Exergames in Individuals with Down Syndrome: A Performance Comparison Between Children and Adolescents

Adrian Macias[1], Karina Caro[2], Luis A. Castro[1(✉)], Veronica Sierra[1], Edgar A. Ahumada[1], and Iván A. Encinas[1]

[1] Sonora Institute of Technology (ITSON), Ciudad Obregon, Sonora, Mexico
{adrian.macias, veronica.sierra}@itson.edu.mx, luis.castro@acm.org, eahumadasolorza@gmail.com, ivanencinasm@gmail.com

[2] Drexel University, Philadelphia, PA, USA
karinacaro@drexel.edu

Abstract. Individuals with Down Syndrome (DS) have delays in the development of motor function associated with impairments including difficulty with precise movements of limbs, poor balance, and poor visual-motor coordination. It has been reported that children and adolescents with DS might present differences in terms of visual-motor coordination skills, task persistence, emotional expressions, among others. Exergames have the potential to support motor coordination as they combine physical exercise with gaming technology. However, little has been said about the game experience of individuals with DS playing exergames. This work presents the results of an exploratory study of 10 individuals with DS playing a commercial exergame. Our results show a significant difference between children and adolescents in terms of task-efficacy, selective attention, and prompts. Finally, we discuss our results and the implications for designing exergames to support motor coordination of people with DS.

Keywords: Exergames · Kinect Monsters · Motor coordination Down Syndrome

1 Introduction

Down Syndrome (DS) is a chromosomal disorder caused by the presence of an extra chromosome, occurring in approximately 1 in 700 births [1]. Children with DS show relative delays when compared to typically developing children of the same chronological age, move through stages of development more slowly, and exhibit more within-group variability than typically developing children [2]. Particularly, children with DS have delays in development of motor function associated with impairments including difficulty with precise movements of limbs (e.g., stepping over a stick while on a balance beam), low muscle tone, poor postural control, poor balance, poor visual-motor coordination and poor visual-spatial perception skills, and, for some children, congenital heart disease, and obesity [3]. These deficits in motor development might be

B. Guidi et al. (Eds.): GOODTECHS 2017, LNICST 233, pp. 92–101, 2018.
https://doi.org/10.1007/978-3-319-76111-4_10

of particular importance for occupational performance in school, daily living, play, and performance in other areas of occupation [4].

It has been demonstrated that play is an important facilitator and an important means for the development of cognitive and motor skills [5]. In addition, several studies have shown that videogames are adequate tools for supporting skills in different areas of development (e.g., cognitive, social, motor) [6]. Exergames, videogames that require physical exercise by players as input to control the game, have the potential to support motor skills of different populations such as older adults [7] and individuals with cerebral palsy [8]. However, little has been said about the player experience of individuals with DS playing exergames to support motor coordination. In this work, we aim at exploring the use of a commercially available exergame in individuals with DS. In particular, we aim at understanding the differences between children and adolescents with DS, since it has been reported that young children with DS show lower levels of task persistence and higher levels of off-task behavior, interfering with task completion, when compared to adolescents or young adults with DS [9]. On the other hand, in [9, 10], they show that young children with DS are more likely to ask for help, when faced challenging tasks, compared with typically developing children.

Additionally, other studies have found relative strengths in visual-spatial perception skills such as visual memory and visual-motor coordination in older children and young adults when compared to other skills (e.g., verbal processing skills) [11]. In terms of emotional expressions, studies have shown that older individuals with DS show relative strengths in nonverbal communication (e.g., facial expressions, gestures and eye contact) [12]. However, other studies have shown that children with DS may also send more positive emotional signals than other children with mental retardation. In one study, 5- to 12-year-old children with DS smiled more frequently than children with other intellectual disabilities, although smile frequency changed as individuals with DS approached adulthood [13]. Although there are studies that show that individuals with DS commonly play videogames (e.g., 90% of 21 individuals with DS [14]), differences in game experience between children and adolescents with DS have not been extensively reported. A study with five children with DS between 6 and 12 years old [15] shows that older children ($\sim$12 years old) found some scenarios very childish when compared to young children.

In this work, ten individuals with DS, 5 children and 5 adolescents, played a Kinect-based exergame designed to support motor coordination skills such as visual-motor coordination and visual-spatial perception. Our results show a significant difference between children and adolescents in terms of task efficacy (i.e., the rate of successful attempts to complete the tasks asked by the exergame), selective attention (i.e., the capability to focus on the exergame ignoring competing distractions), and prompts required to play the exergame. No significant differences were found in children and adults in terms of on-task behavior (i.e., the capability to focus on the exergame), positive emotional expressions, and game experience. These results show that exergames might have the potential to support motor coordination of individuals with DS, but important considerations should be made in terms of the design of exergames for children or adolescents with DS.

2 Related Work

There are several studies that use exergames for supporting motor coordination of individuals with special needs such as older adults [16], cerebral palsy [17] and autism [18]. Few studies have investigated the use of exergames in individuals with DS. A systematic review of the use of exergames in children with neuromotor dysfunction [19] presents only two studies including individuals with DS, both used the Wii gaming technology. The work of [20] presents the effectiveness of a virtual reality (VR) system using the Wii gaming technology when compared to traditional therapy. 105 children between 7 and 12 years old were assigned to Wii-based therapy and 50 to traditional therapy. The results suggest that VR using the Wii gaming technology shows benefit in improving sensorimotor functions among children with DS when compared to traditional therapy. In [21], it is shown that the efficacy of a 2-month Wii-based therapy in 18- to 60-year-old adults with DS. The results suggest that Wii-based therapy can be an effective tool to improve physical fitness, functional mobility, and motor proficiency in adults with DS, including crucial measures such as aerobic capacity and lower limb strength. Also, in [22], the authors present a virtual system for upper limbs rehabilitation in children using a haptic device and Oculus Rift. Using the system, children perform hand rehabilitation exercises such as extension and flexion of wrist and finger pinch. The system was evaluated through a usability study with four children with DS (between 9 and 12 years old). The system was positively rated for rehabilitation, felt immersed, and enjoyed the game.

The related work shows the outcomes of using exergames based on Wii gaming technology and haptic devices in children and adults with DS. However, to the best of our knowledge, little has been said about the use of exergames that use only body movements (e.g., upper-limb movements) beyond fingers on handheld devices (e.g., Wii mote) such as Kinect-based exergames in individuals with DS. Kinect-based exergames could elicit a different player experience in this population. Although several studies have shown differences between children and adolescents with DS in terms of task persistence, off-task behavior, level of required help to complete a task, among others [9–12], the literature shows that none of the studies presents differences between children and adolescents with DS playing exergames.

3 Methods

We have been working closely with an institute for intervention and education for individuals with DS, partially funded by a non-profit NGO, located in a mid-size city of Northwest, Mexico. We carried out a quasi-experiment, in which ten individuals with DS were recruited to play an exergame in a controlled setting.

Participants. We recruited 10 individuals with DS between 6 and 14 years old (AVG age = 10.9 years, ±2.9 years, 5 males), including 5 children (AVG age = 8.4 years, ±1.7 years, 2 males) and 5 adolescents (AVG age = 13.4 years, ±0.9 years, 3 males). Nine of the participants had previous experience with computer games such as puzzles and crosswords. However, only one participant had previous experience playing exergames (i.e., Kinect adventures).

Variables. The variables we are interested in studying are:

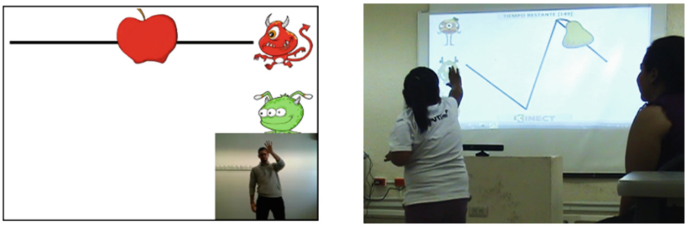
– *Independent variables.* Chronological age: Children (<=10) vs. Adolescents (>10)
– *Dependent variables.* Efficacy (%: successful attempts/total attempts), emotional expressions (%: positive expressions time/total time), attention (%: on-task time/total time), on-task attention (%: selective attention time/on-task attention total time), prompts (%: prompting time/total time), Game experience (N: ratings of perceived game experience through the Game Experience Questionnaire [23]).

Hypotheses. Based on previous knowledge from the literature, we propose six hypotheses we are interested in. H1 to H5 are related to differences in children and adolescents with DS in terms of task persistence [9] (H1), off-task behavior [9, 11] (H3, H4), level of required help to complete a task [9, 10] (H5) and emotional expression [12, 13] (H2). H6 is related to the experience of individuals with DS playing videogames [14, 15], specifically exergames [20–22], as it has been reported that individuals with DS have successfully played videogames and Wii-based exergames, but differences between children and adolescents with DS when playing videogames and exergames have yet to be studied.

– **H1.** *Efficacy:* The proportion of successful attempts will be significantly higher in adolescents than in children with DS.
– **H2.** *Emotional expressions:* The proportion of positive emotional expressions will be significantly higher in children than in adolescents with DS.
– **H3.** *Attention:* The proportion of time for on-task attention will be significantly higher in adolescents than in children with DS.
– **H4.** *On-task attention:* The proportion of time for selective attention will be significantly higher in adolescents than in children with DS.
– **H5.** *Prompts:* The proportion of time spent on prompting will be significantly higher in children than in adolescents with DS.
– **H6.** *Game experience:* There will be no difference in the perceived rating of game experience between children and adolescents with DS.

3.1 Instruments

Kinect Monsters exergame. We used the commercially-available exergame Kinect Monsters (KM). KM is a videogame to support neuro-rehabilitation, mainly for children. Players must feed monsters following a black line (i.e., pattern) (see Fig. 1). Using their hand, participants can move and pick up a fruit by positioning the cursor over it. Once the fruit has been picked up, the cursor fades away, and the fruit is directly controlled by the player's hand. If the player is unable to follow the line, the player must start again. Once the player has successfully taken the fruit to the monster, the word "Good" is shown, and another fruit is randomly shown. KM uses Kinect to track players' movements, thus no additional on-body sensors are needed.



(a) (b)

Fig. 1. (a) KM's interface. Source: kinectfordevelopers.com. (b) A participant playing KM.

Game Experience Questionnaire. To measure the game experience of our participants, we used the in-game module of the Game Experience Questionnaire (GEQ) [23]. The GEQ was answered by a proxy (therapist).

Screen recorders. All on-screen events were recorded for task completion analysis (i.e., successful vs. failed attempts).

Video cameras. Two video cameras (front and rear) were used to record participants.

BORIS. We used BORIS [24] to facilitate video coding and analysis.

3.2 Research Procedure

During the sessions, a therapist and the participants' parents were present at all time. The configuration of data collection was as follows:

- **Stage 1: Pre-play (5 min).** We collected demographics and consent forms signed by the participants' parents.
- **Stage 2: Play (~5 min).** The therapist instructed participants on how to play KM, before proceeding to play. Instructions to participants included how they should move their arms, where to step on (i.e., we drew a square on the floor), open their hands to grab a fruit, and the like. The aim was to feed 5 monsters or play for 5 min. non-stop, whatever happened first. If a participant was unable to complete at least one task (e.g., feed a monster) within 5 min., the game was stopped.
- **Stage 3: GEQ (5 min).** The GEQ was applied to each participant in a structured fashion, i.e., the therapist was asking the questions and filling out the electronic forms designed for collecting data. In the case of low functioning students, the therapist worked as a proxy answering the GEQ; otherwise, participants answered it themselves.

3.3 Data Collection

Participants' performance was collected by non-participant observation during the exergame sessions. In each session, three members of the research team were involved, one therapist, and the participants. The therapist was the only one who interacted with the participants. The sessions were carried out at the lab, as per request of the institute we are collaborating with. Total effective game play time collected includes: Front-facing camera (42:31 min.) and rear-facing camera (42:30 min.).

3.4 Data Analysis

For the analysis, we created a coding scheme based on the literature that included prompts: physical, verbal, gestural, and modeling, or a combination of any of those; emotional expressions: positive and negative [25]; attention: on-task (selective, divided), and off-task [26]; attempt outcome: successful or failed. The coding process was independently carried out by two of the authors. Before coding the whole set of videos, coders refined the schema and criteria with a pilot test in the same conditions. This pilot coding session was collaboratively carried out by the coders. In the end, all differences in coding were discussed by the coders. Videos were replayed as needed. Coders compared their initial set of codes to the final (agreed) one. Accuracy was: 99.6, 94.0, 84.5% for attention, prompts, and emotional expressions respectively for the first coder; and 95.9, 86.7, 78.2% for the second coder. Aggregate accuracy per coder was 94.9% for the first, and 89.6% for the second one.

To determine if there is a significant difference between children and adolescents, we used an independent t test, since our data presented a parametric distribution. The normality of the data was calculated using a Shapiro-Wilk test. Equality of variances was not assumed in the data.

4 Results

In this section, we present the results obtained in the experiments. Our results are organized by dependent variables. Table 1 shows a summary of our results.

Efficacy. Efficacy was the proportion of successful attempts per participant. Some participants performed all five attempts, while some other managed to perform fewer attempts. The proportion of successful attempts was significantly higher for adolescents (mean = 0.93) than for children (mean = 0.52). The mean difference was 0.41. An independent t-test showed that the difference between conditions was significant ($t = -2.7608$, $df = 5.8317$, p-value = 0.0169, one-tailed). Thus, H1 was accepted.

Table 1. Performance by participants by dependent variables

	Children			Adolescents			Sig.
	AVG (SD)	Min	Max	AVG (SD)	Min	Max	
Successful attempts (%)	0.52 (0.30)	0.00	0.75	0.93 (0.15)	0.67	1.00	*
Pos. emo. expressions (%)	0.20 (0.19)	0.01	0.48	0.03 (0.03)	0.00	0.08	
Attention (%)	0.93 (0.11)	0.73	100	1.00 (0.00)	1.00	1.00	
Selective attention (%)	0.82 (0.04)	0.77	0.86	0.97 (0.4)	0.90	1.00	***
Prompts (%)	0.23 (0.15)	0.11	0.48	0.08 (0.05)	0.03	0.16	*
Game exp. (score)	2.09 (0.49)	1.36	2.64	2.27 (0.33)	1.86	2.64	

Significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Emotional expression. We computed the aggregated time spent in which positive emotional expressions were shown by the participants and divided by the total time of the session per participant. The percentage of time in positive emotional expressions was higher for children (20%, SD = 19%) than for adolescents (3%, SD = 3%). The mean difference was 17%. An independent *t*-test showed that the difference between conditions was not significant ($t = 1.9679$, $df = 4.2469$, *p*-value = 0.05817, one-tailed). Thus, H2 was rejected.

Attention. We computed the total time in focusing participants' attention on the requested task (i.e., playing the exergame) vs. being off-task. Adolescents were able to maintain 100% (SD = 0%) their attention on-task, while the percentage of children was lower (93%, SD = 11%). The mean difference was 7%. An independent *t*-test showed that the difference between conditions was not significant ($t = -1.4486$, $df = 4$, *p*-value = 0.1105, one-tailed). Thus, H3 was not supported by our data.

Selective attention. Attention on-task was divided into selective attention and divided attention. Selective attention means that participants can be completely focused on the requested task. The proportion of time spent in selective attention was significantly higher for adolescents (97%, SD = 4%) than for children (82%, SD = 4%). The mean difference was 15%. An independent *t*-test showed that the difference between conditions was significant ($t = -5.4385$, $df = 7.9819$, *p*-value = 0.0003109, one-tailed). Thus, H4 was accepted.

Prompts. The proportion of time in which the therapist was prompting the participants was computed per participant. The proportion of prompts was significantly higher for children (23%, SD = 15%) than for adolescents (8%, SD = 5%). The mean difference was 15%. An independent *t*-test showed that the difference between conditions was significant ($t = -2.0539$, $df = 5.0207$, *p*-value = 0.04747, one-tailed). Thus, H5 was accepted.

Game experience. In Table 2, we present the seven dimensions of the GEQ. The perceived game experience score obtained was higher for adolescents (2.27, SD = 0.33) than for children (2.09, SD = 0.49). The mean difference was 0.18. An independent

Table 2. Average and standard deviation of the GEQ results by dimensions (Min = 0, Max = 4)

	Competence	Immersion	Flow	Tension	Challenge	(−) Affect	(+) Affect
Children							
AVG	2.90	3.00	0.60	0.30	**3.50**	**0.60**	3.70
SD	1.39	0.94	0.42	0.45	**0.87**	**0.89**	0.67
Adolescents							
AVG	**3.13**	**3.63**	**1.38**	**0.25**	3.25	0.25	**4.00**
SD	**0.85**	**0.48**	**0.25**	**0.50**	0.96	0.50	**0.00**
Overall							
AVG	3.29	3.17	0.83	0.28	3.22	0.56	3.83
SD	1.20	0.75	0.61	0.44	0.87	0.88	0.50

t-test showed that the difference between conditions was not significant ($t = 0.52345$, $df = 5.6273$, p-value = 0.6206, two-tailed). Thus, the null hypothesis H6 was accepted.

5 Discussion

Our results show that, for the purposes of education and therapies of any kind, there are aspects that need to be taken into consideration when using exergames with children and adolescents with DS, as significant differences were found in efficacy, selective attention, and prompting between them. Our results indicate that our participants who were older than 10 years were more focused on the task they were working on, which could also result in a higher proportion of successful attempts. On the other hand, our participants who were 10 years old or younger needed considerably more prompting by the therapist. Both of these aspects may have practical implications not only for the design of much more considerate exergames (e.g., if the player is a child, the exergame should provide different kinds of prompts such as visual and verbal ones, including a step-by-step guide when children face challenges during the gameplay), but also in the time invested in each of these children per session.

We found no difference in game experience between children and adolescents, meaning that, regardless the age, individuals with DS can have similar experiences. Regarding game experience, our adolescent participants felt more competent and skillful, which was understandable since their proportion of successful attempts was higher. Since adolescents were more focused on the tasks, they also reported higher levels of immersion than children, meaning that they were really interested in the game. Although slightly higher in children, tension or frustration was minimal for both groups, younger participants showed more positive expressions. Finally, positive and negative affect were generally perceived better for adolescents than for children, but no significant differences were found.

From our observations, those participants who were not able to complete the whole set of attempts did not show any sign of frustration or irritation when an audio was played warning of the end of the game. Also, when adolescents could not successfully complete an attempt, they looked for alternate ways to complete it. This was not the case of children, who often kept performing the same movements, even if the previous ones were not successful. The latter, we believe, could be related to the developmental age of the participants, which tend to be more developed in individuals with higher chronological age. Finally, in terms of the area (i.e., a drawn square) where participants were supposed to stand on, adolescents tended to stay within boundaries, whereas children were generally less aware of this area, resulting in challenging tracking. This could indicate that for the design of exergames for children with DS, tracking should consider that children might not be able to stay in the same area for long time intervals, tracking children's limbs, without needing to stay in one place.

The main limitation of our study was the sample size since it was rather small. Still, sample size is comparable to those found in the literature. We need much more controlled studies with a higher number of participants to present conclusive findings.

6 Conclusions and Future Work

We presented a study with individuals with DS, in which participants played an exergame in a controlled setting, accompanied by a therapist. Our results indicate that there are several aspects that merit careful consideration when working with this population. First, adolescents tend to be much more focused on the tasks, which yield higher proportion of successful attempts. Also, selective attention was significantly higher in adolescents than in children. Regarding therapist prompting, children seem to need more of those, meaning that this requires a presumably higher effort from the therapist. However, neither of those factors affected the overall game experience of the participants. Future work includes working closely with the institute for carrying much more focused experiments (e.g., different types of games), which can help them take decisions in terms of therapies and educational strategies.

Acknowledgements. We thank the participants, family members, and staff of CEART DOWN. This work was partially funded by a research grant by the Instituto Tecnólogico de Sonora and the PFCE federal program in Mexico.

References

1. Davis, A.S.: Children with Down syndrome: implications for assessment and intervention in the school. Sch. Psychol. Q. **23**, 271–281 (2008)
2. Spanò, M., Mercuri, E., Randò, T., Pantò, T., Gagliano, A., Henderson, S., Guzzetta, F.: Motor and perceptual-motor competence in children with Down syndrome: variation in performance with age. Eur. J. Paediatr. Neurol. **3**, 7–14 (1999)
3. Wang, H.Y., Long, I.M., Liu, M.F.: Relationships between task-oriented postural control and motor ability in children and adolescents with Down syndrome. Res. Dev. Disabil. **33**, 1792–1798 (2012)
4. Fidler, D.J., Hepburn, S.L., Mankin, G., Rogers, S.J.: Praxis skills in young children with Down syndrome, other developmental disabilities, and typically developing children. Am. J. Occup. Ther. **59**, 129–138 (2005)
5. Gallahue, D.L., Ozmun, J.C.: Understanding Motor Development Infants, Children, Adolescents, Adults. McGraw-Hill Humanities, Social Sciences & World Languages, New York (1998)
6. Thompson, D., Baranowski, T., Buday, R., Baranowski, J., Thompson, V., Jago, R., Griffith, M.J.: Serious video games for health: how behavioral science guided the development of a serious video game. Simul. Gaming. **41**, 587–606 (2010)
7. Gerling, K.M., Mandryk, R.L., Linehan, C.: Long-term use of motion-based video games in care home settings. In: CHI 2015, pp. 1573–1582 (2015)
8. Hernandez, H.A., Ketcheson, M., Schneider, A., Ye, Z., Fehlings, D., Switzer, L., Wright, V., Bursick, S.K., Richards, C., Graham, T.C.N.: Design and evaluation of a networked game to support social connection of youth with cerebral palsy. In: ASSETS 2014, pp. 161–168 (2014)
9. Pitcairn, T.K., Wishart, J.G.: Reaction of young children with Down's syndrome to an impossible task. Br. J. Dev. Psychol. **12**, 485–498 (1994)
10. Kasari, C., Freeman, S.F.: Task-related social behavior in children with Down syndrome. Am. J. Ment. Retard. **106**, 253–264 (2001)

11. Fidler, D.J.: The emerging Down syndrome behavioral phenotype in early childhood. Infants Young Child. **18**, 86–103 (2005)
12. Chapman, R.S.: Language development in children and adolescents with Down syndrome. Ment. Retard. Dev. Disabil. **3**, 307–312 (1997)
13. Fidler, D.J., Philofsky, A., Hepburn, S.L., Rogers, S.J.: Nonverbal requesting and problem-solving by toddlers with down syndrome. Am. J. Ment. Retard. **110**, 312–322 (2005)
14. Prena, K.: Down syndrome videogame preferences (2014)
15. Macedo, I., Trevisan, D.G., Vasconcelos, C.N., Clua, E.: Observed interaction in games for Down syndrome children. In: Hawaii International Conference on System Sciences, pp. 662–671 (2015)
16. Gerling, K.M., Miller, M., Mandryk, R.L., Birk, M.V., Smeddinck, J.D.: Effects of balancing for physical abilities on player performance, experience and self-esteem in exergames. In: CHI 2014, pp. 2201–2210 (2014)
17. Altanis, G., Boloudakis, M., Retalis, S., Nikou, N.: Children with motor impairments play a kinect learning game: first findings from a pilot case in an authentic classroom environment. Interact. Des. Archit. J. - IxD&A **19**, 91–104 (2013)
18. Caro, K., Tentori, M., Martinez-Garcia, A.I., Alvelais, M.: Using the FroggyBobby exergame to support eye-body coordination development of children with severe autism. Int. J. Hum. Comput. Stud. **105**, 12–27 (2017)
19. Hickman, R., Popescu, L., Manzanares, R., Morris, B., Lee, S.-P., Dufek, J.S.: Use of active video gaming in children with neuromotor dysfunction: a systematic review. Dev. Med. Child Neurol. **59**(9), 903–911 (2017)
20. Wuang, Y.P., Chiang, C.S., Su, C.Y., Wang, C.C.: Effectiveness of virtual reality using Wii gaming technology in children with Down syndrome. Res. Dev. Disabil. **32**, 312–321 (2011)
21. Silva, V., Campos, C., Sá, A., Cavadas, M., Pinto, J., Simões, P., Machado, S., Murillo-Rodriguez, E., Barbosa-Rocha, N.: Wii-based exercise program to improve physical fitness, motor proficiency and functional mobility in adults with Down syndrome. J. Intellect. Disabil. Res. **61**, 1–11 (2017)
22. Pruna, E., Acurio, A., Tigse, J., Escobar, I., Pilatásig, M., Pilatásig, P.: Virtual system for upper limbs rehabilitation in children. In: De Paolis, L.T., Bourdot, P., Mongelli, A. (eds.) AVR 2017. LNCS, vol. 10325, pp. 107–118. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-60928-7_9
23. IJsselsteijn, W., Poels, K., de Kort, Y.A.: The Game Experience Questionnaire: Development of a Self-report Measure to Assess Player Experiences of Digital Games. TU Eindhoven, Eindhoven (2008)
24. Friard, O., Gamba, M.: BORIS: a free, versatile open-source event-logging software for video/audio coding and live observations. Methods Ecol. Evol. **7**, 1324–1330 (2016)
25. Ekman, P., Friesen, W.V., Hager, J.C.: Facial Action Coding System - Investigator's Guide (2002)
26. Corbetta, M., Miezin, F., Dobmeyer, S., Gordon, L., Shulman, L., Petersen, S.: Selective and divided attention during visual discriminations shape, color, and speed: functional anatomy by positron emission tomography. J. Neurosci. **11**, 2393–2402 (1991)