Application Playing Behavior patterns of Individuals with Intellectual Disability

Julia Birgersson, Gustav Cederblad, Hanna Fridholm, Johan Karlsson, Oscar Lundblad, Malin Spaniol

Linköpings Universitet

Abstract

By using log data from a tablet application of which purpose is to aid and improve planning skills, the behaviors of individuals with intellectual disability (ID) were compared to those of typically developing (TD) children. The behaviors we have focused on are, *active play*, *cognitive flexibility* and *reward*. These behaviors were manifested in the data in different patterns, for example how much time passed between clicks, length of sessions, clicks per session and more. The results show that individuals with ID have lower playing activity than TD individuals. The individuals with ID also had a much lower playing activity in the early sessions of the study than the TD individuals. Furthermore, the results showed that there was an increasing playing activity when rewards were utilized. Moreover, the ID group improved as much and even surpassed the TD group when comparing error rate at the first tasks with the last tasks in the application. From this we have concluded that the participants with ID do improve using the application, were more careful and scared of wrongdoing or less motivated to play when first introduced to the application and are more susceptible to rewards.

Introduction

Application playing behavior and strategy use while playing is a new research field that has been rarely looked at in the combination with intellectual disability (ID). Our work is based on an application aimed to improve planning behavior. However, our research does not focus on the planning skills of individuals with ID but on their playing behavior. Our aim is to find patterns describing typical playing behavior of individuals with ID to further the knowledge of designing applications for individuals with ID.

In the past, several studies were conducted, which claim that individuals with ID have problems switching between tasks, changing strategies and solving problems (Danielsson, Henry, Rönnberg & Nilsson, 2010). Moreover, there is research about the importance of reinforcement learning in individuals with ID (Ellis, 1963). Furthermore, there are studies investigating the correlation between cognitive flexibility and IQ. Some claiming that there is a correlation, others claiming that there is none (Willner, Bailey, Parry & Dymond, 2010).

The participants played with an application focused on testing and improving their planning ability. The data analyzed is collected over several playing sessions. We wanted to investigate if we could find patterns in the data which would support or object the previously mentioned theories and if so, how they could help when designing an application for individuals with ID. Therefore, we wanted to look at whether and how individuals with ID use strategies, if there

is a correlation between their IQ, their cognitive flexibility and their playing performance and how important rewards are for them, how actively they play. We compare their patterns to the data of a control group of typically developing (TD) children with approximately the same mental age.

Planera mera

The application that was used in this study is called Planera mera. The purpose of the application is to help individuals with intellectual disability to become better in their everyday planning. The application is a result of Palmqvist (2014) research about Assistive Technologies for Cognition. The application has since then evolved and is now being evaluated on individuals with ID and TD children.

The tasks in the game are related to everyday planning. There are three difficulty levels in the game. To complete one level, the user must perform a variety of tasks.

The application was tested on 26 (*17 female, M =17.96 years, SD = 1.46*) adolescents with ID and 31 (*17 female, M =7.47 years, SD = 0.97*) TD children to see if their planning skills improve after playing with the application 15 minutes every school day for one month. The selection was a convenience sample from schools in Sweden.

Theoretical background

ID commence early in life and appears by limiting the mental functioning. These limitations become visible in intelligence tests (IQ), where ID individuals perform below average. Their abilities to take care of their everyday life and to interact socially is also below average (Saridaki & Constantinos, 2014).

Active play

When designing an application, it is important to know whether it is used actively or not. If it is not used actively it could be because users get bored, that the task is monotonous or that the task is too challenging.

Individuals with ID have shown to be more prone to participate in activities that involve self-improvement and that they prefer to engage alone. (King, Shields, Imms, Black & Ardern, 2013). It has also been shown that individuals with ID often have difficulties with motivation, due to the expectation of negative outcome when performing a task within a field that is directly affected by their disability. (Sardidaki & Constantinos, 2014).

Cognitive flexibility

The ability to shift from one task to another or from one strategy to another quickly is attributed to our cognitive flexibility. Cognitive flexibility is considered a component of the executive functions (EF), (Yu & Pan, 2016) which Anderson (1998) defines as “those skills necessary for purposeful, goal-directed activity” (p.119). Scott (1962) defines cognitive flexibility as “the readiness with which the person's concept system changes selectively in response to appropriate environmental stimuli” (p. 405). In other words, cognitive flexibility involves activation in cognitive processes that allows for adjustments in attention, selecting information, consideration and planning of past and future events. An individual that can change his/her behavior from one task to another or to change strategy in problem solving with good results is considered cognitively flexible.

In complex planning tasks that require goals and sub goals, people with lower EFs tend to perform worse than their peers

with higher EFs. People with executive dysfunction have problems to act impulsively and usually get stuck in well-learned behavior (Rattermann, Spector, Grafman, Levin & Harward, 2001). They have inferior ability for strategic changes in problem solving and tend have problems to adapt their behavior in new situations.

We wanted to test how cognitive flexibility correlates with an individual's tendency to change strategy while using Planera mera. Earlier research suggests that participants that perform well on the cognitive flexibility test will perform better in the sorting tasks in the Planera mera application, i.e. will make less mistakes.

Reward

When designing an application, it can be useful to know whether rewards within the game could influence the player's motivation or not.

Humans have an ability to learn and change their behavior based on the outcomes of their actions. Actions that generate positive outcomes and feelings of enjoyment have a high probability of occurring again further on, while actions with negative outcomes have a low probability of occurring again. This is an ability that is important throughout life, and this skill is known as reinforcement learning (Holroyd & Coles, 2002). Especially children have difficulties with reinforcement learning when they must obtain new behaviors to manage a task (Shephard, Jackson & Groom, 2014).

According to Ellis (1963) reinforcement learning is important for individuals in general and for individuals with ID in particular, since it can lead to both motivation and drive. We wanted to see if the rewards within the game influenced the participation of the participants.

Method

Planera mera generates log files in the JSON format. Therefore, we made a script that converted the data so that it could be opened in MySQL. Using MySQL, we were able to extract the relevant data. This data was then processed by using custom made Python scripts. Lastly, all the data was put together in Excel documents, which made it possible to get an overview of the data to understand and to proceed with further analysis. By using Excel and SPSS the statistical analysis could be performed. we then compared the participants with ID to the TD participants.

Active play

By identifying the first and the last click every session, it was possible to calculate the elapsed time. Sessions shorter than one minute were considers as outliers and thereby excluded. To compare the ID and TD participants, we needed to calculate the mean level of active play for both groups. This was done by calculating the mean number of clicks for every session. The data was the plotted in two different graphs, one for the ID participants and one for the TD participants.

Cognitive flexibility

We wanted to see how likely it is that the participants learn from their mistakes within the application. This will allow us to compare if there is a significant difference between the participants with ID and the TD participants. A comparison between the error rate at the start sessions with the error rate at the end sessions within each group allowed us to see if they improved. We also compared the two groups to see if one group improved more than others. Finally, we examined if

improvement is related to the participants' cognitive flexibility.

Reward
The application has a reward system where the user, after finishing several tasks, gets a new item. All the items a user get are saved in a separate room called the rocket. It is of high interest to us to find out whether the rewards play an important role for how actively the participants use the application.

To see if the reward influenced the active play we wanted to compare how much the individuals visit the rocket and how actively they played. To do that we extracted the number of times each participant visited the rocket and merged that with the data from the active play-behavior.

Results

Active play
The results regarding clicks per session show that the ID group starts with 5.40 clicks per minute, while the TD group starts at 7.64 clicks per minute. The TD group plays more consistently than the ID group, but in the mid-session both groups have similar clicks per minute. During the end sessions, the clicks per minute is lower than the initial clicks per minute among the TD group, but not for the ID group. Participants with ID had a mean of 7.45 clicks per minute (SD = 4.63) while TD participants had a mean of 7.91 clicks per minute (SD = 3.25).

Cognitive flexibility
The results show that both groups decreased in error rate when compared to the error rate of the beginning sessions with the error rate in the end sessions. The ID group improved more than the TD group when comparing the error rate in the first 25 % tasks with the error rate of the last 25 % of tasks. The results also show that the ID participants had problems with tasks containing 2 items and the TD participants had problems with tasks containing 5 items.

Reward
A Pearson correlation coefficient (PCC) test was made to see if there was any correlation between the average rocket visits per session and the average clicks per minute. The result showed that there was a significant correlation between the average rocket visits per session and the average clicks per minute, $r(23) = .60$, $p < .001$. The correlation is illustrated in figure 1.

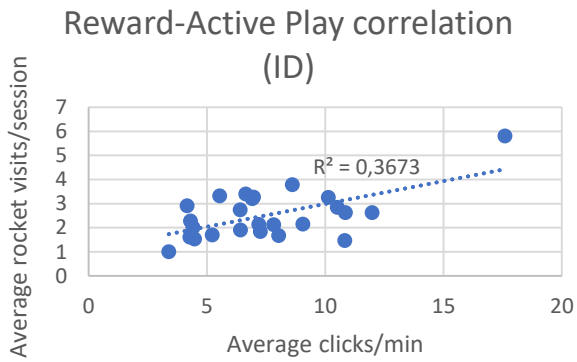

Figure 1. Correlation between the number of rocket visits and clicks per minute to illustrate how rewards change the level of active play for participants with ID.

The same analysis was made on the data from the TD participants and showed the results: $r(25) = .39$, $p < .05$. The results show a weaker and less significant correlation than that of the ID participants. This is illustrated in figure 2.

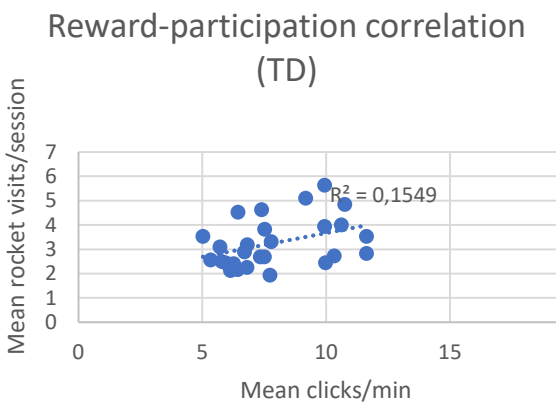

Figure 2. Correlation between the number of rocket visits and clicks per minute to illustrate how rewards change the level of active play for TD participants.

Discussion

Active play
According to the results, the ID participants have a less stable level of activity than the TD participants. The ID individuals are less active the first days of playing the game, and after during the mid-sessions they start to play about as actively as the TD participants. The initial low clicks per minute among the ID participants could be due to a, as described in theory, a low motivation to play the game or the participants are scared of wrongdoing and play more carefully than the TD group.

Cognitive flexibility
Although earlier research indicated that the TD children would improve more than the ID individuals, our results show the opposite. The reason for this could be that the TD children got bored and therefore were less motivated to perform their best as time progressed.

Although the results in the application improved as time passed it does not necessarily mean that the cognitive flexibility improved. It could be a sign of the participants learning how the application works… The fact that the active playing of the ID group increased is however a sign that they could have changed their use of strategy. In the beginning, they had a hard time changing their strategy and thereby played more passively. After using the application for a while they started playing more actively which could point to a trial-and-error behavior. In other words, after using the application, they started to adapt a different strategy.

Reward
When examining the correlations between mean rocket visits per session and mean clicks per minute we can observe a difference between the ID and TD participants. There is a stronger correlation between the number of rocket visits and the number of clicks per minute for the ID participants than the TD participants. This could mean that the ID participants tend to play more actively when they visit the rocket more often. Which could indicate that reward play a bigger role for motivation for ID individuals.

Conclusions

From the results, we can conclude that the TD group play more actively than the ID group, especially in the beginning. This is because the ID group is either scared of wrongdoing and play more carefully or that they have a low motivation to play the game initially.

The results from the reward behavior indicates that the ID group were more susceptible to reward. The participants with ID that engaged with the extrinsic rewards in the game also played more actively. This indicates that extrinsic reward is important when designing learning applications for children with ID since it motivates the players to play more actively.

We can also conclude that ID participants do improve using the application.

References

Anderson, V. (1998). Assessing executive functions in children: biological, psychological, and developmental considerations. Pediatric Rehabilitation, 119-136.

Danielsson H., Henry L., Rönnberg J., Nilsson L. (2010) Executive functions in individuals with intellectual disability, *Research in Developmental Disabilities,* 1299-1304.

Ellis, N. R. (1963). *Handbook of mental deficiency: Psychological theory and research*. New York, NY, US: McGraw-Hill.

Holroyd, C.B., Coles, M.G.H., 2002. The neural basis of human error processing: reinforcement learning, dopamine, and the error-related negativity. Psychol. Rev. 109, 679–709.

King M, Shields N, Imms C, Black M, Ardern C.(2013) Participation of children with intellectual disability compared with typically developing children. Res Dev Disabil. 2013;34(5):1854–62. doi: 10.1016/j.ridd.2013.02.029.

Palmqvist, L. (2014). Executive functions and Planning in everyday life: Assistive Technologies for Cognition and their lack of support for children with Attention Deficit / Hyperactive Disorder.

Rattermann, M., Spector, L., Grafman, J., Levin, H., & Harward, H. (2001). Partial and total-order planning: evidence from normal. *Cognitive Science*, 941-975.

Saridaki, M., Constantinos, M. (2014) Flow, Fun and Frame in the Classroom: Redefining the Engagement and Self-Determination of Students with Intellectual Disability through Games. *2014 International Conference on Interactive Technologies and Games, Interactive Technologies and Games.*

Scott, W. A. (1962). Cognitive Complexity and Cognitive Flexibility. *Sociometry*, 405-414.

Shephard, E., Jackson, G., & Groom, M. (2014). Learning and altering behaviours by reinforcement: Neurocognitive differences between children and adults. *Developmental Cognitive Neuroscience*, *7*94-105.

van de Sande, E., Segers, E., & Verhoeven, L. (2015). The role of executive control in young children's serious gaming behavior. *Computers & Education*, *82*432-441.

Yu, H., & Pan, X. (2016). Different Effects of Cognitive Shifting and Intelligence on Creativity. *Journal of Creative Behavior*