (Eds.), Intelligent technologies for interactive entertainment - INTETAIN 2009, vol. 9, Springer, Berlin Heidelberg, 2009, pp. 1–8. Lecture Notes of the Institute for Computer Science, Social Informatics and Telecommunications Engineering.
[62] M. Rauterberg, Emotions: the voice of the unconscious, in: H.S. Yang, R. Malaka, J. Hoshino, J.H. Han (Eds.), Entertainment Computing - ICEC 2010, vol. 6243, Springer-Verlag, Berlin, Heidelberg, New York, 2010, pp. 205–215. Lecture Notes in Computer Science.
[63] M. Rauterberg, J. Hu, G. Langereis, Cultural computing: how to investigate a form of unconscious user experiences in mixed realities, in: R. Nakatsu, N. Tosa, F. Naghdy, K.W. Wong, P. Codognet (Eds.), Entertainment Computing Symposium - ECS 2010 IFIP, vol. 333, Springer-Verlag, Berlin, Heidelberg, New York, 2010, pp. 190–197. Advances in Information and Communication Technology.
[64] P. Ross, Ethics and Aesthetics in Intelligent Product and System Design, Eindhoven University of Technology, Eindhoven, 2008.
[65] B. Salem, R. Nakatsu, M. Rauterberg, Kansei experience. Aesthetic, emotions and inner balance, International Journal of Cognitive Informatics and Natural Intelligence 3 (2) (2009) 18–36.
[66] P. Salovey, J.D. Mayer, Emotional intelligence, Imagination, Cognition and Personality 9 (3) (1990) 185–211.
[67] S.d. Schonen, G. Leone, M. Lipshits, The face inversion effect in microgravity: is gravity used as a spatial reference for complex object recognition?, Acta Astronautica 42 (1–8) (1998) 287–301
[68] G.J.F. Smets, P.J. Stappers, K.J. Overbeeke, C.v.d. Mast, Designing in virtual reality: perception-action coupling and affordances, in: K. Carr, R. England (Eds.), Simulated and virtual realities: elements of perception, Taylor & Francis, Bristol, PA, USA, 1995, pp. 189–208.
[69] C.D. Spielberger, R.A. Peters, F.S. Frain, Curiosity and Anxiety, in: H.G. Voss, H. Keller (Eds.), Curiosity research: basic concepts and results, Beltz, Weinheim, 1980.
[70] S. Taylor, Waiting for service. The relationship between delays and evaluations of service, Journal of Marketing 58 (2) (1994) 56–69.
[71] N. Tosa, Expression of emotion, unconsciousness with art and technology, in: G. Hatano, N. Okada, H. Tanabe (Eds.), Affective minds, Elsevier, Amsterdam New York Tokyo, 2000, pp. 183–202.
[72] N. Tosa, Unconscious flow, Leonardo 33 (5) (2000) 442.
[73] N. Tosa, *Cultural computing: ZENetic computer*.Unpublished manuscript, Kyoto, 2006.
[74] N. Tosa, S. Matsuoka, ZENetic computer: exploring Japanese culture, Leonardo 39 (3) (2006) 205–211.
[75] N. Tosa, S. Matsuoka, B. Ellis, H. Ueda, R. Nakatsu, Cultural computing with context-aware application: ZENetic computer, in: F. Kishino, Y. Kitamura, H. Kato, N. Nagata (Eds.), Entertainment Computing - ICEC 2005, vol. 3711, Springer, Berlin, Heidelberg, New York, 2005, pp. 13–23. Lecture Notes in Computer Science.
[76] N. Tosa, S. Matsuoka, K. Miyazaki, Interactive storytelling system using behavior-based non-verbal information: ZENetic computer, in: Proceedings of the 11th ACM international conference on Multimedia - MM'03, ACM, New York, 2003, pp. 466–467.
[77] N. Tosa, S. Matsuoka, H. Thomas, Inter-culture computing: ZENetic computer, in: H. Elliott-Famularo (Ed.), ACM Proceedings of SIGGRAPH 2004 - Emerging technologies, ACM, Los Angeles, 2004, p. 11.
[78] E. Ulich, Umgang mit Monotonie und Komplexität, Technische Rundschau 5 (1987) 8–13.
[79] D. Zillmann, Mood management through communication choices, American Behavioral Scientist 31 (3) (1988) 327–340.