DYSL-X: Design of a game-based tool for early risk detection of dyslexia in preschoolers

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ABSTRACT
The goal of the DYSL-X project is to develop a tool to predict whether a preschooler (5 yrs) shows high risks for developing dyslexia. This tool is a computer game that incorporates tests to take specific performance measures that allow for this prediction. The game will thus serve as an assessment tool to be used in school psychology services and clinical diagnostic and rehabilitation centers. During the first phase of the projects several existing games for preschoolers were evaluated using a laddering method. Based on the outcomes several minigames were designed. The results of this first phase will be presented at the Fun and Games workshop.

Keywords
Games for preschoolers, Games as an assessment tool, Game Design

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Dyslexia refers to specific problems to acquire reading and spelling skills despite adequate intelligence and instruction. It has a prevalence of 5-10 % in the population[9,16]. The first signs of dyslexia are typically observed during the first year of formal reading education (age 7 yrs), but very often the diagnosis is only made at an older age. However, dyslexia is a developmental disorder that should be detected and treated as soon as possible. The younger the age of the child at the start of a therapy, the larger the long term effects. Early risk detection allows for taking preventive measures, which has been proven to be effective, even at preschooler age.

Recent scientific studies by research groups of the KU Leuven did provide us with a better understanding of predictive variables for dyslexia that can be measured, even in a preschool population [2,3,4,5,6]. The aim of DYSL-X is to integrate these predictors in a computer game. The objective of DYSL-X is twofold. First, by using a game, preschoolers will display a higher motivation, a longer attention span, and as a result a more accurate measurement can be taken. Consequently, incorporating these measurements into a game will improve the quality of the tests and result in a more reliable and more valid prediction. Secondly, the DYSL-X game-based application will come with automated measurements and scoring. Therefore, no qualified personnel is needed to administer and score the tests. This allows for the deployment of DYSL-X at a wider scale, increasing the utilization potential.

RATIONALE OF THE PROJECT
Existing dyslexia tests with preschoolers [2,3,4,5,6] already made the user interface more attractive and added animations in order to increase the motivation of the child [4,13]. However, the researchers conducting the tests mentioned that it was still difficult to keep the child's attention at a high level throughout the test. Therefore, the test results still contained a lot of variability, certainly for threshold values where the 'best performance' of the child is to be measured. It was suggested that a higher accuracy can be achieved by finding better ways to motivate the child. One possible way to increase the motivation of the preschooler is by incorporating these tests into a fun, challenging application, such as a computer game.

By offering interactive and immersive audio-visual worlds, game designers realize an environment that rouses a child's senses and interests and stimulates exploration. But more

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importantly, well-designed games tailor to the skills of individual players, by continuously assessing performances and adapting the difficulty of the task. By offering challenges that match the abilities of the players, game designers create a psychological state known as flow [7]. During a flow state, a player loses his sense of self and his sense of time and place. Flow is gratifying in and of itself; it is an intrinsic motivation that keeps a player playing. This characteristic additionally ensures that players deliver their best performances. As aforementioned, best performance measuring is also necessary for increasing the reliability of psycho-acoustic testing. By further adding specific reward schemes, game designers condition the player to exhibit preferred behavior within the game. These characteristic of game-based applications – immersive worlds, flow triggering tasks and rewards – transform repetitive testing into entertaining interactions. They become even more important when designing likeable applications for preschoolers [19,21,24].

Whereas serious games are an interesting approach to captivating the interest and to augmenting the motivation of adults, they might even be more promising to engage the enduring attention of our target group, namely preschoolers. User evaluation and user testing of fun and usability of applications, with preschoolers, has been under the recent scrutiny of several researchers [1,12,14,24]. This research has demonstrated that traditional user tests with preschoolers should last no longer than thirty minutes [12], but that this time can be doubled when testing games [24]. It is therefore a valid assumption that administering 'boring' tests via a game will lengthen the attention span of the preschooler. Furthermore, research studies indicate that when testing games with children, directive prompts or assigning clear cut tasks are superfluous. The intrinsic motivation of preschoolers demands less direction and steering from test administers. Therefore, administering tests via game-based applications is likely to augment the reliability and the validity of the test results.

However, creating a good serious game is not straightforward. On the one hand, there is always the threat of sugar coating: a superficial embellishment of what is actually a boring task with a couple of fun animations and a little bit of shallow game play. Good serious game design requires a seamless integration of the external goal and game dynamics. The aim of serious games is 'stealth learning' or in the case of DYSL X 'stealth testing': the children are unaware of the fact that they are tested, the overall game experience should simply fun. On the other hand, the fun factor should not intrude upon the serious goals.

In the case of DYSL-X, special care should be taken that possible confounding variables such as prior game experience, spatial skills or problem-solving skills do not interfere with the test outcomes and affect the validity of the tests. The test outcomes should only depend on the child's ability to perform well on the auditory and speech perception tasks.

Therefore, the challenge remains to elicit a rich game play experience while offering a reliable and valid test platform. The DYSL-X project will therefore yield new insights on how to design and to evaluate such game-based assessment tools for this specific target group of young children.

PROJECT OVERVIEW

The first step in the DYSL-X project is to design and implement a game in which the game experience – being motivating and inviting (due to the X-factor) – is aligned with the purpose of the game – measuring the performance on a certain task. To achieve this, we adhere to a participatory design process where all stakeholders are continuously involved in the design process, from the generation of initial ideas until the final user tests. This process is according to the PIII framework, involving 1) player-centered design, 2) iterative development, 3) inter- and multidisciplinary teamwork, and 4) seamless integration of play and learning [18]. The stakeholders of DYSL-X are comprised of the creators of the game, the players of the game (the preschoolers), preschool teachers, and the administrators of the game as an assessment tool (the staff members of the specialized centers and school psychology services).

The second step in the DYSL-X project is to compare the newly developed game with the classical methods used in the aforementioned scientific studies through an intra-subject analysis in a preschool population. Correlations between the measurements of both the game and the classical methods will be investigated, as well as differences in attention span, reaction times and attitudes of preschoolers towards the game and the classical tests.

The third step is to define the critical values of the performance measures that are obtained by playing the computer game. Therefore, the game will be played by children from four groups: a sample of five-year olds that are hereditary predisposed, i.e. children having at least one first-degree relative with dyslexia, a sample of five-year olds having no close relatives with dyslexia, a sample of eight-year olds with a diagnosis of dyslexia and a sample of eight-year olds without a diagnosis of dyslexia. From these data, the critical values will be distilled, and hopefully, the validity of the game will be proven.

CURRENT STATUS OF THE PROJECT

The first step of the project (designing and implementing the game) consists of three phases: Explorations and Observations, Game Design, and Game Development. We will describe the methodology of the first two phases as these are completed at the moment.

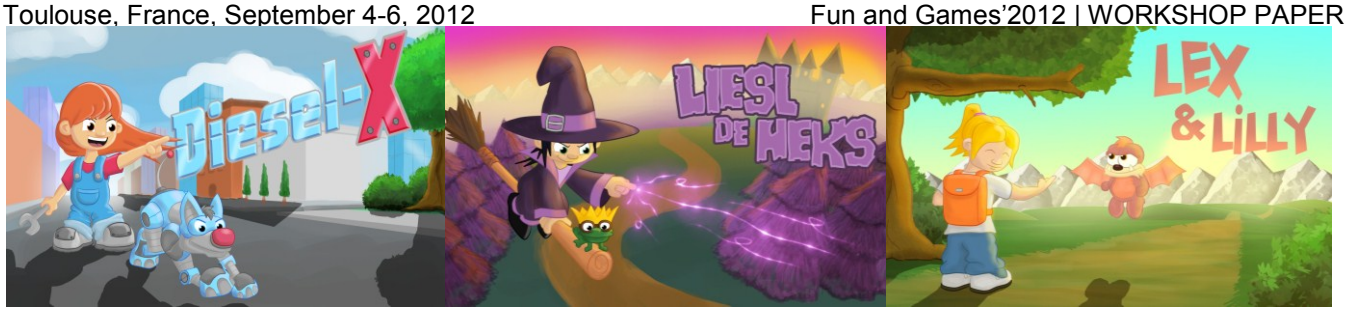

Fig. 1 - The three different game concepts, the left concept (Diesel-X) was preferred by 18 out of 20 preschoolers.

Explorations and Observations

During the Explorations and Observations phase, the entire core team first became familiar with the problem domain, i.e., dyslexia. This way, everyone has an understanding of the outcomes of the previous research projects on which this project is based, and the methodology that was used.

Also during this phase, more specific knowledge was gathered on the target group, the preschoolers, e.g., on the way they experience the classical tests used in the previous studies. Therefore, sessions were organized during which the preschoolers took the classical tests as well as played popular, commercial-of-the-shelves games for preschoolers. These observations contributed to a further understanding of the specific tests and measurements that were taken, but also provided insight into the specific developmental (cognitive, behavioral and affective) limitations of preschoolers and how these might impact the game design of the DYSL-X game. 25 preschoolers were involved in these sessions, divided over 3 classes. In order to analyze their experience, the preschoolers were interviewed in order to find out what they did and did not like about these tests according to the This-or-That method [22,25]. More insight into the motivations of their choice was gained using a laddering method [20,23].

The outcomes of this phase are currently processed and will be presented at the Fun and Games workshop.

Game Design

In the Game Design phase, the game concept was defined. Two brainstorm sessions were organized with all stake-holders to obtain a list of ideas for the games, taking several constraints into account:

- the results of the first phase, i.e. the knowledge on how preschoolers experience the classical tests and the representative computer games,
- the motivational factors of a computer game for preschoolers and
- the goal of the game, i.e. taking accurate psycho-physical measurements

From these ideas, the creators of the game (Game Designer, Game Developer, and Digital Artist) generated three different concepts (see fig. 1). Every concept was a one-page document which contained a splash image with the title, the protagonist(s) in their environment, and an antagonist where applicable. Furthermore, every document contained a brief description of the narrative and the goal of the game.

These concepts were again evaluated by the users (preschoolers) of the game via focus groups. In particular, 20 children (15 girls, 5 boys) of one kindergarten class participated. These children were divided in to three focus groups of each six or seven participants. The focus groups interviews were adapted to the characteristics and developmental limitations of preschoolers [10,15]. Firstly, the evaluation took place in their class room. This natural context increases the reliability and validity of the data [11,17] and minimizes the power differential between researcher and the preschoolers [8:183] as the preschoolers are in a familiar place whereas the researcher is not. Secondly, at the start of the focus group, the researcher presented the three different prototypes, by means of a story of each approximately five minutes, accompanied by some illustrations (see Fig. 1). The children were each handed out three cards, each card containing a picture of the respective game concept. After explaining the three game concepts (i.e. listening to the three stories and looking at their respective artwork), the children were asked to choose the concept card they liked most, but in such a way that the other children and researcher could not see their preferred game concept. Upon a signal of the researcher, the preschoolers unveiled their choice, all at the same time. With the chosen card in front of them, preschoolers were prompted to explain their choice. This process mitigated the risk for group influences and/or social desirability with respect to the researcher.

The game concept at the left side (see fig. 1) was preferred by 18 out of 20 preschoolers, who described it as "a nice story" and "It's funny" and provided explanations such as: "The dog can do it, he's strong ", "I want to be the dog", "I want to be the girl", "It's funny cause the cat is made of iron", etc. While these justifications lacked depth, the dominance of preference for the first game over the other two game concepts was surprising. Again, a more extensive rationale behind the three game concepts as well as an account of the focus groups will be given at the Fun and Games workshop.

Game development

Currently, the game is being developed, with two iterative playtests after approximately three months and six months of development.

Again, the latest results of the play tests as well as the game in its latest format will be presented at the workshop.

SUMMARY

To summarize, the final goal of DYSL-X is the use of the game as an assessment tool for detection of children with high risks of developing dyslexia, in all school psychology services and clinical diagnostic and rehabilitation centers in Flanders. At the moment, we are in the middle of the game development process. During the workshop, we will present the intermediate results of this phase in the project.

REFERENCES

1. Barendregt, W., Bouwhuis, D., de Ridder, H., and Bekker, M. Evaluating fun and usability in computer games with children. 2006. http://library.tue.nl/catalog/LinkToVubis.csp?DataBib=6:602065.
2. Boets, B., Ghesquière, P., van Wieringen, A., and Wouters, J. Speech perception in preschoolers at family risk for dyslexia: Relations with low-level auditory processing and phonological ability. *Brain and Language 101*, 1 (2007), 19–30.
3. Boets, B., Wouters, J., van Wieringen, A., Desmedt, B., and Ghesquière, P. Modelling relations between sensory processing, speech perception, orthographic and phonological ability, and literacy achievement. *Brain and Language 106*, 1 (2008), 29–40.
4. Boets, B., Wouters, J., van Wieringen, A., and Ghesquière, P. Auditory temporal information processing in preschool children at family risk for dyslexia: Relations with phonological abilities and developing literacy skills. *Brain and Language 97*, 1 (2006), 64–79.
5. Boets, B., Wouters, J., van Wieringen, A., and Ghesquière, P. Coherent motion detection in preschool children at family risk for dyslexia. *Vision Research 46*, 4 (2006), 527–535.
6. Boets, B., Wouters, J., van Wieringen, A., and Ghesquière, P. Auditory processing, speech perception and phonological ability in pre-school children at high-risk for dyslexia: A longitudinal study of the auditory temporal processing theory. *Neuropsychologia 45*, 8 (2007), 1608–1620.
7. Csikszentmihalyi, M. *Flow: The Psychology of Optimal Experience*. Harper and Row, New York, 1990.
8. Eder, D. and Fingerson, L. Interviewing children and adolescents. *Handbook of interview research: Context and method*, (2002), 181–201.
9. Fawcett, A. and Nicolson, R. *Dyslexia in Children: Multidisciplinary Perspectives*. Harvester Wheatsheaf, 1995.
10. Fuchs, M. Children and Adolescents as Respondents. Experiments on Question Order, Response Order, Scale Effects and the Effect of Numeric Values Associated with Response Options. *Journal of Official Statistics 21*, 4 (2005), 701–725.
11. Golafshani, N. Understanding reliability and validity in qualitative research. *The qualitative report 8*, 4 (2003), 597–607.
12. Hanna, L., Neapolitan, D., and Risden, K. Evaluating computer game concepts with children. *Proceedings of the 2004 conference on Interaction design and children: building a community*, ACM (2004), 49–56.
13. Laneau, J., Boets, B., Moonen, M., van Wieringen, A., and Wouters, J. A flexible auditory research platform using acoustic or electric stimuli for adults and young children. *Journal of Neuroscience Methods 142*, 1 (2005), 131–136.
14. Markopoulos, P. and Bekker, M. Interaction design and children. *Interacting with Computers 15*, 2 (2003), 141–149.
15. Morgan, D. *Focus Groups as Qualitative Research*. Sage Publications, Inc, 1996.
16. Nicolson, R.I. and Fawcett, A. *Dyslexia, Learning, and the Brain*. The MIT Press, 2008.
17. Patton, M.Q. *Qualitative Evaluation and Research Methods*. Sage Publications, Inc, 1990.
18. Vanden Abeele, L.R., De Schutter, B., Geurts, L., et al. P-III: A player-centered, iterative, interdisciplinary and integrated framework for serious game design and development. Springer-Verlag (2011).
19. Vanden Abeele, V. and Zaman, B. The Extended Likeability Framework: A Theoretical Framework for and a Practical Case of Designing Likeable Media Applications for Preschoolers. *Advances in Human-Computer Interaction 2008*, Article ID 719291 (2008), 11.
20. Vanden Abeele, V. and Zaman, B. Laddering the user experience! *User Experience Methods, Interact 2009, Uppsala, Sweden*, (2009).
21. Zaman, B. and Vanden Abeele, V. Towards a likeability framework that meets child-computer interaction & communication sciences. *Proceedings of the 6th international conference on Interaction design and children*, ACM (2007), 1–8.
22. Zaman, B. and Vanden Abeele, V. How to Measure the Likeability of Tangible Interaction with Preschoolers. *Proceedings of CHI.NL*, Infotec Nederland BV Woerden (2007), 57–59.
23. Zaman, B. and Vanden Abeele, V. Laddering with Young Children in User eXperience Evaluations: Theoretical Groundings and a Practical Case. *Interaction Design and Children*, (2010).
24. Zaman, B. Introducing contextual laddering to evaluate the likeability of games with children. *Cogn. Technol. Work 10*, 2 (2008), 107–117.
25. Zaman, B. Introducing a Pairwise Comparison Scale for UX Evaluations with Preschoolers. In *Human-Computer Interaction – INTERACT 2009*. 2009, 634–637.