The Good Mobile: Facilitating Human Relations Using an Ethologically Grounded Attachment Model

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Final report

1 General introduction

The aim of the current project was to develop a proactive mobile phone launcher (user interface) for children with scientifically validated social facilitation properties. Children tend to use mobile phones at an increasingly early age; many start using them before age 1 (!) (Kabali et al., 2015). Young children need hands-on exploration and social interactions with trusted caregivers and peers to develop their cognitive, language, motor, and social-emotional skills. In particular, good quality social interactions (mainly with parents (Csibra & Gergely, 2009), but also with siblings/peers) are necessary for the normal development of skills in children (McAlister & Peterson, 2007; O'Connor & McCartney, 2007; Pears & Moses, 2003). However, activity on mobile phones may replace other kinds of activities (Vandewater et al., 2007), including social interactions. On the other hand, it is also clear that early mobile use can also improve some skills. For example, the usage of touchscreen improves fine motor skills in children (Bedford et al., 2016), and computer games improve spatial skills (Subrahmanyam & Greenfield, 1994), or iconic representations (Greenfield, Camaioni, et al., 1994). Therefore, our aim was to retain the potential advantages yet to move forward. We developed the "Good Mobile" which we think is a pioneer of a new generation of interactive mobile phones which do not replace, but directly facilitate social interactions and offline activities.

We believe this role could be achieved most effectively if mobile phones (i.e. the interfaces used) would act as if they were personalized agents with emotions and attachment towards the user. Ethological research has shown that artificial agents showing emotions and attachment are perceived more lifelike and hence, they could have more influence on the user's behaviour than simple messages (Backer et al., 2005; Bruce et al., 2002).

Based on the above, our aim was to develop an application launcher (a "Good Mobile" interface) for 4-6 years old children and their parents, which contains:

- an Attachment Activating System (AAS)
    - which facilitates parent-child interaction (e.g. by providing games in which children have to ask for help from the parent; games that they have to play together, etc.)
    - feedbacks for the parents about the child's activities, achievements, improvements, etc.
- an ethological emotion module
- an ethological attachment module
- skill-improving games
- an offline living facilitator: fostering physical activity (e.g. by tasks and games) as well as physical interaction with peers (by including activities in real life).

All of these functions have been addressed during the three years of the project: many of them have been fully integrated, some of them partly. The first version of the launcher is released and tested, and the second version (with the above functions fully implemented) is expected to be released in the autumn of 2021.

2 Determining the target skills of the "Good Mobile" (basic human ethological studies)

At the beginning of the project we had to determine which skills are affected negatively by the use of mobile touch screen devices (MTSDs), as these skills should be developed by the "Good Mobile", Alphie. Therefore, we carried out two studies to investigate 1) the association between pre-schoolers' MTSD use and attentional and socio-cognitive skills, 2) the effects of a digital game (vs. a non-digital one) and the speed of the game on attentional processes.

2.1 Differences in the skills of mobile device user and non-user children

2.1.1 Introduction

MTSDs may influence cognitive development as they present a different type of sensorimotor stimulation than do traditional activities or toys. A frequent concern regarding the effects of electronic media use in children is that it may lead to attention problems, with empirical findings confirming this concern (for a review see Beyens, Valkenburg, & Piotrowski, 2018). MTSD use is frequently associated with multitasking (i.e., simultaneous consumption of more than one stream of content) even in childhood (Kabali et al., 2015). Repetitive multitasking, in turn, decreases the ability to filter out irrelevant information, that is, selective attention ability (Ophir, Nass, & Wagner, 2009). On the other hand, frequent multitasking may also improve divided attention skills.

Playing games on MTSDs may also require more attentional resources to allocate to details, instead of the global pattern. While the typical attentional bias both in children and adults include global advantage and global-to-local interference (i.e. the faster and more accurate detection of targets appearing at a local, as opposed to global level), MTSD users are frequently required to execute very precise movements and to detect fine details, which may attune their attentional system to details (Job, van Velzen, & de Fockert, 2017).

MTSD use may take time away from other, offline activities ('displacement' hypothesis), including ones essential for the appropriate development of socio-emotional skills, such as good-quality social interactions with caregivers (Dunn, Brown, & Beardsall, 1991; Fonagy, Steele, Steele, & Holder, 1997) or social, "pretend" and dramatic play (Ashiabi, 2007; Burns & Brainerd, 1979; Lindsey & Colwell, 2003). Indeed, the data do show that children who spend more time viewing TV, spend less time with their parents and siblings and with creative play (Vandewater, Bickham, & Lee, 2006). Similarly, more background-TV time is related to fewer and lower quality parent-child interactions (Kirkorian, Pempek, Murphy, Schmidt, & Anderson, 2009). As such, the use of both older and newer types of media negatively affects socio-cognitive and socio-emotional skills (Raman et al., 2017; Nathanson et al., 2013).

Based on these findings, we were interested in whether MTSD use can affect attentional and socio-cognitive development. In a cross-sectional study, we investigated whether frequent MTSD user pre-schoolers (those who use the MTSD for at least 15 minutes per day) exhibit different attentional and socio-cognitive skills compared to non-users (i.e., those who have not used MTSDs earlier, on more than just a few occasions).

2.1.2 Method

40 pre-schoolers (median age: 5 years; IQR=4.64–5.56; 22 girls and 18 boys) participated in the study: 20 Users and 20 Non-users. The median time Users spent using MTSDs was 45 minutes per day (IQR= 21.1-168.9) and they had been using the MTSD for 3.05 ± 0.97 ($M \pm SD$) years (range: 1.12-5.72).

Behavioural tests were administered to measure attentional control (selective versus divided attention, global versus local processing) and socio-cognitive/socio-emotional skills.

To assess selective and divided attention and the global/local processing of hierarchical stimuli, an adapted, preschool version (Sjöwall, Backman, & Thorell, 2015) of the Navon test (Navon, 1977) was modified and used. In a computerized task (programmed by Bence Ferdinandy) the children were presented with large shapes (sun, star, snowman) made up of (congruent or incongruent) small shapes (sun, star, snowman; see Figure 1). Children had to respond by pressing one of two buttons, depending on whether a target shape (sun) was present. In the selective-local session children had to indicate the presence of target shape only if it appeared at the local level (i.e., as small shapes), in the selective-global session only if it appeared at the global level (i.e., as a large shape), and, in the divided session, if it appeared either at the global or at the local level. Reaction time (on correct trials) was used as a dependent variable.

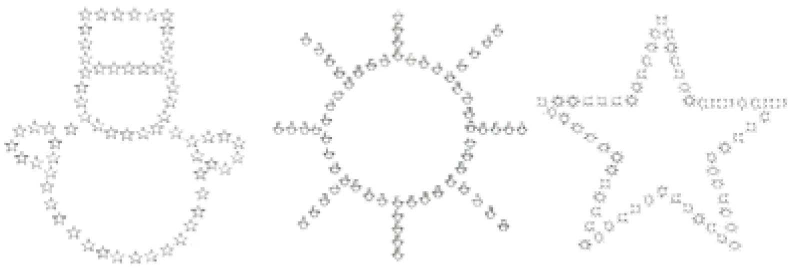

Figure 1: Examples of the composite shapes used in the Navon test

Two tasks were used to measure theory of mind (ToM) skills. The Contents false belief task (Gopnik & Astington, 1988; Hogrefe, Wimmer, & Perner, 1986) measures children's ability to attribute a false prior belief to themselves and to comprehend that another person could also have a false belief. Children were shown a small container that contained an unexpected object. Children were allowed to look in the container and asked to (1) recall what they believed the container contained before having seen the unexpected object and (2) indicate what they believed another person, who has never seen the contents, would have thought was in the container.

The Real-apparent emotion task (Harris, Donnelly, Guz, & Pitt-Watson, 1986; Wellman & Liu, 2004) is designed to measure whether children understand that overt behavior can differ from covert mental state; children have to recognize that a person can display one emotion but feel another. Scores for the test questions in the Contents false belief task and the Real-apparent emotion score were summed to create a ToM score (ranging from 0 to 3) used as a dependent variable in the analyses.

Emotion recognition skills were measured by static facial displays (Radboud Faces Database; Langner et al., 2010) and dynamic gestural displays (EU-Emotion Stimulus Set; O'Reilly et al., 2016), portraying five basic emotions (anger, fear, happiness, sadness and surprise), presented on a laptop. In both tasks, children had to name the portrayed emotion. Across the tasks, scores for each correctly recognized emotion were summed to form an emotion recognition score (ranging from 0 to 15).

2.1.3 Results

In the selective attention task of the Navon test, those children performed better (i.e., had a shorter reaction time) who had to indicate the target shape on the global as opposed to the local level, independently of the group (Users vs. Non-Users) or of the place where the target actually appeared (GLMM; $F_{1,562}$=8.270; p=0.004).

However, when children had to pay attention to both the small and the big shape (divided attention task), there was a significant interaction effect between group and the level of appearance of the target shape (GLMM; $F_{3,266}$=3.916; p=0.009): Users, relative to Non-users, reacted slower when the target shape appeared at the global level, but there was no between-group performance difference in the other three trial types (Figure 2).

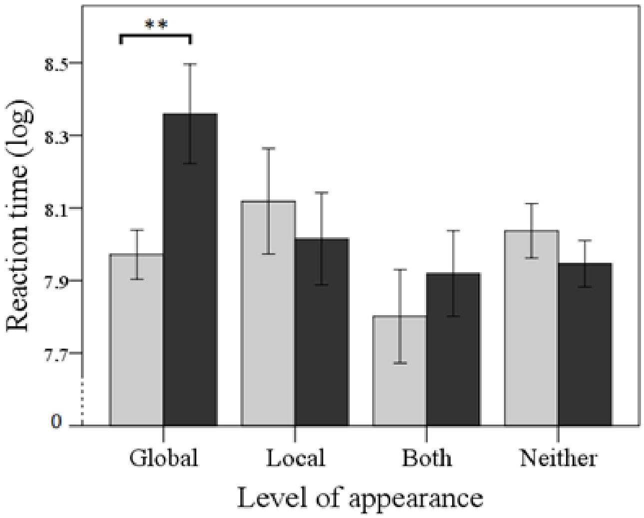

Figure 2: Log-transformed reaction time (mean ± SE) in the divided attention task of the Navon test. Bars indicate different levels of appearance (global; local; both; neither) of the target shape for Users (black), and Non-users (grey), separately.

Regarding the socio-cognitive and -emotional skills, Users and Non-Users did not differ in the emotion recognition skills (linear regression; X^2=0.175; p=0.676), but Users performed poorer in the ToM tasks (ordinal regression; X^2=3.915; p=0.048).

2.1.4 Discussion

The results show that MTSD use is associated with a typical, global precedence in selective attention tasks, but an atypical, local precedence in a divided attention task. This may be attributable to MTSD use often requiring focus on fine details and the execution of precise motor movements, thereby enhancing attention to local stimulus features (Job et al., 2017). Additionally, digital screens reveal only a portion of the entire picture or stimulus at a time (one has to scroll downwards or upwards for the entire image; Manguel, 1996) and in contrast to printed documents, where flipping and scanning helps us get a sense of the whole text, scrolling on a computer screen does not support this mode of information processing (Liu, 2005).

MTSD use was not associated with emotion recognition but was associated with a lower level of theory of mind. The development of ToM skills requires considerable experience with social interactions and non-digital play, and device use takes time away from these activities (Vandewater et al., 2007). Previous findings also showed similar effects of excessive media use: higher TV exposure has been linked to poorer ToM performance in pre-schoolers (Nathanson et al., 2013).

The study confirmed that the “Good Mobile” should facilitate social and offline interactions, and (as much as possible for an artificial agent) substitute for the lack of social experience (by interactivity and emotional expressions) to enhance the user children’s socio-cognitive development. Many functions of the “Good Mobile” are based on this insight (see below).

Additionally, although the local precedence shown by Users cannot be regarded unequivocally as being negative (they might as well perform better in certain areas of life later, e.g. in engineering), we aimed to integrate games into Alphie where the entire picture can be seen at a time (no scrolling is necessary, no changes of the scenes occur, etc.).

2.2 Testing the effects of digital vs. non-digital games and game speed

2.2.1 Introduction

As the previous study was purely observational, we cannot make conclusions about causality. Long-term experimental studies are not feasible in this field due to ethical reasons, but very short exposures to digital contents could only have short-term, transient effects. Therefore, in a second, experimental study we tested whether exposing children for some minutes to a digital game affects subsequent attentional processes (as compared to children who have been exposed to a non-digital game). Although in adolescents and adults, video game use is associated with better visual attention (for a review see Green & Bavelier, 2008), in children it is associated with later attentional problems (e.g., Swing, Gentile, Anderson, & Walsh, 2010). One of the most frequent MTSD activities is playing games (Konok et al., 2020), and in games, the entire picture cannot usually be seen at once (e.g. the scenes are changing as the character moves around), thus, it can be assumed also in the case of video game playing that the focus of attention shifts toward the details.

Additionally, we were interested in the specific mechanisms that may play a role in the effects of MTSD use on attention. One of the characteristics of digital contents (videos, games) is that they contain fast-paced, simultaneous and rich stimuli, with a high frequency of attention-grabbing, perceptually salient features (Gentile, Swing, Lim, & Khoo, 2012; Goodrich, Pempek, & Calvert, 2009), making some to assume that these contents overstimulate the developing brain and result in impaired cognitive functions (Christakis, Ramirez, & Ramirez, 2012). Thus, we aimed to investigate whether game pace moderates the observed effects of the digital game on attention.

2.2.2 Method

We recruited children independently of whether they have been using MTSDs before. The final sample consisted of 56 children (32 girls; median age= 4.9, IQR= 4.6-5.52) who were randomly assigned to one of three groups receiving different treatments:

1. *Slow digital treatment* (*n*=19): children played with a digital game on a tablet (balloon game, slow mode).

2. *Fast digital treatment* (*n*=17): children played with the same digital game on a tablet as in the slow digital treatment, but the game had a faster speed (balloon game, fast mode).

3. *Non-digital treatment* (control condition; *n*=20): children played with a non-digital game that was similar in many respects to the digital games, albeit with more variable speed (whack-a-mole).

Digital game:

As part of the informatics subproject, we developed a balloon popping game where colourful ellipses rise from the bottom of the screen to the top, and the child has to touch them to make them explode. If the child succeeds in exploding a balloon, the balloon disappears accompanied by an explosion sound and an animation. (Later we integrated this game into Alphie.)

The game had configuration parameters, thus, the experimenter could adjust the lifting speed (i.e., how much time it took for the balloons to reach the top of the screen from the bottom) and the pop-up interval (the time interval between two consecutive balloons to appear). Lifting speed was 5 sec in the slow treatment, and 3 sec in the fast treatment, whereas the pop-up interval was 850 msec in the slow treatment and 600 msec in the fast treatment.

Non-digital game:

In the non-digital game, a whack-a-mole game, the child has to push down moles that are popping up, using their fingers. If the child succeeds in the right moment (when the mole is in the upmost position), then the game makes a sound (music). Therefore, the game is very similar to the digital balloon game, except that it does not appear on a digital, two-dimensional screen but in the three-dimensional reality. The speed of this game was more variable than that of the digital games: the pop-up interval (time duration between mole pop-ups) varied between 100 and 2800 msec.

The experiments consisted of treatment and measurement phases. The treatment was divided into 2-minute-long blocks, and each block was followed by a 3-4-minute-long block of measurement and a short break. The measurement was the Navon test described above, but we optimized it for playing on tablet devices. Response accuracy was used as an index of performance.

2.2.3 Results

Response accuracy was affected by the interaction of test type (selective-global/ selective-local/ divided) and treatment (GzLMM; $F_{4,2452}=2.661$; $p=0.031$). In the non-digital group, children tended to perform better on selective-local and selective-global test types than on the divided attention test type (GzLMM; $F_{2,857}=2.715$; $p=0.067$). In the slow digital group, this difference was more pronounced (GzLMM; $F_{2,920}=11.308$; $p<0.001$). However, in the fast digital group, performance was not different across test types (GzLMM; $F_{2,675}=0.146$; $p=0.864$; Figure 3).

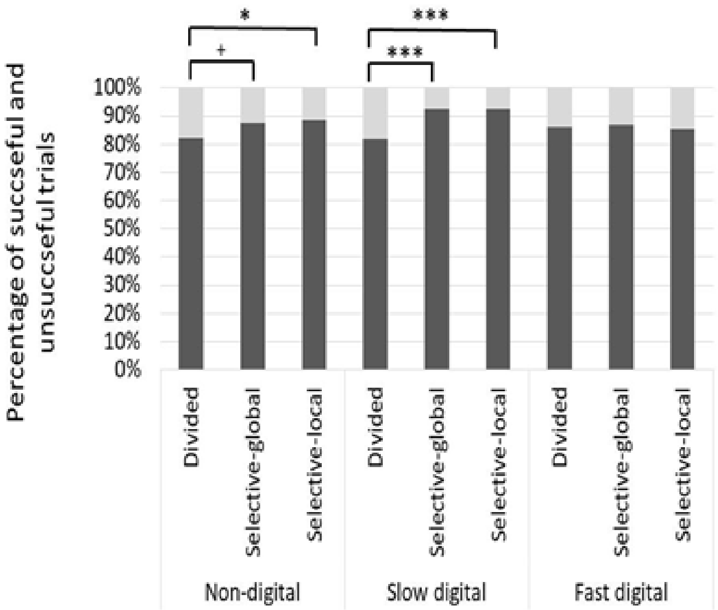

Figure 3: Percentage of successful and unsuccessful trials (i.e., whether the child pushed the correct button or not) in different test types (divided; selective-global; selective-local), depicted separately for children in different treatment groups (non-digital; slow digital; fast digital). Dark grey colour indicates successful trials, light grey colour indicates unsuccessful trials.

In the divided attention test, there was a significant effect of the interaction of target level (whether the "sun" appeared at the global, local, both or neither level) and treatment on response accuracy (GzLMM; $F_{6,793}$=2,202; p=0.041; Figure 4): the differences between local and global trials in the digital groups were in the opposite direction (local > global) compared to the non-digital group (global > local). Separate models for each treatment indicated this difference was significant in the slow digital group only (non-digital: $F_{1,135}$=2.544; p=0.113; slow digital: $F_{1,144}$=12.063; p=0.001; fast digital: $F_{1,106}$=1.779; p=0.185). Comparison of the same target levels across treatment groups (i.e., the reverse of the above analyses) showed that child performance on global trials was better in the non-digital group than in the slow digital group, but their performance did not differ across treatments in local trials (local: $F_{2,192}$=1.827; p=0.164; global: $F_{2,193}$=3.075; p=0.048).

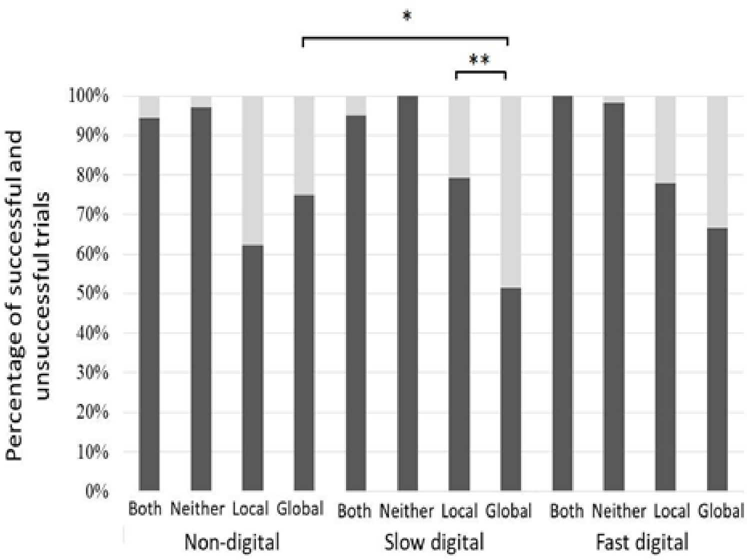

Figure 4: Percentage of successful and unsuccessful trials (i.e., whether the child pushed the correct button or not) in different target level appearance (both; neither; local; global), depicted separately for different treatment groups (non-digital; slow digital; fast digital). Dark grey colour indicates successful trials, light grey colour indicates unsuccessful trials.

In selective attention tests, only target level had an effect on response accuracy (GzLMM; $F_{3,1652}$=15.693; p<0.001) with better performance in "neither" and "both" trials than in local and global trials.

2.2.4 Discussion

The results of this study provide experimental support for the findings of the observational study, whereby in the selective attention task, children in all groups showed a global precedence. However, in the divided attention task, children who played with a digital game showed a local precedence in contrast to children who played with a non-digital game.

Further, playing with a fast digital game eliminated the advantage of selective attention over divided attention observed in the non-digital and slow digital game conditions. Perhaps having to attend simultaneously to multiple stimuli in the fast game trains divided attention (and thus leads to subsequent improvement in performance), but not selective attention. Consistent with this hypothesis, prior results show that in adults, greater experience with videogames is linked to better divided attention skills (Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994; for a review see Bediou et al., 2018), and frequent videogame-player pre-schoolers react more quickly than do non-players in a parallel-processing task (Yuji, 1996). Nevertheless, our experimental setup does not allow for distinguishing whether it was divided attention per se that improved or the selective attention that decayed, or both (whereas neither change was significant). As multitasking has been found to be associated with more limited selective attention (Ophir et al., 2009), it is also plausible that the fast digital game deteriorated this skill. Although we have assumed that the fast digital game will be overstimulating and cause a decrement in general performance (but this was not confirmed), it seems to affect attentional control in a subtler way, and not necessarily in a negative direction. However, longer use or games that are more stimulating than the balloon game may lead to different effects, thus, we avoided integrating overstimulating contents into the Good Mobile.

As the results of the two studies described above support each other, we decided to merge them into one manuscript and published them in Computers in Human Behaviours.

3 Development of Alphie, the "Good Mobile" (informatics development)

3.1 General description

Alphie is the main product of the "Good Mobile" project. It was designed to counterbalance the negative effects of early MTSD use and to use the mobile interface for purposes beneficial for children. For this reason, four modules were developed and integrated into Alphie.

1) Ethological emotional and attachment module

   MTSD use is usually a lonely activity, that often substitutes social activities resulting in slower development of socio-emotional skills (Hinkley, Brown, Carson, & Teychenne, 2018; Konok et al., 2021; Raman et al., 2017). Previous studies showed that artificial agents expressing emotion-like responses could be effectively used to improve children's socio-emotional skills (Logan et al., 2019; Rudovic, Lee, Dai, Schuller, & Picard, 2018).

   This ethological emotion and attachment module offers socio-emotional guidance, meaning that Alphie gives nonverbal emotional feedback to the user's behaviour and offers various actions based on predefined attachment centred scenarios. For example, if the child uses the device for a long time, Alphie makes different sounds expressing fatigue indirectly motivating the child to put down the device, as Alphie "got tired".

   The module contains seven basic emotions: happiness, anger, fear, curiosity, sadness, boredom, fatigue. The emotions are expressed with nonverbal, child-friendly sounds (n = 30). The sounds were validated by 87 participants according to the expressed emotional contents. We have also selected colours for the emotional expressions based on psychological/ biological literature, and added vibration to those emotions which entail a higher arousal (e.g. anger).

2) Parental control module: time and content limitations

   Through the parental control module parents could set time limits for children (in a session and per day), and allow which applications will be displayed on the child's device. This module was designed to help parents balance their children's online and offline life, and set a safe environment for online activities through content limitations.

3) Attachment Activating System (AAS) and the offline living facilitator

   Besides that Alphie compensates for the lack of social experience by expressing emotions, an even more important aim was to facilitate the child to develop real social interactions with family members and peers. An Attachment Activating System (AAS) was created to strengthen the parent-child relationship with the help of Alphie. For this purpose, an interactive bedtime story (titled "The Secret of the Blue Door") was created (for which we have contracted a writer and a graphic designer), where the parent and the child participate in a role-play game and create the storyline together. The story takes place in the zoo of Budapest, where the parent and the child are visitors, and they get involved in various magical adventures. At the end of every page, the child and sometimes the parent has to make a decision how they would like to continue the story. Through these decisions children can solve ethical dilemmas according to their age (e.g. report something to the parent or keep it secret) or learn about animals (e.g. children have to choose an animal's favourite food). As reading the entire bedtime story lasts ca. one month, this gives the opportunity to strengthen the parent-child relationship on a daily basis. Parents could also set a daily notification, which reminds them to read the story.

Parent-child reconnecting games are designed and the informatic development has started in cooperation with the Faculty of Informatics, ELTE. In a digital board game, the child and the parent (or the parents) have to complete tasks together, and most of the tasks require them to do things in the offline world (e.g. going out and taking a photo of a flower, going to hike and uploading the GPS track etc.). With this game we would like to facilitate offline activities shared with others. In another game we teach everyday storytelling both to the parent and to the child with the help of images and some predefined story-parts. Storytelling of daily events help structuring the incoming information and forming long-term memory (Jack, MacDonald, Reese, & Hayne, 2009; Reese, 2002; Taumoepeau & Reese, 2013), while sharing experiences is also a good opportunity for bonding with family members (Nelson, McClintock, Perez-Ferguson, Shawver, & Thompson, 2008; Trees & Kellas, 2009). Other games are played online, and they require the child and the parent (or sibling/peer) to cooperate in creating something (e.g. a rhythm or a drawing) together. These games not only facilitate cooperation and social interaction, but creativity as well.

Some of our new game ideas require two devices with their own Alphie instance each and a real-time communication between them. Moreover, we are planning to integrate the measurement of physical distance (inside the same household) between two Alphie-running devices, to help us estimate whether the parent and the child are in the same room, which would be useful in new games and scenarios. With the help of a new grant, we are in the process of contracting developers to implement these features.

4) Skill training games

Alphie contains games that are child-friendly, avoid overstimulation and the necessity of scrolling to strengthen global processing and are designed to train various skills like memory, logic, visuo-spatial skills and creativity. Also, the effects of these games are under scientific investigation, which is rare in the area of game development.

3.2 Branding

For making Alphie, the "Good Mobile" launcher well-known for the public, we have built a brand. Alphie (in Hungarian: Alfi), is referred to our research lab (Alpha Generation Lab) and the target group of our studies, the alpha generation (children born since 2010, surrounded by smart devices from birth). To make Alphie popular and to recruit users for research, we have built a webpage and a facebook page. We also use these platforms to share our results and other news in the field of childhood media use.

The Alphie logo and the application package were accepted as a trademark by the European Union Intellectual Property Office (serial numbers: 018295846, 018295878).

3.3 Measuring user experience with a built-in module

To obtain feedback from children about Alphie, some questions and a playful task were built into the launcher regarding users' experience of Alphie's (1) games, (2) emotional expressions, (3) Alphie as a character:

1. Games can be rated by choosing one of three emojis (sad, neutral, happy). Before the choice the icon of the game is shown accompanied with the question of "How much do you like this game?". This question is read out by the launcher itself.
2. We asked children about what kind of emotions they think Alphie feels when it expresses a certain vocalization. The vocal expressions are played for the children and they can respond by touching one of the seven faces (angry, happy, sad, bored, feared, curious, tired).
3. We aimed to assess whether children attribute agency to Alphie (agentic animisms, i.e. the tendency to attribute biological, artefactual, psychological and perceptual properties to an artificial agent; based on Okanda, Taniguchi, & Itakura, 2019). Questions included whether the child thinks that Alphie can feel things, can think, can get older, etc. Additionally, a playful task was designed, where the children's task is to sort pictures of living/non-living items, Non-living items include objects like a chair and a ball, while living items include a child or a cat (based on Okanda, Taniguchi, & Itakura, 2019). If children perceive Alphie as an agent, they might categorize it as a living item.

These questions are important not only from a user experience (UX) perspective, but they have implications for social robotics and the science of artificial emotions too. Unfortunately, only 30 children answered, and not to all of the questions, thus we could not analyse the data yet. We contracted two UX designers (and psychology students) who worked up solutions to obtain a higher response rate (along with other suggestions to improve Alphie's user experience, as below).

3.4 Measuring user experience with usability tests and interviews

Two psychology students who have considerable work experience in UX design and research helped us in conducting usability tests and interviews with parents and children on their experience with Alphie. The main purpose of this study was to investigate the general attitude towards Alphie, and to assess the possible difficulties during its usage. 9 tests were carried out online with parent-child pairs. Participants' task was to discover all games and functions in Alphie, during which the interviewer observed the participants' behaviour and asked questions if they met difficulties. The parents' attitude was generally positive and they all expressed their need for a reliable and beneficial application for their children. Games were evaluated mainly positively, however, results of the usability tests also declared some weak points of Alphie (e.g. difficulties with setting of the parental control; logic of the exit menu; personalization of the device), which we intend to correct in the future (the UX designers provided us useful suggestions to improve the games' and the launcher's design).

3.5 Technical background

In the beginning of the project, we decided to build Alphie using an open-source software development framework called Apache Cordova, which had a lot of advantages. It generates most of the native code of the application, therefore we could focus on developing the user interface and the logging mechanism. In Cordova applications, the user interface can be developed via web technologies (HTML, CSS, JavaScript), which made the development process easier and faster for us, and this way computer science students from ELTE could build us more games for Alphie. We have been developing our application for Android, but Cordova can also help to make our application available on other platforms in the future, such as iOS.

Besides Alphie, it is worth mentioning that we have built a separate application to fit the needs of the human ethological experiments, that only performs logging tasks and has a simplified user interface. We implemented separate Cordova plugins for the launcher's native functions and the logging mechanism. While the logger application only uses the latter module, Alphie uses both of them. The common logging module retrieves and stores system information, for example the Android version, screen size, volume settings, screen activity, installed applications, etc. Alphie also logs activity of integrated games and the bedtime story, as well as the launcher settings and certain scenarios.

Logging works with a device ID and an individually issued child ID. Log entries are sent via HTTP protocol from the application to a web application on our server, and then they are stored in a database. The logger module in our applications is queueing the gathered log entries in a client side database, and sends them to the server periodically. This way, we do not lose any data due to internet connection or server problems. We developed various export mechanisms into the backend application which aggregate measurements for further processing and analysis.

As we were struggling to find enough participants for the efficacy study, we found that it would be desirable if children without their own device (i.e. those who use their parents' device) could also participate. In PY3, we introduced a user management feature in both the logger application and the research version of Alphie. From this point, multiple users can be added and edited on the user interface, and there is an option to switch between users. Integrated skill-improving games and certain scenarios became user-specific, meaning that they measure and store information separately for each user. All configuration options in Alphie's launcher interface (time limits, selected applications) were also refactored in a way that each user can have different settings. This way a single mobile device is sufficient in families where there are more than one users, and we can differentiate log entries based on user identifiers and the user-switch events. Moreover, we made user identifier an optional field and it is handled on a per-user basis, which enables us to export and process only the data of users who participate in our study (who has user identifier) and ignore the rest of the log entries (e.g. the activity of parents).

4 Human ethological study of the developed launcher (testing the effects of Alphie on children's socio-cognitive and -emotional skills)

4.1 Introduction

Previously (see the first study) we have shown that even short-time MTSD use can have an effect on cognitive skills, and we have also found correlation between lower performance on socio-emotional tests and regular use of mobile devices. In the present study we aimed to replicate the latter finding by comparing socio-emotional skills of nonuser and MTSD-user pre-schoolers. Moreover, in this study we have investigated whether Alphie could counterbalance the negative effects of MTSD use. Socio-emotional skills can be trained with artificial agents, especially to people who have difficulties with social cognition (Logan et al., 2019; Robins et al., 2005; Rudovic et al., 2018). As social cognition is also affected by MTSD use, perhaps because of the displacement effect, we aimed to compensate for the lack of social stimuli during MTSD use through Alphie's own emotional expressions (ethological emotion and attachment module) and through the facilitation of real-life relationships. The latter is achieved via games facilitating bonding with parents and via limiting the time spent with lonely MTSD use.

4.2 Method

We investigated the socio-emotional skills and parent-child relationship of 4-6-year-old pre-schoolers in three groups: in a nonuser group and in two MTSD user groups. MTSD users were randomly assigned to the Alphie group, where participants got Alphie after one month and a control-user group, where they did not get it. We applied a longitudinal design with two test sessions (at the beginning and in the end of the study) and a two-month digital data logging session (in the nonuser group digital data collection phase was missing). Based on our previous results, we assumed that children in the non-digital group outperform children in the control-user and Alphie group at the beginning, but after two months of Alphie use the difference between Alphie users and nonusers decreases or disappears (thus, there will be an interaction between test session and group).

We developed an online screening questionnaire to assess children's use of digital devices, to decide whether they fit into one of our study groups. Participants were included in groups according to the following criteria: nonuser group: no digital device use; Alphie/control user group: digital device use min. 2 hours/week and owning an own Android device.

Pre- and post-assessment tests included two parent-child interaction tests (free play and structured play), ToM and emotion-recognition tests, and a questionnaire about the child's device use, behaviour problems and joint activities in the family (digital as well as non-digital). The ToM and emotion recognition tests included the Smarties/ Content false belief task (inferring own past and other's false beliefs about the content of a closed box, Gopnik & Astington, 1988; Hogrefe, Wimmer, & Perner, 1986), the Real-Apparent Emotion test (differentiating overt and hidden emotions task, Harris et al., 1986; Wellman & Liu, 2004), emotion recognition from pictures and videos (Langner et al., 2010, O'Reilly et al., 2016; Konok et al., 2021) and the Faux pas test (understanding a socially awkward or improper act, Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999). The tests were carried out in a child-friendly setting, and a parent of the child was always present during the test sessions.

In the Alphie and the user-control group we logged the digital activity of children for 2 months. In the second month, parents of children in the Alphie group activated Alphie on the children's own device, while children in the user-control group used their own games and applications as previously. Children in the nonusers group did not use mobile devices during the two months. Logged digital data included information about children's general screen time; how much and how often they played with specific games of Alphie.

So far, we have performed 68 pre-assessment tests (26/22/21 = nonuser/Alphie/control-user) and 52 post-assessment tests (22/15/17 = nonuser/Alphie/control-user). Data collection is still in progress, as we have had difficulties with the recruitment of digital device users because of the strict requirements set by us (at least two hours of device use per week, having an own device on which an Android platform of version 5 or higher is running). Additionally, because of the Covid19 pandemic, we had to suspend testing for 4 months. To reach more participants, we are now offering reward for the participation, and we widened the inclusion criteria (6-year-olds are also eligible, and children can use a device together with other family members as we implemented a multiple user management system), also, we advertised our research at many events (e.g. Researchers' night; "Kis Tudósok Délutánja") and media platforms (at our Facebook page and website; in popular online journals, e.g. Dívány, Mindennapi Pszichológia).

4.3 Analysis and preliminary results

We have carried out a preliminary analysis and found that nonusers performed better than control-users in the complex ToM task (faux pas test) (U = 616.5; $p = 0.013$), but non-users did not differ from the Alphie users (U = 679, $p = 0.17$), and also there was no difference between the performance of Alphie users and that of control users (U = 598,5, p = 0,46) (Figure 5). Despite our assumptions, there was no difference between the user and nonuser groups in the performance in the other ToM tasks (smarties, real-apparent emotion task) and emotion recognition tasks. Moreover, in contrast to our original hypothesis, the interaction between test session and group had no significant effect on ToM and emotion recognition scores.

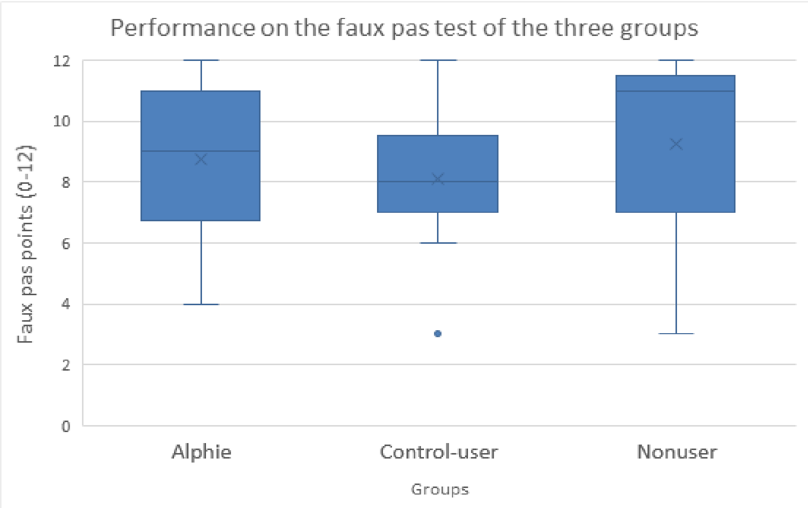

Figure 5. Performance on the faux pas test of the three experimental groups (Alphie, Control-user, Nonuser) on the first test session

4.4 Discussion

With the study we partly succeeded in replication of the previous results according to social cognition, as one of the MTSD user group performed worse in one of the ToM tasks than nonusers. Based on these results, further research and intervention in the field is highly required, as the future of the next generation may depend on that.

Results did not support our assumptions about Alphie's beneficial effects. Beside the fact that data collection is still in progress in the MTSD user groups, one explanation for this result is that, based on parental reports and digital log data, the popularity of the games was uneven, especially compared to other commercial games. This is partly due to the simpler graphic design of Alphie, which we are currently improving. Additionally, most of the parents did not use the parental control and launcher functions in spite of our request. Some parents claimed that they could not restore the original launcher or they did not understand how it works, thus the lack of use could be due to parents' limited technical skills and their uncertainty. We have already discussed these issues with the UX (user experience) consultants and we are working on a solution.

5 Preparation of Alphie as an online research tool

Due to the pandemic, and partly because of our general research purposes, we aim to achieve that Alphie can be used not only for improving, but also for measuring children's skills. This way we could use Alphie as an online research tool, i.e. as a platform for studying many research questions completely online. Experimental treatments (e.g. the usage of an online game, decreasing screen time, etc.) and the tests that measure the effects of these treatments (e.g. tests of cognitive, socio-emotional or fine motor skills) can be also realized within the framework of Alphie.

Therefore, we developed the gamified and digital touchscreen version of standard cognitive/ socio-cognitive tests which can be used on the web with a single browser, and can be also integrated into Alphie later.

The Navon-test created in PY1 was modified in PY3: we included audio form of instructions using voice recordings and a demo animation so that the test can be used without the presence of an experimenter, and without literacy skills of the children. A digital version of the Corsi-block (Corsi, 1973) was also implemented to measure spatial memory, and the Tower of Hanoi (credited to Édouard Lucas) too, to measure executive functions, specifically, planning and problem-solving (Guevara et al, 2012). In the digital versions that we have created, the instructions are explained via visual demonstrations using animations. The tests have been already used in a digital version by previous studies and they have been validated using the traditional version (e.g. Robinson & Brewer, 2016).

Additionally, we have developed the digital versions of certain socio-cognitive tests. There is a paucity in measuring ToM skills digitally: these tests usually require an experimenter telling a story to the child, showing puppets or pictures to illustrate the story and asking questions from the child afterwards (Baron-Cohen, Leslie, & Frith, 1985). Besides that, they cannot be used in online research, another limitation of these tests is that they often require not only ToM skills, but linguistic and/or executive function skills (e.g. inhibition, working memory) as well (Garcia-Molina, & Clemente-Estevan, 2019). Tests on a tablet or a mobile phone make it possible to include more visual aid in helping the children to understand and remember details of the story, thus decreasing the burden on working memory and language. Additionally, these tests often include open-ended questions which require the child to freely recall the whole story. Close-ended questions can help in decreasing this unnecessary burden by providing cues for recall. Another shortcoming of existing research is that there are few tests which are appropriate for older, school-aged children (so-called advanced ToM tasks; (O'Hare, Bremner, Nash, Happé, & Pettigrew, 2009).

For these reasons, we have developed/ are currently developing (with the help of computer science students) a digital version of standard ToM tasks which require other cognitive skills to a lesser degree than do the non-digital versions, and which can be used for school-age children. We have developed the Sally-Anne task (Baron-Cohen, Leslie, & Frith, 1985) measuring false belief attribution, and we are currently developing a modified version which will require children to attribute second-order beliefs. We have developed the digital version of the Real-Apparent Emotion task (Harris, Donnelly, Guz, & Pitt-Watson, 1986), where children have to recognize that a person can display one emotion but feel in fact another (the non-digital version was used in the first study of the current project). We are currently developing the Faux pas test (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999) which measures the understanding of somebody transgressing social norms because of a lack of knowledge, and thus hurts someone's feelings. We are also working on the digital version of the Second-order belief test (Baron-Cohen, 1989). These tests are suitable for measuring ToM in older children. We are substituting open-ended questions for close-ended ones. In all of these tests, children have to answer by touching on one of two or three pictures (in some cases, the pictures are speech balloons and audio recording is played for each of them when the child touches them).

We are also developing socio-cognitive tests which have already been used in a digital way in previous studies, but now we implement these as touchscreen games. We have developed the touchscreen based automatized version of the emotion recognition test used in the first study (based on Langner et al., 2010; O'Reilly et al., 2016). The child version of the Reading the Mind in the Eyes test (Baron-Cohen et al, 1997) is also under development.

We are planning a study where we could validate the digital version of the ToM tasks using the original, non-digital versions. We have already worked up the protocol, and a PhD student is going to carry out the tests at the end of the Summer.

6 Validation of parent report on children's mobile device use

During our research, we had to realize that there is no validated measure (e.g. parental report) of the children's mobile device use. We have decided to fill this gap: we aim to carry out a study in which we validate parents' reports on child mobile use by digital log data. Parents with school-aged children (age 6 - 15) could participate in the study by applying through an online form. The data collection of mobile/tablet use lasts two months, and at the end of the first and second months parents are asked to report about their children's media use in the previous month. Above the age of 10, children are also asked about their media use habits through a questionnaire. The questionnaires include general questions about screen time (e.g. mean duration of screen time on a day) and questions about how much time children spent with a specific application (e.g. Facebook, Tiktok) or with a specific activity (e.g. video call, chat, listening to music). In order to summarise logged information for specific activities, application categories have to be defined first in our software. We found that it would be practical to rely on the categorization system used by Google Play store, thus we have also implemented a crawler which fetches the Google Play categories for each application in our database. We also built a useful web user interface for ourselves, where we can explore this information and decide on which Google Play categories we can use in our study and whether it is necessary to define new categories based on existing ones. Data collection has begun, but recruitment of additional participants is needed.

7 Dissemination

7.1 Scientific publications

We have published two articles (one of them contains two studies) in Q1 peer-reviewed international journals, one article in a Hungarian educational journal, and one manuscript has been submitted to a computer science journal. We have also published a book chapter on a closely related topic.

7.1.1 Published articles

Konok, V., Liszkai-Peres, K., Bunford, N., Ferdinandy, B., Jurányi, Z., Ujfalussy, D. J., Réti, Zs., Pogány, Á., Kampis, G. & Miklósi, Á. (2021). Mobile use induces local attentional precedence and is associated with limited socio-cognitive skills in preschoolers. Computers in Human Behavior, 120, 106758.

Konok, V., Peres, K., Ferdinandy, B., Jurányi, Zs., Bunford, N., Ujfalussy, D.J., Réti, Zs., Kampis, G., Miklósi, Á. (2020) Hogyan hat a mobileszköz-használat az óvodások figyelmére és társas-kognitív készségeire? Gyermeknevelés Tudományos Folyóirat, 8(2), 13-31.

Konok, V., Bunford, N., & Miklósi, Á. (2020). Associations between child mobile use and digital parenting style in Hungarian families. Journal of Children and Media, 14(1), 91-109.

7.1.2 Submitted article

Jurányi, Zs., Konok, V., Peres, K., Ujfalussy, D.J., Miklósi, Á., Kampis, G. (submitted) 'Good mobile': A mobile launcher for children to facilitate human interactions and improve social skills. *The Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*

7.1.3 Published book chapter

Miklósi, Á., Konok, V. (2020) Runaway processes in modern human culture: Evolutionary approach to exaggerated communication in present human societies. In: Barkow, J.H., Workman, L. & Reader, W. (eds). Cambridge Handbook of Evolutionary Perspectives on Human Behavior. Cambridge University Press.

7.2 Scientific conferences:

We have participated (and in the next week are going to participate) in 8 scientific conferences:

Miklósi, Á. (2021) A 'Mobil-bolygó' lakói: A szülő-gyermek kapcsolat új kihívásai a digitális korszakban. Élni a kultúrát! – Játék, művészeti nevelés és tudomány. 4. Művészetpedagógiai Konferencia. Budapest, 2021.05.20-21

Konok, V. (2021) Játék a mobilon: a digitális játék hatása a kognitív fejlődésre és egy gyerek-barát applikációcsomag bemutatása. Élni a kultúrát! – Játék, művészeti nevelés és tudomány. 4. Művészetpedagógiai Konferencia. Budapest, 2021.05.20-21

Liszkai-Peres, K., Konok, V, Jurányi, Zs., Tóth-Farkas, R., Budai, Zs., Kocsis, A., Kampis, Gy., Miklósi, Á. (2021). Alphie, the good mobile - The effect of an interactive mobile interface on 4-6-year-old children's socio-emotional skills. BCCCD Budapest CEU Conference on Cognitive Development. 4-8. January, 2021, Budapest.

Konok, V, Peres, K., Ujfalussy, D.J., Jurányi, Zs., Kampis, Gy., Miklósi, Á. (2020) Short term exposure to fast and slow mobile games influences attentional control in preschoolers. BCCCD20. Budapest CEU Conference on Cognitive Development. 9-11 January, 2020, Budapest.

Konok, V., Bunford, N., Ferdinandy, B., Réti, Zs. Á., Miklósi, Á. (2020) Top-down attentional and sociocognitive processes are impaired in mobile user preschoolers. BCCCD20. Budapest CEU Conference on Cognitive Development. 9-11 January, 2020, Budapest.

Konok, V, Peres, K., Ujfalussy, D.J., Jurányi, Zs., Kampis, Gy., Miklósi, Á. (2019) Short term exposure to fast and slow mobile games influences attentional control in preschoolers. Magyar Etológiai Társaság XXI. konferenciája. 2019. nov. 29 - dec.1., Mátrafüred

Peres, K., Konok, V., Ujfalussy, D., Jurányi, Zs., Kampis, Gy., Miklósi, Á. (2019). Különböző sebességű digitális játékok rövid távú hatása óvodás korú gyermekek végrehajtó funkcióra és figyelmére. PECMH, Lelki Egészség a Perinatális Időszaktól a Kora Gyermekkorig – Prevenció és Klinikai Gyakorlat, Budapest, 2019.5.8-11.

Konok, V., Ferdinandy, B., Réti, Zs. Á., Bunford, N., Miklósi, Á. (2018). Mobile device usage is associated with cognitive skills in preschool children. BCCCD18. Budapest CEU Conference on Cognitive Development. 3-5 January, 2018, Budapest.

Konok, V., Ferdinandy, B., Réti, Zs. Á., Bunford, N., Miklósi, Á. (2017). Mobile device usage is associated with cognitive skills in preschool children. Magyar Etológiai Társaság XIX. konferenciája. 2017. Dec 1.-3., Debrecen.

7.3 Dissemination for the public

For our project it is especially important to reach the public, partly for recruiting study participants (which was rendered more difficult because of the special target group and of the pandemic situation), partly for advertising the main product of the project, Alphie.

7.3.1 Public events and conferences

We participated in many public events and conferences, and we also organized events ourselves:

Konok, V. & Peres, K. (2020) Az Alfa Generáció nyomában: hogyan hat a digitális eszközhasználat a gyerekek fejlődésére? Kis Tudósok Délutánja, Budapest, 2020. 02. 22. (oral presentation)

Budai, Zs. & Tóth-Farkas, R. (2020) Kütyüzés a tudomány tükrében - az Alfa Generáció Labor kutatásai. Kis Tudósok Délutánja, Budapest, 2020. 02. 22. (poster presentation)

Budai, Zs., Jurányi, Zs., Kocsis, A., Tóth-Farkas, R. (2020) Alfa Generáció Labor: Hasznos kütyük? Gyerekkori készségfejlesztés és szűrés okoseszközökkel. Kis Tudósok Délutánja, Budapest, 2020. 02. 22. (workshop)

Budai, Zs., Kocsis, A., Peres, K. (2020) Mit csinálnak a kutatók? - Bemutató foglalkozás gyerekeknek. Summer camp of the Nemzeti Tehetség Központ, Budapest, 2020.07.29. (workshop)

Konok, V. & Peres, K. (2020) Az Alfa Generáció nyomában: hogyan hat a digitális eszközhasználat a gyerekek fejlődésére?. ELTE Tanárképző Kar, Budapest, 2020. 04. 05. (oral presentation)

Alfa Generáció Labor (2019) Játékok virtuálisan és a valóságban: Online-offline játszóház ovisoknak és beszélgetés a szülőkkel a kütyüzésről. Kutatók éjszakája, Budapest, 2019. 09.27. (workshop)

Alfa Generáció Labor (2019) Alfi, a „jó mobil”: hogyan fordíthatjuk pozitív irányba a gyerekek kütyüzését? Kis Tudósok Délutánja, Budapest, 2019.03.30. (workshop)

Alfa Generáció Labor (2019) Alfa Generáció Labor open day, Budapest, ELTE TTK, 2018.11.09. (workshop)

Peres, K. & Konok, V. (2018) A kicsik és a kütyüzés. Silvanus Játszótér, Baby’s club, Budapest, 2018.11.07. (workshop and oral presentation)

Konok, V., Ujfalussy, D. J., Peres, K., Jurányi, Zs., Miklósi, Á., Kampis, Gy. (2018). Jó mobil/ rossz mobil? A digitális eszközök használatának hatásai a gyerekekre és egy új irányvonal kezdő lépései. Pest Megyei Pedagógiai Szakszolgálat Szakmai Napja, Budapest, 2018. 04. 16. (oral presentation)

7.3.2 Radio and TV interviews

We gave several radio and TV interviews:

Inforádió, Kossuth Rádió (Trend-idők, Felfedező), Sláger FM, Szlovák Közszolgálati Rádió, Katolikus Rádió, Csillagpont Rádió

Spektrum Home Magazin, 2021.4.16.

https://www.youtube.com/watch?v=IqkBd7I6nvQ

Duna TV Családbarát magazin, 2020.10.06.

Magyar Televízió, M5, Novum, 2020.03.22: http://novumtv.hu/adasaink/2020-03-22?fbclid=IwAR2m2zlYf-ehtbMarqdXVAK0NWrCy82B_2q65jaPNYIt1MsjqzPRtBT5mIo

7.3.3 Press news

We wrote press releases of which online press articles have been written by journalists, or wrote press articles by ourselves. The followings are only examples of these:

Dailymail: "Time to ditch the iPad? Tablets and smartphones are 'rewiring' children's BRAINS and making them less able to see the bigger picture"

https://www.dailymail.co.uk/sciencetech/article-9330573/Psychology-Devices-rewiring-kids-BRAINS-making-able-bigger-picture.html

Eurekalert: "Pre-schoolers frequently using tablet or mobile can't see the forest for the trees"

https://www.eurekalert.org/pub_releases/2021-03/elu-pfu030121.php

Qubit: "A mobilozás alapvetően megváltoztatta, ahogy a 2010 után született gyerekek befogadják a világot“

https://qubit.hu/2021/03/06/a-mobilozas-alapvetoen-megvaltoztatta-ahogy-a-2010-utan-szuletett-gyerekek-befogadjak-a-vilagot

Telex: "A sokat mobilozó gyerekek nem látják a fától az erdőt“

https://telex.hu/tudomany/2021/03/05/elte-pszichologia-kutatas-mobil-tablet-figyelem-fokusz-gyerekek

HVG: "Az ELTE kutatói szokatlan jelenséget tapasztaltak a mobilozó gyerekeknél"

https://hvg.hu/tudomany/20210304_elte_kutatas_gyerekek_mobilozas_mobiltelefon

Index: "Milyennek nevelje a gyereket a mobil? Mit kezdjen egy gép a zaklatással?"

https://index.hu/techtud/2020/09/28/mesterseges-intelligencia-unicef-mobil/

Mindennapi Pszichológia: „Hagyjam vagy ne hagyjam? A „kütyüzés" hatása a gyerekekre"

https://mipszi.hu/cikk/200919-hagyjam-vagy-ne-hagyjam-kutyuzes-hatasa-gyerekekre?fbclid=IwAR1JfN3QHRwKzUZxBU97iJiQO-GPoVOdGzyGu7C7J2eoCYeK0UFIf7Q3mLs

Origo: „A kétéves gyerekek fele már 'kütyüzik'"

https://www.origo.hu/tudomany/20191106-a-gyerekek-digitalis-eszkozhasznalatat-kutatjak-az-elte-n.html

Dívány: "Hazai kutatók szerint így alakítja át agyunkat a digitális világ" https://divany.hu/szuloseg/2018/08/30/digitalis-okos-gyerek-csalad-kiborg/?utm_source=index.hu&utm_medium=doboz&utm_campaign=link&fbclid=IwAR2_OzVFCFUPDqvKnAtgmMraoZsMjDDSqMBz_g7bRMnnymxFIotyfhmaq2g

Élet és Tudomány: "Kicsik és kütyük- Interjú Konok Veronikával"

http://eletestudomany.hu/kicsik_es_kutyuk

7.3.4 Social media and webpage

We are continuously posting on our Facebook page where we have around 1500 followers now (www.facebook.com/alfageneraciolabor).

We have created a webpage (www.alfageneracio.hu) which we are continuously improving, creating new contents.

7.3.5 Releasing Alphie

After releasing the demo version, we implemented a public version of Alphie which contains all features without limitations, and released it on Google Play store. We made a showcase video for the application page in Google Play store which summarizes and presents the main features of Alphie.

7.3.6 Dissertations

Many BSc and MSc dissertations have been written on the topic of the project. PhD students also participated in the project and helped in recruitment, data collection and other work phases.

PhD students working on the project:

2019- Tóth-Farkas Renáta
2019- Budai Zsófia

Undergraduate students working on the project:

2020-2021 Kocsis Adrienn (MSc)
2020-2021 Pauleczki-Varga Anita (MSc)
2020-2021 Petkes Csaba Balázs (BSc)
2019-2020 Antus Antónia (BSc)
2018-2019 Kocsis Adrienn (BSc)
2018-2019 Strukla Domonkos (BSc)
2017-2018 Csányi Evelin (BSc)
2017-2018 Réti Zsófia Ágnes (BSc)

7.3.7 Future work

The current grant helped us in receiving other grants with which we can continue the work with Alphie. We have won a new NKFIH (OTKA K) grant (project ID: 135478; 48 million HUF; https://nkfih.gov.hu/palyazoknak/nkfi-alap/tamogatott-projektek-k20). Additionally, we won a smaller grant („Az ELTE Innovációs Ökoszisztémájának fejlesztése az ipari elvárásokkal összhangban", 2019-1.2.1-EGYETEMI-ÖKO-2019-0004; 7 million HUF) from which we can improve Aphie's graphical and user experience design, and develop some new games. These grants along with the current one give us an opportunity to apply for European fundings and make Alphie suitable for attracting potential investors.

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