Breaking the flow

Intervention in computer game play through physical and on-screen interaction

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ABSTRACT
This article investigates issues of controlling the amount of time during computer game play and potential solutions to help prevent excessive gaming. The study incorporates the realization of three different variants. Two screen based solutions and one based on a physical agent, outside the computer screen, provide notification and additionally even "intervention" to the user. The three realizations have been put to the test and the results, both quantitative and qualitative are presented. The physical agent-based solution was most attractive.

Keywords
Game support robots, computer games, RSI, flow

INTRODUCTION
This article reports on the effectiveness and attractiveness of three different solutions designed for children to help them controlling the amount of time spent on computer game play. The following concepts play a role: game play, flow and physical interaction. These concepts will be introduced next.

Game play: Computer games have been around since computers have. They developed starting in the early days of computers to the games for PC, console and mobile platforms we know nowadays. Most children in the developed countries spend significant amounts of time on computer game playing. In [11] the intrinsic motivations for individual game playing are identified: challenge, curiosity, control and fantasy. Gaming can be fun but can also be helpful to develop cognitive and computer skills. Playing or working with a computer too long, or without sufficient breaks may be the source of mental and physical problems. The research of violent games is extensive, see e.g. [6] and [7]. *Excessive* game play goes at the expense of other activities, and even may damage physical and mental health. Stakeholders in this problem area are game designers, players –in our study children in the age 10 to 15– and parents (See "Focus Group" in section "FB: a Flow Breaker"). Game designers want earnings, so they want their games to be popular. Game designers are interested in designing games that generate a flow experience (see [9]). On the other hand, it is not in their interest that games are considered addictive (see [1]), or bad for mental health. Therefore, it might be in the interest of game designers to add a controlled way out of flow. Parents and children usually do not share the same worries about excessive game play, and certainly do not agree on the strategies to prevent it; they do agree that game play tends to get out of hand sometimes. Apart from the parental interaction, that in most cases children consider to be inappropriate (see "Roles and Scenarios" in section "FB: a Flow

Breaker"), especially the distorted sense of time is recognized and identified as a problem source. In [2] Csikszentmihayli describes the mental state a player may enter when totally entangled by the game.

Flow: Both [8] and [16] describe the altered state with the flow experience: flow is an optimal experience, characterized by a sense of playfulness, a feeling of being in control, concentration and highly focused attention, mental enjoyment of the activity for its own sake, a distorted sense of time, and a match between challenge at hand and one's skills. In Figure 1, flow is characterized as a situation where both skills and challenges are high. This figure provided us with one of the starting points for the present research: there are two directions in which flow can be broken. Either reduce the ability to apply skills (disturbing messages, blocking the keyboard) or reduce the challenge. Both variations have been tried.

Physical interaction: In literature numerous papers are found on embodied interaction, tangible interfaces, robots for kids (e.g. [3]; [4]; [13]). In [5] we added physical applause robots to a Pacman type of game, and observed children playing the game. The following observation was made: as long as children were in a position of observer, they found the behavior of the robots fascinating and funny. However as soon as they were playing, all attention was focused on the screen. This observation provided us with another starting point for the present research: to add a mechanism that draws the player's attention away from the screen when it is time to break the flow.

The paper is organized as follows: Section "FB: a Flow Breaker" describes the design of three different solutions. We call them mini-designs because the designs are deliberately kept sober, yet playful, each essentially embodying a single idea. The mini-designs have sufficient aesthetic and technical qualities to attract users and let them have fun playing. The steps of the design process are described: requirements analysis by means of a focus group, requirements analysis by identifying roles and scenarios, and realization of three mini-designs. Section "User Evaluation" describes the user evaluation by means of experiments in which children were asked to rank the three solutions. The participants, materials, procedure, quantitative results, quantitative results, flow questionnaire and a number of remarks are described. The final section gives the conclusions.

FB: A FLOW BREAKER

Focus Group

In a focus group on game play we systematically explored the topic of excessive game play and its effects together with a group of game players. We

also explored strategies and design solutions that could decrease differences in actual, perceived and desired game playing time. Our group of game players consisted of 10 children, 5 girls and 5 boys, ages between 12 and 15 years, that worked together for 3.5 hours to elaborate on the issues mentioned.

All participants agreed that there should be rules set to prevent excessive game play and that breaking the rules should have consequences. They thought both parents and children should be involved in setting the rules and the consequences. If it could be guaranteed that the game, or a physical robot attached to the game, would act consistently and fair, the children even indicated that they would prefer system intervention to parent supervision. Further, when intervening, the system should be considerate with the game, e.g., the game should not be stopped abruptly, but interruptions or interventions should always come gradually. Also, the system should wait for, or anticipate natural moments, e.g., the system should help the player make a good estimation whether or not it would make sense to start a new game, or help in estimating the extra time needed to complete a level.

Roles and scenarios

Assuming there is a need to manage the duration of gaming sessions we distinguish two roles: a *player* and a *supervisor*. The roles may or may not be performed by a single person. The player is attracted by the game, plays the game, gets into a flow state, and feels the need for achievements in the game (points, levels, etc). The supervisor considers the balance between game playing and other activities, makes explicit decisions about playing times *and* effectuates them. In practice several scenarios occur. First, the two roles can coincide, i.e. the person to play the game decides that the next session is to take at most 30 minutes e.g. and then, when playing, he or she takes care of timing for him/herself, stopping after 30 minutes perhaps, or (more likely) play longer and regret it afterwards, or (also likely), play longer and get into conflicts with others (Figure 2).

Alternatively, the two roles correspond to two persons, typically a child and a parent (Figure 3). The child wants to play, the parent fixes the allowed time, the child plays and exceeds the planned time and the parent intervenes. This scenario may give rise to several negative feelings or discussions on responsibilities.

As a third scenario, the child and the parent together act as one supervisor by agreeing on a time planning in advance, but during the game, the child is just a player: the child stops being part of the supervisor and it may play too long, perhaps until the parent intervenes (Figure 4).

The *distorted feeling of time* and the highly *focused attention*, which are characteristics of flow, are essential for these scenarios. There is a the *time shift* between planning and stopping: the persons playing enter another state of mind in which their feeling of time is distorted and the attention is focused on the game. This prevents the persons from implementing the planning, even if they were a supervisor in the planning phase. The mini-designs embody potential solutions for the problems inherent to all three scenarios and to the problem that the parent cannot always be present. The following modification of the above scenarios underlies these mini-designs (Figure 5). FB is either

software or an embodied agent that checks the planning and effectuates the intervention

Realization

Game: The game taken is a Pac Man clone, called *Snack Attack*, developed by Michael Packard in the context of his “crash course in game design”, which is publicly available. The original game, designed by Iwatani of Namco is a classic in game history. In this version, the screen character is called Snacky. We assume the reader is familiar with the game (a maze, filled with dots to be eaten, power pills, bonus fruits and ghost opponents). Credits are given for achievements such as eating the dots, power pills, bonus fruits or a ghost. The aim of the game is to gather as many credits as possible. If all dots in a maze are eaten, the player enters a next level where a new maze filled with dots and power pills is presented. Eating a power pill temporarily make Snacky invulnerable so the ghosts cannot harm him. If Snacky is vulnerable, each collision with a ghost is lethal. The player has four lives before the game is over. Whenever the "game over" state is reached, the user is requested to type his/her name if the score is high enough to be entered into the high-score list. After that the user is requested to type 1, 2 or Q, meaning to proceed with one or two players or to stop the game. Only in case of Q, the user leaves the game.

Game extension: The extension of *Snack Attack* has been realized in two ways. Besides the software adaptations done, a physical flow-breaker (*FB*) device is created. In order to satisfy the requirement that it has to understand the game, i.e. doesn't stop the game rudely but waits/anticipates for natural moments, three possibilities exist:

(1) Give it sensors and intelligence to see or hear what is a natural moment for arbitrary games.

(2) Let it use a (non-existing) standardized software interface by which games export the game status.

(3) Let it be suited for one given game only (to investigate the problem and do a mini-design).

The third possibility has been chosen. In order to satisfy the requirement that interventions are gradually announced, an approach in stages is chosen. The stages and the nature of the actions taking place in each stage will be described in section "functions" below. Once the game is fixed, *narrative* elements (see [10]) and *iconic* forms (see [14]) of the game can be reused in the device. More details will be given in section "form" below. The technical aspects are described in section "hardware and software" below.

Functions: The stages, needed for having a gradual announcement of interventions, will be described next. We prefer to describe the stages in an abstract way first, choosing the action details later.

- Stage 0: normative
- Stage 1: informative
- Stage 2: interactive
- Stage 3: disruptive

Stage 0 is the interaction of setting the initial time, to be done either by a child or a parent. In the realization this is done outside the game software, using the

start-up sequence of the game. Initial game time (i.e. until stage 2) is chosen when installing the game software. Stage 1 allows the player to continue playing, causing some disturbance, about 0.5 seconds, to indicate that time is almost up. Stage 2 is a real disturbance that may take short or long. It does not go away unless the player really takes action. This action informs the game of the amount of extra time requested by the player (0, 1, 2, 3 or 4 time units). A typical time unit is one minute. Stage 3 is disruptive, i.e. the user is blocked from continuing.

Form: The actual implementations of the game resulted in 3 different forms, referred to as FBA, FBB and FBC. These 3 forms have some common qualities. First of all, all game versions show the played time on screen so there is a feedback of the playtime, which is stopped in "non-play" situations so it displays *actual* played time. Furthermore, game interventions are postponed in "near end-of-level" situations (that are detected by the remaining number of dots).

Stage	Color	Text	V
1	Orange	Your time is up –almost –	0.5 sec
2	Red	Need extra time? Type 0,1,2 or 3 (min)	Until 0,1,2,3 typed
3	Red	Your time is up – play stopped –	1 sec

Form FBA: The interventions are pop-up windows containing a message at stages 1-3 as shown in Table 1. During the time the pop-up windows are visible, the actual

Table 1: FBA stages

playtime is stopped, so the playtime remaining is not influenced by the duration the pop-up is on the screen. After removal of the pop-up window in stage 3 the game is ended.

Form FBB: In this game the interventions are a decrease of game difficulty level. For each stage (except 0) a specific decrease is done. As can be seen in Table 2, after stage 3 is entered most of the challenges of the game are removed.

Stage	Action
1	Ghosts stop hunting Snacky
2	Ghosts start avoiding Snacky
3	Dots and ghosts no longer eaten. Points and levels come automatically

Table 2: FBB stages

Form FBC: Here the implementation of the game consists of several parts: the first part is the *Board*, like a traditional physical game board. It shows a maze and has four power pills at the usual positions. The power pills in our case are LEDs (light emitting diodes), each equipped with a magnetic sensor. The second part is the *Yellow Ball Character* (*YBC*), a Snacky look alike made of a

ball of 10 cm diameter; it has eyes, a mouth and a flashlight inside. It can also rotate by means of a rotating platform on the board that makes motor sounds when turning. The platform is also equipped with a magnetic sensor. The game board and YBC are shown in Figure 6. The third part is a modified keyboard that is only enabled if light shines on the light dependent resistor that is mounted on the keyboard. The idea is that the keyboard enabling mechanism is very visible and that it is plausible for the player to assume that the YBC is indeed the cause of the keyboard being enabled or disabled. The abstract stages 0-3 are mapped onto actions of the device as shown in Table 3.

Stage	Action
0	YBC turns towards keyboard, light is turned on, and power pill LEDs are turned off.
1	YBC turns away 90° for about 0.5 seconds and turns back, making a mechanical sound and temporarily disabling the keyboard.
2	YBC turns away 90° making a mechanical sound and switches off the light disabling the keyboard, power pills LEDs are lit. The player has to pick up YBC, “pick up” 0..4 power pills and return YBC to its platform.
3	YBC turns away 180° and switches off the light, making a mechanical sound and disabling the keyboard, game ends.

Table 3: FBC stages

Detection of the YBC presence at the platform and the specific power pill positions is done using the magnetic sensors. Each pill's LED will turn off when “picked-up”. When the YBC is put back onto its appropriate platform position (recognizable by the foot-print corresponding to that of the YBC), the game proceeds immediately (the YBC light turns back on).

Hardware and software: The public domain software of Snack Attack (written in the language Euphoria) is extended with software needed to display the pop-up windows, to show playtime, to reduce the challenge, to determine “near end of level” situations, to terminate the game and to control the board and YBC through the PC's serial port. All of these extensions are part of the main control loop of the game. The software contains some option-bits to accommodate all alternative implementations. Controlling the LEDs, the platform position, the YBC's light and reading the 5 magnetic sensors is done by a dedicated circuit that performs a conversion from the PC's serial port I/O to parallel bit I/O. One output bit is used for activation of each pill's LED, the flashlight and each platform position. One input bit is used for each magnetic sensor (4 LED sensors and 1 platform sensor).

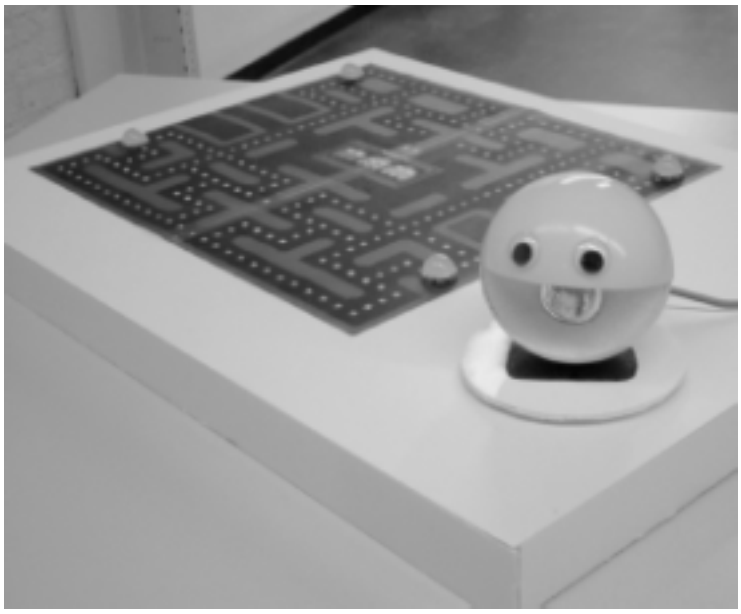

Figure 6: The game board and YBC

USER EVALUATION

In this section, we report on an experiment that was set up to investigate the following two questions:

1. Reducing the challenges of a game, or influencing the ability to apply the player's skills by interfering or interrupting the player-game interaction, both provide alternative means to get players out of the game. We would like to know which alternative the player prefers.
2. We compare two alternatives for interrupting player-game interaction: a screen-based and a robot-based solution. We would like to know which solution the player prefers.

Participants: Nine of the ten children that were involved in the focus group on game play also participated in this experiment. One of the girls, however, was not able to take part in the experiment and therefore was substituted by another girl. All subjects got a small present.

Materials: The three versions under investigation, FBA, FBB and FBC, have been described above.

Procedure: The experiments were conducted in the Kids-Lab, a TU/e laboratory created for research on interaction design with children. The experiment took about one-and-a-half hour and comprised four parts.

First the participants were instructed to play the original Snack Attack game for about eight minutes. This phase was used to get them acquainted with the game, but, more importantly, to bring about (or at least approach) the state of 'flow' that our solutions were supposed to break in the next phase of the experiment.

To measure to what extent the state of 'flow' was reached after playing Snack Attack for 8 minutes, we decided to develop a questionnaire that could be filled out during the second part of the experiment. In [12], Novak et al. have operationalised their elaborate model of flow with a survey instrument containing a total of 62 nine-point rating scales and semantic differential scales. This survey was considered too comprehensive for our purposes. Moreover it was developed specifically for another application, viz. flow during visiting web sites. We therefore decided to develop our own questionnaire based on the original work of Csikszentmihayli ([2]). Our questionnaire puts forward fourteen propositions for which the subjects had to indicate on a 5-point scale whether they agreed or disagreed with each proposition. In [2] Csikszentmihayli describes seven dimensions that can be used to characterize flow. For every dimension the questionnaire put forward two propositions: one positive and one negative formulation. For example, the dimension that describes that flow is characterized by a transformation of perceived time was expressed in the following two propositions: “Time flies when I play the game” and “I can easily judge the amount of time I have been playing”.

The third part of the experiment started with an explanation of the three mini designs that we developed and that were supposed to help the participant stop playing. We also explained that they were to enter a high-score competition based on the playing of nine games for which the highest scores were captured in a high-score list. All three versions were played three times. The order of the versions was determined pseudo-randomly, excluding the same version being played consecutively. At the end of the third phase, the participants were asked to make two rankings: first they were asked to order the versions with respect to effectiveness, next, a ranking with respect to how much they liked each version (fun factor).

In the last part of the experiment a semi-structured interview was conducted in which participants could reflect on some of the design decisions. We wanted to know from the participants whether or not “we got it right”. This interview concluded the experiment.

We videotaped the experiments to be able to score the video material afterwards on human behavior characterizing 'flow' or transitions from 'flow' to other mental states like 'boredom' or 'anxiety'. For the time being, we used the videotapes primarily to make transcriptions of the structured interviews.

Quantitative results: All ten participants ordered the three versions according to the effectiveness to get the player out of the game, and according to the 'fun factor'. For both orderings, we determined the association among the ten rankings by calculating the Kendall coefficient of concordance W (see [15]).

For the effectiveness ranking, the coefficient of concordance is significant at the 0.01 level of significance ($W = 0{,}57$; $\tilde{}^2 = 11.4$). This means that the pooled ordering, which corresponds to the order FBB (least effective), FBA, FBC (most effective) may serve as the best estimate of the 'true' ranking of the three versions.

For the 'fun factor' ranking, the coefficient of concordance is significant at the 0.001 level of significance ($W = 0.73$; $\tilde{}^2 = 14.6$). This means the order FBB (least fun), FBA, FBC (most fun) is the best estimate of the 'true' ranking of the three versions.

Flow questionnaire: From the 'flow' questionnaire we can make the following observations; the scores between brackets are the mean of the propositions rated by the 10 subjects on a 5-point scale ranging from –2 (don't agree) to +2 (agree):

- when game play is going smoothly, a high score is reached easily, even without having to stress too much (1.2, $\hat{U} = 0.89$),
- the participants were concentrated on the game (1.15, $\hat{U} = 1.04$),
- the subjects consider the game challenging (0.85, $\hat{U} = 0.67$),
- the subjects tend to forget time while playing the game (0.75, $\hat{U} = 1.21$),
- the subjects were ambivalent in their opinion whether or not the game had clear goals and feedback (0.3, $\hat{U} = 1.49$),
- the subjects are ambivalent with respect to the propositions that they become one with the game while playing and stop thinking about other things (0.2, $\hat{U} = 1.2$), and
- a merging of action and awareness does not happen for most subjects, i.e., they don't forget the world around them (-1.2, $\hat{U} = 0.7$).

From this we draw the tentative conclusion that a moderate state of flow was reached (we think that the development of instruments to measure flow more accurately is an interesting open question).

Qualitative results: After doing the transcription of the interviews and a clustering of the responses, insights were acquired in the similarities and differences in the answers given. The most striking similarities and differences are discussed in the next paragraphs. They give an overview of what works according to our test group and what does not. These insights mostly agree with the expectations, but several interesting new ideas came out of these interviews as well.

General remarks: The number of interventions in each version of the game was mostly agreed upon as being just right – only one subject would have liked more warnings. The timing of interventions did get some comments though and it was suggested to add a clock. We quote some representative remarks made by the subjects:

> "It depends on how long you play, if for example you play ten minutes, and you also *want* to play ten minutes, because you have to do all these other things, then that thing has to turn two times, turn every five or ten minutes, then when it starts turning, the little clock shows already that you have played five or ten minutes" / "Interventions should come at dead moments" [*lost a life, next level*] / "You could not save the high-score when time was up".

Also, most subjects thought it was their own responsibility to use the time limiting versions of the game and said they would probably do so if they had lack of time:

> "Yes, I would use it, for example if we had to go somewhere and I could play for say 10 minutes or so or if I had to go to dinner" / "… then it could warn you like: 'you won't have enough time to complete your homework' …"

A need for limitation –some distorted sense of time because immersion into the game causes long playtime– was also acknowledged, e.g.:

> "… It warned you after, say 4 minutes and you think oh sh*t already 4 minutes passed, I'll just do another minute, and that minute passes very quickly and you want another minute. Later on you know you're just kidding yourself".

Remarks about the different versions:

FBA (screen messages): Most subjects found this version to be the clearest. The pop-up boxes and their text were noticed very well, although some comments were made on the size and contrast of the box colors:

> "They were just very clear, of course you could imagine other forms, but then perhaps not enough characters fit in. It is about the message and I think it was very clear".

Some of the proposed changes were: "position the pop-up box at Snacky's position", "add some fun graphics to it", "more contrasting colors" and "bigger pop-up windows".

FBB (reduced challenges): This was the least understood version. As it seems not all reduction of challenges was noticed (at least not immediately). Some subjects noticed reductions that were not there and others thought the game was broken. Although this version was considered the least effective and the least funny, most subjects thought it was effective:

> "You will quit the game because it's getting boring. At first perhaps it is fun, but then it gets boring".

In fact the same reason was also mentioned as the probable cause for not playing this game version at all after some time, a side effect that was not foreseen. Another valid remark not foreseen was that "it really affects the game play". This game version was the one least likely to be installed: "I'm not sure if I would install this version on my computer".

Some of the proposed changes include: "At a certain moment the game should stop by itself" [*when all challenges have gone the game should stop*], "That all the little roads disappear" [*the maze disappears*], "The game could slow down"

FBC (board and YBC): A common reason given for being fun as well as for being effective when playing version FBC was the physical movement in the game involved in picking up the YBC and "getting" the power pills from the game board. This distracted the game players from the actual game on the screen, forced them to focus on the board and do some physical movements. Some citations:

> "That it starts turning and so that's nice, that looks real, ehh..., what's this thing doing, and then it *does* get you out of the game, and then you *do* stop". / "It was fun picking up the ball" / "It really attracts your attention away from the computer".

Some of the subjects reported that they had a feeling of presence of the YBC:

> "I think it is real. He looks really like it, also because you're playing that game. It is attractive that such a Pacman is standing next to you, that's really funny, as if he is playing along ... just like if he is watching the game."

The design of the board and the YBC were appreciated as well as criticized: “Nice looks.” / “The board is nice because it really looks like the game.” / “The board is too big” / “I think it’s more suitable for small children”. Other downsides of this version mentioned were the fact that it’s an extra item to buy and the board/YBC design being specific for this game. The fact that the board and YBC were distracting was also mentioned as a negative quality. Proposed changes include “a built in clock” and “talking” (cheering, make comments, warning, telling time).

CONCLUSIONS AND DISCUSSION

In this article we identified the problem of breaking the flow of gaming in order to prevent excessive game play. The analysis of the problem showed that the concept of flow, notably the distorted feeling of time and the focused attention, is at the heart of the problem. Through a process of participatory design involving children of age 10-15 and through the development of mini-designs we created and experimentally evaluated three different technical solutions. We applied performance measures to investigate which flow breaking strategies were preferred by the children and reflection measures to verify and validate our design considerations. Behavior measures will be applied in the next phase of the project. Next to the obvious techniques of *automated time bookkeeping* and programmed *screen-messages*, two innovative elements are added. The first comes from the theory of flow: instead of blocking the player's actions, reducing the skills, the flow can also be broken by *reducing the challenges*. The second innovation is an extra *physical agent* that draws the attention away from the screen and invites the player to a non-keyboard physical interaction.

The strong and weak points of these solutions have been identified. All three mini-designs are shown to be *effective*. The physical agent is most *attractive* although there are a number of points that need attention (size of the device, adding a clock, YBC being childish for older children). The challenge-reducing solution, though effective, is confusing. The focus group and user evaluation give a wealth of options to fine-tune each of the solutions and make them more attractive.

In [5], during intense game play, the children (age 10-11) paid no attention to the physical agent next to the computer. Tentatively, this can be formulated in terms of action spaces. If the player is in the flow state, his or her attention is very focused upon the *action space* that is related to the flow (the screen and the keyboard actions logically connected to it). The physical agent is in another action space. So when in flow, there is no attention for the agent. Therefore if the player is forced to move attention to the agent, the flow must be broken.

Another discussion point is the design of FBB (reducing the challenges). Although the basic idea to move away from “flow” along the vertical axis seems to work, it turns out not to be attractive. We conjecture that this is mainly because it makes the accounting of points worthless. Especially in a competition this is troublesome. We leave it as an option for future projects to invent other implementations of the challenge-reduction idea that are more compatible with the concept of *achievement* in the game.

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