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Enhancing academic performance of three boys with Autism Spectrum Disorders and Intellectual Disabilities through a computer-based program

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Abstract

We assessed a computer-based rehabilitative program (i.e., tablet device with touch screen and adapted software) to improve academic performance and to increase the on-task behavior of three children with autism spectrum disorders and mild intellectual disabilities in a school setting. Furthermore, the study pursued the following objectives: (a) monitor its effects on the generalization process, occurring two months after the end of the intervention, within home context, (b) reduce repetitive (stereotypic) behaviors exhibited by the participants (i.e., hand clapping, washing and voice noises), and (c) carry out a social validation assessment involving 48 support teachers (i.e., professionals who follow children with developmental disabilities with a special and individualized training program within a school context) as external raters. The study was conducted according to a changing criterion design for each participant. Results showed an improvement in performance (i.e.,

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academic activities correctly achieved and percentage of intervals with on-task behavior), for all participants recruited, that they generalized once the program was implemented within their homes. Moreover, all children showed a reduction of repetitive behaviors during intervention phases compared to baseline. Finally, external raters (i.e., support teachers) considered the use of the technology favorably. Educational, practical and psychological implications of the findings were discussed.

Keywords: Autism Spectrum Disorders; Intellectual Disabilities; Constructive engagement; On-task behavior; Computer interventions; Stereotypic behaviors; School setting; Generalization; Social validation.

1. Introduction

Children with Autism Spectrum Disorders (ASD) are frequently described as socially, communicatively and intellectually impaired, and may have learning difficulties. They commonly are quite passive and isolated and show repetitive (i.e., stereotypic) behaviors that hamper their social image, status and desirability. Moreover, they present pervasive developmental disorders interfering with academic performance (Matson & Wilkins, 2008; Matson & Kozlowski, 2011; Imeraj, Antrop, Sonuga-Barke, Deboutte, Deschepper, Bal *et al.*, 2013). Although they may attend regular classes, they often need special educational arrangements to carry out profitably school tasks (Attwood, 2006; Kagohara, van der Meer, Ramdoss, O'Reilly, Lancioni, Davis *et al*., 2013). By providing additional supports to students with ASD and Intellectual Disabilities (ID) within school settings, one may improve their independence and self-determination, enabling them to appropriately complete their work, facilitating academic progress, with beneficial effects on school staff and peers (Barnard-Brak, Thompson, Wei, & Richman, 2014). That is, inclusion of children with ASD and ID may be undoubtedly fostered (Hutchings, Martin-Forbes, Daley, & Williams, 2013; Abu-Hamour & Muhaidat, 2014). One encouraging way of ensuring students with ASD and ID to autonomously improve their academic performance is the use of computer-based programs (CBP) (Murray & Healy, 2013; Galla, Wood, Tsukayama, Har, Chiu, & Langer, 2014). Among this research area, different rehabilitative interventions have been designed for improving academic skills of those children, such as vocabulary, writing, remembering material and home work recording (Ferguson, Myles, & Hagiwara, 2005; Pennington, Stenhoff, Gibson, & Ballou, 2012).

Recently, emerging high technology pointed-out the application of tablets, iPad, iPod and adapted software fitting in with a relevant range of educational and/or rehabilitative goals among children with ASD and ID (Mazurek, Shattuck, Wagner, & Cooper, 2012; Mechling & Swindle, 2013; den Brok & Sterkenburg, 2015). With regard to communication and social skills, Kagohara, Sigafoos, Achmadi, O'Reilly and Lancioni (2012) worked with two students with ASD teaching them the spelling of words through video-modeling proposed with the use of an iPad. The study, carried out according to multiple baseline design across participants, emphasized the effectiveness and the suitability of such technology enhancing the capacity of participants involved in the checking of spelling words. Sigafoos, Lancioni, O'Reilly, Achmadi, Stevens, Roche *et al*. (2013) employed an iPad

based Speech Generating Device (SGD) to improve the request of play continuing by two nonverbal boys with ASD, within a rehabilitative program. Its effects were outlined through the implementation of a multiple baseline design, which showed that both participants learned to use the SGD to ask for play. Furthermore, both participants maintained this skill autonomously over time. Moreover, aggression decreased during intervention phases, replaced by socially acceptable communication. Desai, Chow, Mumford, Hotze and Chau (2014) implemented an intervention program through the use of an iPad, within a school setting, assessing the communicative skills of a student diagnosed with cerebral palsy and ASD. Results outlined an improvement of the communication abilities when the technology was applied. Roche, Sigafoos, Lancioni, O'Reilly, Schlosser, Stevens *et al*. (2014) exposed two boys with neuro-developmental disorders and severe communication impairments to an alternative augmentative communication program focused on the request of preferred stimuli through the use of a tablet and an adapted software. Results showed that both participants improved their performance with the implementation of the technology. At the same time both children consolidated their production of natural speech, once the SGD was removed.

With regard to academic skills, the performance of children with ASD and ID through the use of computer-based programs in school settings has also been investigated (Pennington, 2010; Knight, McKissick, & Saunders, 2013; Fletcher-Watson, 2014). For instance, Ganz, Boles, Goodwyn and Flores (2014) implemented a tablet computer-based intervention on vocabulary skills of three children with ASD, ranging between 8 and 14 years old. Results showed that all participants increased their performance during intervention phases compared to baselines, needing less prompts along the sessions. Plavnick, Mariage, Englert, Constantine, Morin and Skibbe (2014) exposed four non-verbal children with ASD (i.e., three boys and one girl) ranging in age between 5 and 8 years old to a web-based instructional program aimed at teaching to read at a mid-second grade level within approximately one year of instruction. Results pointed out that participants: (1) required the behavior intervention to engage with the program and (2) emphasized an increase in engagement and correct interactions per minute and a reduction in behavior that interfered with engagement when the behavior intervention was applied. Smith, Spooner and Wood (2013) assessed an embedded computer-assisted explicit instruction to teach science to three students with ASD and ID in an inclusive classroom through a multiple probe design across participants.

Results outlined a functional relationship between the number of correct responses produced by participants involved and the intervention.

However, all the aforementioned studies considered a specific feature of children with ASD and ID (e.g., vocabulary, writing, ask for play, spelling of words, speech production, access to preferred stimuli, teaching science) and only one of them (Sigafoos *et al*., 2013) emphasized the beneficial effects of the intervention program on challenging behavior. At the same time, only Roche *et al*. (2014) pointed-out details of the constructive engagement of participants involved. None of them proposed neither a social validation assessment nor an outcome measure of the on-task behavior (Stasolla, Perilli, & Damiani, 2014). Thus, social validation assessment represents a standard procedure commonly used within rehabilitative interventions for individuals with severe to profound developmental and multiple disabilities, involving external raters to corroborate the clinical validity of the intervention program (Lancioni, O'Reilly, Singh, Groeneweg, Bosco, Tota *et al*., 2006). Furthermore, even if the on-task behavior seems to be crucial for the performance of students dealing with academic skills, it has been rarely investigated among children with ASD (Ducharme & Ng, 2012).

2. Aims of the study

In light of the above, the rationale of the present study is to extend the empirical evidence available in terms of adopted responses and participants involved, pursuing the following four objectives: (a) providing a new setup including a computer-based program aimed at improving up to five academic skills of three boys with ASD and ID (i.e., novelty feature), (b) assessing its effects on the on-task behavior of participants involved, (c) reducing the repetitive (i.e., stereotypic) behavior exhibited by participants (i.e., voice noises, hand clapping and hand washing), which interfered with their academic performance, and (d) carrying out a social validation procedure involving 48 support teachers (i.e., professional teachers who follow children with developmental disabilities through individualized special training within a school setting) as external raters (Lancioni *et al*., 2006).

3. Method

3.1. Participants and settings

The participants (Arthur, Randy and Steven) were 9.4, 8.8 and 10.2 years old at the beginning of the study (mean age 9.46) and were diagnosed with autism spectrum disorders by their neurologists who reported them to the research team. By the time of the study their clinical severity was assessed through the *Childhood Autism Rating Scale* (CARS) (Schopler, Reichler, & Renner, 2002) with scores rating of 42, 44 and 43 respectively (i.e., confirming the severe level of autism spectrum disorders). Intellectual quotient scores were, respectively, 62, 60, 61 at the beginning of the study, carried out through the *Wechsler Intelligence Scale for Children* (WISC-IV) (Wechsler, 2004). Furthermore, their mental age, measured through the *Vineland Adaptive Behavior Scale – Second edition* (VABS-II) (Sparrow, Cicchetti, & Balla, 2005), was about 8.2, 7.3, and 8.5, respectively, at the beginning of the study. All the scores to the aforementioned scales (i.e., CARS, VABS-II and WISC-IV) were carried out by the psychologist working in the school attended by the participants. Accordingly, they were considered within the mild range of intellectual disabilities. They attended regular classes with a support teacher who followed them with a special training for 24 hours per week. They all presented difficulties of speech, although they were capable of reading short sentences and verbally answering easy questions. The participants showed stereotypic behaviors such as voice noises (Arthur), hand clapping (Randy) and hand washing (Steven) and unawareness of sphincter control. However, they were all able to give autonomous ambulation responses. They spent a substantial part of school timing off-tasks, dealing with their repetitive behaviors. They received stimulation sessions twice per week (Arthur and Steven), and speech sessions three days per week (Randy).

The study was carried out within a school setting, during classroom hours (i.e., baseline and intervention phases) with the assistance of their support teacher. Conversely, generalization was implemented at participants' homes with the parents' involvement (see experimental conditions). All participants were included in the study since it seemed that they could greatly benefit (i.e., in terms of academic performance) from a CBP. Both parents and school staff considered the intervention program highly desirable. In fact, they signed a formal consent for the participation of Arthur, Randy and

Steven in the study, which was approved by a local scientific and ethics committee.

3.2. Target behaviors

The first step of the procedural assessments consisted of defining the target behaviors. Thus, all participants were considered as on-task when they: (a) were correctly seated at their desk (i.e., absence of postural abnormalities), (b) listened to support teacher's explanations (i.e., gaze oriented to her), and (c) correctly achieved their tasks and were consequently fully involved as reported by the inter-rater agreements of two research assistants, who watched and coded simultaneously and independently participants' performances. Moreover, the repetitive (i.e., stereotypic) behaviors were recorded once participants exhibited: (a) voice noises, (b) hand clapping, and (c) hand washing (Stasolla, Perilli, Di Leone, Damiani, Albano, Stella *et al*., 2015).

3.3. Coding systems

The second step was constituted by the recording strategy for each target behavior. Thus, the on-task behavior was recorded according to a total interval recording system. In fact, participants were requested to be on-task along the whole 10 sec observation interval (see below sessions and data collection section). Conversely, the stereotypic behaviors were recorded according to a partial interval coding system. That is, Arthur, Randy and Steven were expected to exhibit just for one second the repetitive behaviors to be recorded as stereotyped within the observed 10 sec interval (Stasolla, Damiani, Perilli, Di Leone, Albano, Stella *et al*., 2014).

3.4. Technology, response and procedure

During all the sessions, participants disposed of a 10-inch android touch screen sensitive tablet equipped with a clicker 5 adapted software package for tablets (Crick House Moulton Park, Northampton, UK), fixed on a wooden lectern on their desk in front of them. The software enabled the participants to chose among items hierarchically organized. The technology provided a speech generating device (SGD) ensuring participants with a vocal output utterance concerning each option (academic disciplines with questions and answers available), except for baseline sessions (see below

experimental conditions section). All participants were required to touch with their hands the sensitive area of the tablet (screen) in order to use and activate the appropriate technology (i.e., a response naturally present in their behavioral repertoire) for completing their academic activities (i.e., Italian literature, mathematics, history, geography and natural sciences). The training included a first period (i.e., varying up to 5 min, depending on the criterion), where participants listened to a teacher's explanation. Subsequently, a second part of the session was implemented. That is, each participant was requested to complete and achieve the academic activity, by responding to the questions proposed by the technological system (see experimental conditions section). Overall, 10 questions concerning the different academic activities were disposed, automatically and randomly provided by the system, within each session (i.e., all questions were systematically varied across the phases by the system). Maintaining fixed the number of questions presented in constant across sessions was by design. Arthur, Randy and Steven would be expected to complete the activities by correctly responding to each proposed question. In fact, they were expected to use a multiple choice system, where each option (academic disciplines, questions and answers) was automatically scanned, ensuring participants with a double cue: a visual yellow colored encirclement and a vocal output, except during baseline (see experimental conditions section). The activities' difficulties were rigorously adapted to participants' capacities, in accordance with their parents, support teachers and school staff. Moreover, the selected activities represented the best compromise between the school demands and participants' preferences. Specifically, all selected and investigated academic domains constituted part of their school curriculum. Within each session of a criterion, the questions and answers available were graded according to a growing level of difficulty, adapted for each participant, formulated by the support teacher, according to school staff, psychologist and parents guidelines. That is, the technology adopted represented a highly individualized (i.e., customer-tailored) solution. The switch to the following grade level and criterion (i.e., growing difficulty) was guaranteed only once the participant correctly completed the previous level, as automatically recorded by the technological system. Precisely, the basic criterion required that participants correctly achieved (i.e., by completion the first time) at least 80% of the proposed activities before switching on to the following phase.

3.5. Sessions and data collection

All sessions lasted 10 min and were video-recorded. Typically, four sessions five days per week for each participant were collected, with 15-20 min of rest intervals, according participants' availability and their general conditions. The duration of the study lasted approximately four months (i.e., comprised the rest interval between the end of the fifth intervention phase and the generalization); 185 sessions for each participant were carried out, overall. Consequently, 555 sessions were collected for the three participants involved. During the sessions, data collection concerned: (a) the frequency of academic activities correctly achieved, (b) the percentage of intervals with the on-task behavior, (c) the percentage of intervals with stereotypic behaviors, and (d) scores of social validation assessment. Mean percentages of inter-rater agreements between two research assistant, who watched independently and simultaneously the video-recorded sessions interval by interval were carried out in terms of presence/absence, by dividing the number of agreements by the number of agreements and disagreements and multiplying it by 100 (Lancioni, Singh, O'Reilly, Sigafoos, Chiapparino, Stasolla *et al*., 2007). Overall, the mean percentages were 99 (range 96-100), 94 (range 90-100), and 96 (range 88-100) for the achieved tasks, the on-task and the stereotypic behaviors respectively.

3.6. Experimental conditions

The study was carried out according to a changing criterion design (Barlow, Nock, & Hersen, 2009) for each participant, where the criterion was represented by the number of academic activities that participants were expected to complete within each session. Subsequently to an initial baseline, within the first phase, Arthur, Randy and Steven have achieved the Italian literature (i.e., stories narrative) activity. Once consolidated (i.e., at least 80% of activities correctly achieved), within the second phase, participants were expected to achieve two activities: (a) Italian literature and (b) mathematics (i.e., basic arithmetic operations). Once their performance improved, the following (third) criterion required to them to achieve three activities (i.e., literature, mathematics and history). The fourth phase included four activities such as literature, mathematics, history, and geography. Finally, the fifth phase was constituted by all enhanced academic activities: (a) literature, (b) mathematics, (c) history, (d) geography and (e) natural sciences. This phase was identical to the generalization phase, which

was implemented two months after the end of the intervention phases, at participants' homes.

3.6.1. Baseline

During the baseline phase, participants were equipped with access to technology. Its use, however (i.e., participants' responses by touching the sensitive area of the tablet with their hands) did not produce any environmental consequence (i.e., neither the selection of an option nor a vocal output). Options were automatically scanned and encircled by the system each 2 sec, without any chance for participants to select and choose any option. That is, the choices were in view, participants were able to read although they could not select any item. Essentially, the technology was available but inactive. Eventually, all participants were expected to answer verbally and/or on a paper with a pencil to the questions, depending upon their capacities. Five sessions were collected within 2 days for each participant.

3.6.2. First phase (literature)

The technology was available and active. By touching selecting areas, participants were enabled to select items. That is, the first page displayed a little boy who was looking for a story, automatically encircled with yellow color by the system. By touching the sensitive area with their hands, participants produced a vocal output which said "Italian literature, let's start"! The following page presented a question in accordance with the previous explanation provided by the support teacher, with four answers automatically scanned. For example, the system would ask: "When the mother was telling a story to the child, the child was", then four pictographic options were available: (a) a little boy who was listening, (b) a little boy who was writing, (c) a little boy who was playing music, and (d) a little boy who was coloring, automatically scanned each 2 sec. To respond, the participants would select the option "listening" by touching the sensitive area. If they did it, a green encircled option would appear confirming them the correct response. Otherwise, a red encircled option was provided, telling them that the answer was wrong and re-proposing the question until the correct response was provided by the participants. Thirty sessions were collected during two weeks for each participant. All the 10 questions proposed concerned only the literature activity.

3.6.3. Second phase (literature and mathematics)

Within the second phase, the first page of the system would propose two options automatically scanned every two seconds, namely: (a) literature (a little boy who was following a story) and (b) mathematics (a little boy who was calculating basic operations such as adding and subtraction). By selecting the last one (i.e., mathematics), the system would propose an arithmetic operation asking for its result. Participants were requested to select the correct response between four options proposed as in the first phase. Once the correct response was chosen, the system was forced to select for the following activity, the literature option. Consequently, the system provided participants with a question including four answer options. Only if the correct response was selected, the system switched on the following opportunity/question. Since two activities were combined together, the 10 questions were equally divided: five for each activity. Thirty sessions were collected within this phase within 2 weeks for each participant.

3.6.4. Third phase (literature, mathematics and history)

Once consolidated the previous phase, the intervention program switched on to the following third phase, which proposed the history option added to the previous two: literature and mathematics. Thus, the first page of the system disposed of three options automatically scanned: literature, mathematics and history. Once selected the activity, the system proposed four answer options for the first selection, four answer options for the second and four answer options for the third one, according to participants' strategies (e.g., history, math and literature). Only when the correct responses were selected did the system switch to another activity (within the three). Otherwise, it would re-proposed the same question/activity. Thirty sessions were collected within two weeks for each participant involved. Since three activities were proposed, the ten questions were divided as followed: four question for the first activity and three for both second and third activity, according to participants personal selection.

3.6.5. Fourth phase (literature, mathematics, history and geography)

The first page of this phase presented 4 options according to the number of activities involved. The system followed the criteria above reported. Thus, depending on participants' selection, it would provided Arthur, Randy and Steven with four options respectively, based on the sequence chosen by participants. Thirty sessions were collected within two weeks for each

participant. Consequently, the 10 questions were divided as follows: three questions for the first and the second activity and two questions for the third and the fourth activity, depending upon participant's choice.

3.6.6. Fifth Phase (literature, mathematics, history, geography and natural sciences)

Within this final phase, all activities were available. Conditions were identical, by adding the last activity. Two questions for each activity were provided. Thirty sessions were carried out for each participant, within two weeks.

3.6.7. Generalization

Once elapsed a two-months rest interval, a generalization phase occurred, implemented at participants' homes. Experimental conditions were identical to those of the final fifth phase. Thirty sessions were collected for each participant within two weeks with the participation of their parents rather than their support teachers.

3.6.8. Social Validation

Forty eight support teachers (mean age 35.6, standard deviation 7.48, ranging age between 23 and 64 years old) were involved as external raters in a social validation assessment. They represented a convenience sample of professionals interested in the fields under consideration. Consequently, they were expected to be sensitive to the intervention program proposed to them (Pedhazur & Schmelkin, 1991). They were equally and randomly divided in 6 groups (8 raters for each group). Thus, the first group rated a 3 min standard session of baseline versus a 3 min standard session of the first phase. The second group rated a 3 min standard of baseline versus a 3 min standard session of the second phase. The third group rated a 3 min standard session of baseline versus a 3 min of standard session of the third phase. The fourth group rated a 3 min of standard session of the baseline versus a 3 min standard session of the fourth phase. The fifth group rated a 3 min standard session of baseline versus 3 min standard session of the fifth phase. Finally, the sixth group rated a 3 min standard session of baseline versus a 3 min standard session of generalization phase. All of them responded to a 6 items questionnaire (see table 1), rating each question on a 5 points scale, where 1 and 5 represented the least and the best positive rating respectively (Stasolla, Stella, & Damato, 2014).

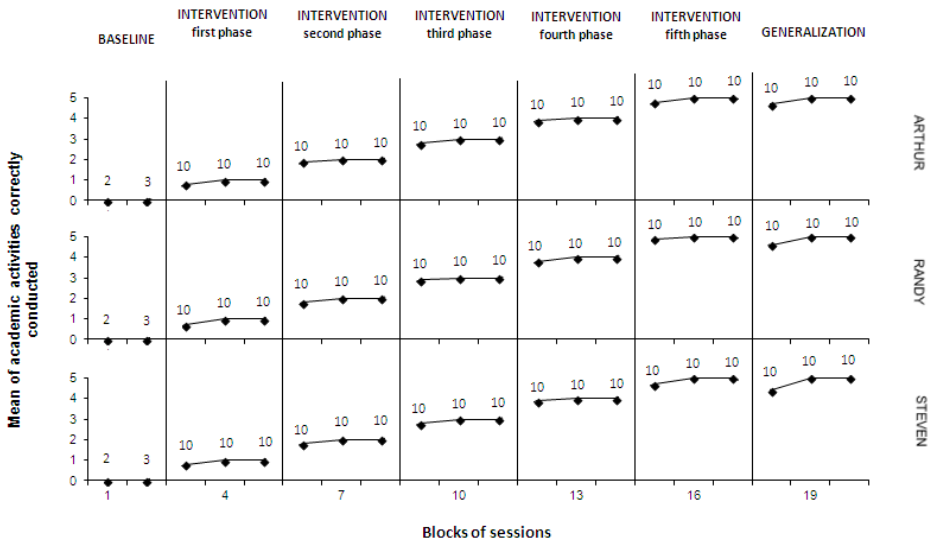
Table 1 - *Social validation questionnaire*

Do you think that the child is comfortable in this condition?
Do you think that this condition has beneficial/rehabilitative effects?
Do you think that this condition is suitable for school settings?
Do you think that this condition is suitable for a home setting?
Do you think that the child is constructively engaged in this condition?
Do you support (agree with) this condition?

4. Results

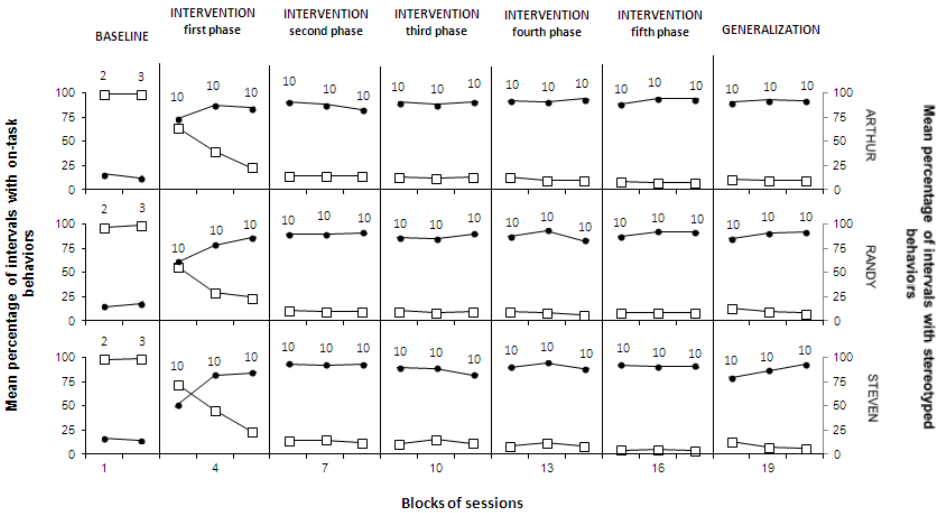
Data for all participants were summarized over blocks of sessions and plotted in figures 1 and 2. None of them correctly completed any activity during the baseline phase.

Figure 1- *Academic activities correctly conducted*



Note: The graph summarizes the data for Arthur, Randy and Steven. The black diamonds indicate the mean of academic activities correctly conducted (i.e., by completion at the first attempt) over blocks of sessions for the baseline phase, the five intervention phases and the generalization phase. The number of sessions included in each block is indicated by the numeral above it.

Figure 2 - *Intervals with on-task behaviors*



Note: The graph summarizes the data for Arthur, Randy and Steven. The black circles indicate the mean percentage of intervals with on-task behaviour over blocks of sessions for the baseline phase, the five intervention phases and the generalization phase. The empty squares represent the mean percentages of intervals with stereotyped behaviours over blocks of the same sessions. The number of sessions included in each block is indicated by the numeral above it.

The upper panel of figure 1 concerns Arthur's data about the academic activities. He completed his first intervention phase with a mean frequency of academic activities correctly completed about .93 (range 0-1). He switched to the second phase by increasing his performance to 1.96 (range 1-2). He further improved his trend in the third phase by augmenting to 2.92 (range 2-3). Arthur consolidated his performance within the fourth phase with a mean frequency about 3.95 (range 3-4) and he ended his fifth phase with a mean frequency about 4.91 (range 4-5). During the generalization occurred within home context, he consolidated his trend to 4.9 (range 4-5). The upper panel of figure 2 included Arthur's data about the on-task and stereotypic behaviors. Initially, his mean percentages of on-task and stereotypic behaviors during the baseline were about 14.63 (range 11-20) and 98.7 (range 96-100) respectively. He switched within the first intervention phase with mean percentages of on-task behavior about 82.11 (range 50-94) and of stereotypic behavior about 42.41 (range 15-80) respectively. He moved to the second phase by increasing his mean percentage on-task behavior to 87.55 (range 76-97) and by decreasing his mean percentage of stereotypic behavior to 14.44. (range 10-20). Arthur further consolidated his performance within the third phase with scores of

89.92 (range 78-99) and of 12.88 (range 6-21) regarding the on-task and stereotypic behaviors respectively. Arthur completed the fourth phase with a mean percentage of 92.52 (range 85-97) and of 11.11 (range 6-17) concerning the on-task and stereotypic behavior respectively. He ended his final fifth phase with mean percentages about 92.41 (range 80-97) and about 7.81 (range 4-13) regarding the on-task and stereotypic behaviors respectively. Within his home, the child consolidated his performance with scores of 91.88 (range 84-97) and of 10.04 (range 6-13) for the on-task and stereotypic behaviors respectively.

The middle panel of figure 1 described Randy's arrangement for the academic activities. He started his first intervention phase with a mean frequency of .9 (range 0-1). He carried on the second phase with a mean frequency of 1.94 (range 1-2). Within the third phase Randy improved his performance to 2.96 (range 2-3). The child further increased his score to 3.93 (range 3-4) within the fourth phase. Randy completed his final (fifth) intervention phase with a mean frequency of 4.94 (range 4-5). Switching on his home, the participant consolidated his performance during the generalization phase to 4.86 (range 4-5). The middle panel of figure 2 included Randy's performance about the on-task and stereotypic behaviors. He initiated his baseline with mean percentages of 16.57 (range 13-20) and of 97.96 (range 94-100) of on-task and stereotypic behaviors respectively. During the first intervention phase the child improved both performances to 75.22 (range 40-91) and to 36.55 (range 20-78) for the on-task and stereotypic behaviors respectively. He switched on the second phase with mean percentages of 90.04 (range 81-95) and of 10.22 (range 6-16) concerning the on-task and stereotypic behaviors respectively. Within the third phase, Randy improved his scores to 86.85 (range 77-97) and to 9.74 (range 4-14) regarding the on-task and stereotypic behaviors respectively. He further consolidated those performances to 87.81 (range 76-97) and to 8.41 (range 3-14) during the fourth phase and he completed the fifth phase with mean percentages of 90.52 (range 75-97) and of 8.88 (range 2-13) respectively. Finally, within his home he ended the generalization phase with scores of 89 (range 73-95) and of 10.70 (range 3-20) concerning the on-task and stereotypic behaviors respectively.

The lower panel of figure 1 reported Steven's data on the academic activities correctly completed. He ended his first intervention phase with a mean frequency of .96 (range 0-1). His performance grew during the second phase with a mean frequency about 1.93 (range 1-2). The child increased his trend within the third phase with a mean frequency about 2.93 (range 2-3).

Steven augmented his mean frequency to 3.96 (range 3-4) within the fourth phase and completed his final (fifth phase) with a score up to 4.9 (range 4-5). Switching on the generalization phase carried out within the home context, he consolidated to 4.8 (range 4-5). The lower panel of figure 2 included the child's performance concerning the on-task and stereotypic behaviors. Steven started his baseline with mean percentages of 15.55 (range 13-17) and of 98.61 (range 96-100) concerning the first and the second observed behavior respectively. He switched to 72.41 (range 30-87) and to 47.07 (range 17-86) for the on-task and stereotypic behaviors respectively within the first intervention phase. The participant completed the second phase increasing his on-task to 92.92 (range 87-98) and decreasing his stereotypic behaviors to 13.92 (range 7-20). At the end of the third phase, his mean percentages were about 86.85 and 12.74 (ranges 77-95; 6-20) for the on-task and stereotypic behaviors respectively. The fourth phase was completed by the participant with mean percentages of 90.88 and 9.77 (ranges 81-97; 3-17) about the first and the second behavior respectively. Finally, he completed the fifth phase reaching mean percentages about 91.52 and to 4.55 (ranges 86-97; 2-6) for the on-task and stereotypic behaviors respectively. Steven switched on generalization consolidating his learning process to 86.11 and to 8.96 (ranges 71-97/3-17) for the on-task and stereotypic behaviors respectively. All differences between baseline and intervention phases on one hand and between baseline and generalization on the other, were confirmed statistically significant ($p < .01$) to the Kolmogorov-Smirnov test (Siegel & Castellan, 1988). Conversely, no differences were statistically relevant between intervention and generalization phases.

Means and standard deviations of the social validation assessment were summarized in table 2.

Table 2 - *Means and standard deviations of baseline and intervention/generalization conditions*

Items	Baseline *M*	Int/Gen. *M*	Baseline *SD*	Int/Gen. *SD*	*T* test	*P*
Comfort	2.13	4.35	.67	.73	21.32	< .0001
Rehabilitation	2.11	4.27	.75	.62	12.35	< .0001
School	2.15	4.43	.54	.69	29.59	< .0001
Home	2.27	4.36	.86	.57	28.74	< .0001
Engagement	2.06	4.67	.49	.52	43.67	< .0001
Support	2.09	4.55	.66	.84	39.96	< .0001

Note: Intervention and generalization values were computed and reported together, since differences between them were not statistically significant. T values and their significance levels of baseline phase compared to intervention/generalization phases were also included.

All items were scored up to 3 in the baseline phase, while each of them received at least 4 within the intervention and generalization phases. Therefore, paired *t* tests performed for each comparison were highly significant ($p < .0001$) ranging between $t(47)$ 12.35 and 43.67 (Hastie, Tibshirani, & Friedman, 2009). That is, external raters (i.e., support teachers) highly scored (i.e., more positively) the intervention and generalization phases compared to baseline on all questionnaire's items.

5. Discussion

Although preliminary, data confirmed the affordability (i.e., about USD 450 for both hardware and software), the effectiveness and the suitability of a computer-based intervention program for enhancing academic performances of the three children with autism spectrum disorders combined with mild intellectual disabilities within school setting. Results showed an increasing on-task behavior and learning process by all participants involved. Arthur, Randy and Steven generalized their performance within the home context. Moreover, stereotypic behaviors exhibited by the children were significantly reduced. Furthermore, support teachers involved in the social validation assessment favorably appreciated and positively rated the use of technology in the classroom and its application within the home setting. The empirical evidences emphasized in this study were largely supported by previous contributions (Cowan & Khan, 2005; Bouxsein, Tiger, & Fisher, 2008; Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009; Bult, Verschuren, Jongmans, Lindeman, & Ketelaar, 2011; Lydon, Healy, O'Reilly, & McCoy, 2013; Stasolla, Damiani, & Caffò, 2014) allowing to point out the following considerations.

First, such technology adopted in this study may represent an useful extension of previous evidence, in light of four main characteristics: (a) number of participants involved, (b) number of responses (i.e., academic skills) requested by the participants, (c) generalization process in home setting, and (d) social validation assessment. Thus, by adapting a changing criterion design (Kennedy, 2005; Stasolla *et al*., 2014), the participants were required to gradually extend their skills, enhancing their academic capacities and fostering their ranges of learning opportunities (Kazdin, 2001). Moreover, by using the technology within home context, the three children with ASD and ID could generalize their learning by improving their overall performance (Najdowski, Walace, Penrod, & Cleveland, 2005; Machalicek, O'Reilly, Beretvas, Sigafoos, Lancioni, Sorrells *et al*., 2008). That is, in light of the above, a CBP was useful and successful for those children with ASD and ID for performing correctly their academic skills (Smith *et al*., 2013), if compared to baseline phases, where they were expected to answer traditionally (i.e., with verbal or written responses).

Second, a CBP may constitute a relevant educational and rehabilitative resource aimed at improving and facilitating the on-task behavior (Bouck, Savage, Meyer, Taber-Doughty, & Hunley, 2014). Thus, by providing ASD and ID children with a high-tech set-up emphasizing their strategies of choice (Stasolla, Caffò, Picucci, & Bosco, 2013; Stasolla, Perilli, Damiani, Caffò, Di Leone, Albano *et al*., 2014; Stasolla, Damiani, Perilli, D'Amico, Caffò, Stella *et al*., 2015), one may argue that saturation is prevented, with beneficial effects on their social image, desirability and status (Stasolla & De Pace, 2014). Furthermore, by providing those children with a double cue (i.e., visual with the automatic encircled scanning and verbal with the SGD) one might enrich the participants varying their sensorial inputs (Lancioni O'Reilly, Singh, Stasolla, Manfredi, & Oliva, 2004; Lancioni, Sigafoos, O'Reilly, & Singh, 2012; van der Meer, Kagohara, Roche, Sutherland, Balandin, Green *et al*., 2013; Lancioni & Singh, 2014; Stasolla, De Pace, Damiani, Di Leone, Albano, & Perilli, 2014), although it should be compared with other conditions (e.g., verbal and/or visual cues only) within a unique experimental design (Kennedy, 2005; Barlow *et al*., 2009).

Third, consequently to the previous consideration, independence and self-determination of Arthur, Randy and Steven were particularly promoted (Chiapparino, Stasolla, De Pace, & Lancioni, 2011). Thus, the CBP enabled the participants with the autonomous achievement of their academic tasks, with positive consequences on their school participation (Lancioni, Singh, O'Reilly, Sigafoos, Oliva, Smaldone *et al*., 2010; McDougall, Evans, &

Baldwin, 2010; Stasolla & Caffò, 2013; Stasolla, Caffò, Damiani, Perilli, Di Leone, & Albano, 2015). Furthermore, school inclusion of those children was significantly favored (Chantry & Dunford, 2010; Cihak, Fahrenkrog, Ayres, & Smith, 2010; Reichle, 2011) and caregivers' burden was, at the same time, reduced (Stasolla, Caffò, Albano, Damato, & Stella, 2013; Kuhlthau, Payakachat, Delahaye, Hurson, Pyne, Kovacs *et al*., 2014; McGrew & Keyes, 2014).

Fourth, being on-task, all participants reduced their stereotypic behaviors during intervention and generalization phases. It was not a given fact, since both behaviors (i.e., achieved activities and on-task behavior on one hand and stereotyped behavior on the other) were not mutually exclusive. One may argue that it might have positive effects on their quality of life (Felce & Perry, 1995; Brown, Schalock, & Brown, 2009; Lancioni, Singh, O'Reilly, Sigafoos, Perilli, Campodonico *et al*., 2015), although an outcome measure of the latter construct, namely the indices of happiness (Lancioni, Singh, O'Reilly, Oliva, & Basili, 2005) were not recorded in this study. Thus, they no more needed to stimulate by themselves since they were positively occupied and engaged achieving their academic tasks through the use of technology (Tureck & Matson, 2012). In fact, Arthur, Randy and Steven were progressively on-task through the implementation of the CBP, ensuring them with adequate and constantly varied environmental stimulation and/or different opportunities of choice/strategy, decreasing consequently their necessity of self-stimulation (Stiegler & Davis, 2010; Devlin, Healy, Leader, & Hughes, 2011). Specifically, the stereotyped behaviors were positively replaced by new adaptive responses such as achieving academic skills and the on-task behavior (Stasolla *et al*., 2014).

Fifth, all participants generalized their performance switching on the home setting. Thus, by suspending the intervention program and by transferring it at children's home, Arthur, Randy and Steven consolidated their learning process, enhancing their academic skills, choice strategies and input environmental stimulation, with their parents, pointing out their capacities, even within different contexts (Paynter & Peterson, 2013; den Brok & Sterkenburg, 2015). That is, one may argue that the study promoted, at least, a basic form/level of external validity (Shattuck, Orsmond, Wagner, & Cooper, 2011; Sniezyk & Zane, 2015).

Sixth, support teachers involved in the social validation assessment formally endorsed the intervention program. In other words, all raters favorably and positively considered the use of a CBP aimed at enhancing academic activities, regardless the group membership. That is, irrespective

of the comparison within each of them was randomly assigned (i.e., baseline versus one of the intervention phases or baseline versus generalization), all the sample (i.e., 48 raters) estimated the use of such technology as suitable, comfortable, promoting constructive engagement, beneficial and supported it for the participants involved, corroborating the clinical and rehabilitative validity of such intervention for children with ASD and ID (Perilli, Lancioni, Hoogeveen, Caffò, Singh, O'Reilly *et al*., 2013; Perilli, Lancioni, Laporta, Paparella, Caffò, Singh *et al*., 2013; Caffò, Hoogeveen, Groenendaal, Perilli, Damen, Stasolla *et al*., 2014).

Seventh, despite the aforementioned positive outcomes, this study presents some limitations. For example, it is based on a single-subject experimental design, involving three participants with ASD and ID. Consequently, to generalize the findings an extension to new participants with ASD, ID and/or other developmental disorders (e.g., cerebral palsy) is undoubtedly necessary. An outcome measure of the quality of life such as the indices of happiness and/or indices of positive participation (Stasolla *et al*., 2015) is recommended. A new assessment of participants involved via CARS, VABS-II and WISC-IV before the generalization phase would be preferable. A maintenance/generalization phase within the school setting involving other staff personnel (e.g., a second teacher) and/or a sixth academic discipline (e.g., foreign language) should be suggested. Finally, the number of questions presented across sessions and phases was constant. It would be preferable to increase and vary it as well.

In conclusion, this study underlined the overall utility of a CBP for improving academic skills by children with ASD and mild ID both in school and home settings. Furthermore, it was suitable fostering the on-task behavior, and preventing withdrawal, isolation, passivity and repetitive behaviors exhibited by those children. New research perspectives in this area should deal with the following topics: (a) further extension of the technology both in terms of more responses adopted and participants involved, eventually with different levels of functioning and various autism spectrum disorders, compared to those of the present study (e.g., children with tantrum behaviors), (b) the consideration of an outcome measure of the quality of life such as the indices of happiness (Lancioni, Singh, O'Reilly, Oliva, Smaldone, Tota *et al*., 2006), (c) eventually a carrying out of a follow-up and/or a maintenance phase, (d) an enlargement of the social validation assessment, involving parents and students as raters (Lancioni *et al*., 2006), and (e) a comparison between two or more technological devices and/or

resources/conditions (e.g., two or more different rehabilitative strategies) within the same experimental design (Barlow, Andrasik, & Hersen, 2006).

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