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A REVIEW OF INTERVENTIONS IN AUTISTIC CHILDREN BY USING SOMATIC GAMES

LEI Xian-mei
Research Center for the Education of Autistic Children, Faculty of Education, Beijing Normal University, Beijing, China

LIU Yan-hong (201321010110@mail.bnu.edu.cn)
Research Center for the Education of Autistic Children, Faculty of Education, Beijing Normal University, Beijing, China

HU Xiao-yi
Research Center for the Education of Autistic Children, Faculty of Education, Beijing Normal University, Beijing, China

Abstract
Technology-aided instruction and intervention (TAII) is an evidence-based practice intervention method for autistic individuals. With three-dimensional display and body awareness, somatic games are video games operated through body movements. It achieves human-computer interaction in an effective way, and has great potential to support autistic individuals to obtain target skills. This study reviews research literature on the studies of intervention in autistic children by using somatic games, sums up the strength and problems of the study, and then gives enlightenment on related research and practice in future.

Keywords: autistic children, somatic games, intervention

Introduction
Autism is a pervasive developmental disorder caused by abnormal brain function. According to the Diagnostic and Statistical Manual of Mental Disorders-fifth edition (DSM-V) published by the American Psychiatric Association in 2013, autism spectrum disorder is identified by two diagnostic markers: persistent deficits in social communication and social interaction, and the restricted, repetitive patterns of behavior, interests, or activities (American Psychiatric Association, 2013). With regard to these deficits, individuals caring for children and youth with autism spectrum disorder have been striving to explore more scientific and effective treatment methods. In January 2014, National Professional Development Center published a report, which was called Evidence-Based

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Practices for Children, Youth, and Young Adults with Autism SpectrumDisorder. This report described 27 intervention practices designated as evidence-based practices. One of those intervention approaches is technology-aided instruction and intervention (TAII). TAII are those in which technology is the central feature of an intervention that supports the goal or outcome for the student, which can be used effectively to address social, communication, behavior, joint attention, cognitive, school-readiness, academic, motor, adaptive, and vocational skills (Wong et al., 2014).

In TAII, natural user interface (NUI) shows great potential benefits in autistic individuals. “Natural user interfaces” have been adopted as a generally accepted term to refer to a new classification of computerized interactions that extend beyond traditional mice and keyboards, including pens/writing, gestures, speech, eye-tracking, and tangible computing. NUIs enable a variety of input mechanisms specific to the needs of individuals who present with different sensory impairments (Kientz et al., 2013). With the development of sensor technology, speech recognition, and computer vision, the use of motion sensing allows users to interact without any intermediary device to reach perfect natural user interface (Ma et al., 2012; Kandroudi, Bratitsis, 2013). Based on motion sensing, somatic games are video games operated through body movements (Wang et al., 2014), which means that the body motion is the game mechanic. Somatic games are digital games requiring neither mice nor keyboards, but a great number of body movements while being played.

The high potential of somatic games for learning is grounded on two relationships: the one between digital games and children’s development, and the other between body movements and children’s development. In terms of the relationship between digital games and children’s development, American education expert Marc Prensky (2001) proposed that integrating digital games with education would achieve better learning outcomes. Because digital games constitute potentially powerful learning environments (Oblinger, 2004), and children are not receiving knowledge passively but participating in the activities very positively (Whitton, Moseley, 2012). Therefore, those digitalgames aiming at making children be producers of knowledge (Gee, 2003), can make their learning more easier, more enjoyable, and more interesting, and thus, more effective. In general, digital games that encompass educational objectives and subject matter are believed to contribute to children’s development. As for the relationship between body movements and children’s development, Piaget’s theory at first stated thatknowledge acquisition is derived from active experiences in the world. Then, embodied cognition theory also emphasized that cognition originate itself from the interaction between body and environment. Later, more studies suggested that body movements affect emotional processes, and affective and social communicative mediation apartfrom cognitive processes (Byrne, Byrne, 1993; Yeung, 1996; Bianchi-Berthouze, 2013).With respect to children with autism, previous studies have shown that there is apositive correlation between behavioral problems and lack of body movements (Huang, 2003). Thus, engaging in body movements will contribute to reduce their self-stimulatory behaviors (Celiberti et al., 1997), class destruction behaviors (Gordonet al., 1986), and improve their body aptitudes, such as stamina, strength, and agility (Lochbaum, Crews, 2003; Pitetti et al., 2007).

While theoretical arguments and empirical results suggested that both digital games and body movements will be beneficial for autistic children, the marriage of body movements with digital games, also known as somatic games, is a promising approach for children with autism that has been increasing in attention and popularity in recent years. Since individuals with autism demonstrate delay in fine motor skills which causes difficulties in grasping and manipulating objects, such as a mouse (Christinaki et al., 2014), and combining with their strong motivation and interests for somatic games (Finkelstein et al., 2013), it is not difficult to conclude that somatic games will be a highly promising way to empower the teachers or parents of children with autism with valuable tools to develop important skills, such as cooperation, attention, and imitation, and then to improve their quality of life. The current study is supported by the Fundamental Research Funds for the Central Universities, in which we attempt toreview empirical studies that applying somatic games to promote autistic children's skills, and then summarize and analyze the characteristics of these studies, hoping to provide insights into related research and practice in future.

Methods

The aim of this study is to provide a complete and structured literature review of interventions for autistic children by using somatic games. To locate suitable articles, a computerized multi-database literature search on the China National Knowledge Infrastructure (CNKI), Web of Science, ProQuest, and Google Scholar search engine was performed using combinations of the following search terms and phrases: active video games, somatic games, motion-based touchless games, motion interactive games, exergames, autistic children, children with autism, children with autism spectrum disorder. Then, a dataset of 252 articles were received. After having read these articles' titles and abstracts, we excluded the same articles, books, and review articles, then reserved 43 articles in English language. Afterwards, we conducted a detailed reading for the full paper to select the most appropriate ones, which met the following criteria: (1) the subjects in the research must be identified as having a diagnosis of autism spectrum disorder, (2) the research must examine the use of somatic games as an intervention tool for children with autism, (3) the research must be an empirical study, not a theoretical one, and (4) the research can be retrieved online. Ultimately, 7 articles were identified for this review. The main information of these articles is shown in TABLE 1.

Table 1 – Main Information of the Studies Included

Author and Nationality	Years	Subjects	Consoles	Somatic Games	Sites of Intervention	Duration of Intervention	Target Behaviors
Li et al. (Taiwan,China)	2012	three autistic children, aged 8-10	Webcam	Swimming Race Game (There is no further information for the game.)		30 minutes	sensory integration
Bartoli et al. (Italy)	2013	five autistic boys, aged 10-12	Kinect	(1) Bump Bash (The children should avoid a moving ball thrown against the player's avatar from the opposite side of the field.) (2) Body Ball (The children should hit a volley ball thrown from the opposite side of the field.) (3) Pin Rush (As in real bowling, the children should throw a ball towards a set of distant pins.) (4) Target Kick (The children should kick the ball towards a target area defended by a virtual goalkeeper.) (5) It's not what you think! Honest! (The goal is to create body postures that mimic closed shapes shown in the virtual world. At the same time, some fantasy characters, white rabbits, will attempt to interfere with the player's activity and disturb him by laughing and jumping here and there.)	Associazione Astrolabio, a therapeutic center in Florence	3 hours and 40 minutes	attention, emotion, and behavior

Shoemaker (USA)	2013	eight autistic children, aged 4-11	Wii	(1) Just Dance 3 (2) Wii Sports (3) Mario Party (4) Just Dance for Kids (There is no further information for these games.)		1hour	visual-motor coordinati on
Hillier (USA)	2013	three autistic boys, aged 3-5	Wii	(1) Dora the Explorer Dance Video (2) Nickelodeon Dance (3) Zoo Adventures (There is no further information for these games.)	a preschool classroom	2 to 3 minutes	engagement andpeer interaction
Ferguson et al. (USA)	2013	six autistic boys, aged 7-11	Wii	Wii Sports Games (There is no further information for the game.)	an outpatient clinic of a large southeastern university	90 minutes	giving compliments, taking turns, and making a positive postgame comment
Garzotto et al. (Italy)	2014	five autistic boys, aged 6-8	Kinect	Pixel Balance (The goal of this game is to create body postures that mimic closed shapes shown in the virtual world. The child is realistically mirrored on the screen and he must find the correct movements to "fill" the shape, maximizing the area that is "covered" by his body.)	Associazione Astrolabio, a therapeutic center in Florence	10 minutes	imitative capability, body schema awareness, and social skills
Bartoli et al. (Italy)	2014	ten autistic children (nine boys and one girls), aged 6-8	Kinect	(1) Bubble Game (The children have to catch as many appearing objects as possible.) (2) Space Game (The children have to move their body to avoid falling objects.) (3) Shape Game (The children have to	Associazione Astrolabio, a therapeutic center in Florence	30 minutes	selected attention, sustained attention, visual perception, motor coordination, and visual-motor coordination

	replicate a particular shape shown on screen using their body.)	

Review

The consoles of somatic games

Somatic games can't run without motion sensing devices. Currently, there are three common motion sensor technologies, namely Nintendo Wii, Microsoft Kinect, and Sony PlayStation Move. The Nintendo Wii was developed by Nintendo Company in 2006. Its distinguishing features is the wireless controller, the Wii remote which contains a sensor able to detect motion and rotation in three dimensions and then can be utilized as a gesture recognition and pointing tool (Pearson, Bailey, 2007; Kandroudi, Bratitsis, 2013). Wii somatic games can not only improve health conditions such as heart rate, fat consumption, oxygen uptake, respiratory exchange ratio, and hand-eye coordination(Lin et al., 2010), but also increase participants' motivation for physical rehabilitation (Chang et al., 2011). But Wii requires users to hold the sensors in the hands to detect motions, which possibly causes inconvenience and discomfort (Chang et al., 2011), and may not be suitable for some special groups (Li et al., 2012). PlayStation Move is a motion-sensing game controller platform created by Sony Corporation in 2010, which uses a PlayStation Eye camera to track the wand's position, and inertial sensors in the wand to detect its motion (Kandroudi, Bratitsis, 2013). The wand contains a three-axis accelerometer and a three-axis gyro sensor, which are used to track rotation in overall motion and can be used for dead reckoning in cases when the camera tracking is insufficient, such as when the wand is obscured behind the player's back (Tanaka et al., 2012). However, due to certain reasons, existing studies didn't apply PlayStation Move. Kinect is a motion sensing input device implemented by Microsoft Corporation in 2010. The device can detect user movements and gestures and transfer them to the computer, providing a natural user interface that enables users to control and interact without the need to touch a game controller (Chang et al., 2011; Altanis et al., 2013; Kandroudi, Bratitsis, 2013; Wang et al., 2014). Kinect somatic games can also enhance participants'motivation and promote health-related fitness (Chin, 2012). However, Kinect has some limitations as well. For instance, it can only recognize the head, body, and limbs, but can not identify fingers acutely. Besides, it can just capture some simple motions (Ni et al., 2013). In addition to the three common motion sensor technologies above, some studies also applied the web camera (webcam). Webcam is a kind of digital camera video monitor service terminals with an inbuilt web server by which people can monitorvideo, control remotely and manipulate PTZ (Guan, 2009). Li et al. (2012) proposedthat webcam was similar to Kinect and was relatively cheaper. Taking into account the mutability of autistic children, future consoles selection can be determined by the target behaviors and children's cognitive abilities and motor skills.

The characteristics of somatic games

Somatic games in the existing studies include ball games, sports, dance, adventures and so on. Some were chosen from commercial games, and some others were designed by researchers themselves. For example, Li et al. (2012) selected the swimming race game from an online Flash game resource website. Bartoli et al. (2013) selected the five games from various packages and over 150 entertainment products. Whereas Garzotto et al. (2014) and Bartoli et al. (2014) designed their own games according to the characteristics and learning needs of autistic children. It has been shown that games developed according to some guidelines are more effective than commercial games, which have a similar game logic but are not explicitly designed for autistic children (Bartoli et al., 2014).

Generally speaking, somatic games applied in the existing studies present several characteristics as the following. (1) task simplicity: considering autistic children tend to have difficulty in finishing tough works, Li et al. (2012) and Bartoli et al. (2013) required the task difficulty of the games should not be too high, to fit the abilities of autistic children and to focus their attention and emotions on play rather than onunderstanding the complexity of multiple game rules. (2) short duration: as playing somatic games for a long time may lead to exhaustion, games in existing studies were demanded to be finished in short time. For example, Bartoli et al. (2013) suggested that the game session should be completed in few minutes, for the purpose of favoring concentration and keep physical fatigue at an affordable level. (3) ordering: in order to keep autistic children's interests and motivation, Bartoli et al. (2013) stressed that it must have an order of complexity among the games. And Garzotto et al. (2014) divided the game's configurations in 5 levels with growing difficulty. (4) diverse: on the one hand, it refers to the diversity of the game content, which include ball games, sports, dance, adventures and so on. On the other hand, it means the multiplicity of the game modes. For instance, the pixel balance game and the shape game in existing studies bothcan be played in single player or in multiplayer mode. While in multiplayer mode, participants have to cooperate to finish the tasks, which contributes to their social interaction skills. (5) customizable: to fit different children's interests and abilities, existing studies highlighted the customizable mechanism of the games. For example, Bartoli et al. (2014) emphasized that the designed games should be strongly customizable according to the characteristics and learning needs of the autistic children, including the game speed, object density and enabled body parts. Similarly, Garzotto et al. (2014) also stressed the game's parameters should be set personally, including the shape to match, steady duration, and time limit.

The implementation of the intervention

Despite different studies conducted different intervention procedures, the implementation of the intervention shows several characteristics in general as follows.
(1) diversity of evaluation tests: considering the use of evaluation tests can objectively reflect the change of the subjects before and after the intervention, which is veryimportant to examine the effectiveness of somatic games, existing studies adopted multiple evaluation tests, such as the Developmental test of Visual-Motor Integration (VMI), Wilcoxon Signed Rank Test, Bell Test, and Supplementary Subset Wisc IV. (2)

different duration of intervention time: existing studies showed very different intervention time. For example, Bartoli et al. (2013) made an arrangement that each child played five games for approximately 3 hours and 40 minutes. Whereas Hillier (2013) let the children play the Wii game just for 2 to 3 minutes. Actually, autistic children require intensive and sustained intervention, and the effect will be significant. But the long-time intervention may bring about exhaustion and loss of motivation and interests, and thus affect the effectiveness of the intervention. As a result, intervention duration should be reasonable and be determined by the intervention goals, procedures, and autistic children's characteristics and stamina. (3) flexible arrangement of the intervention activities: most research intervened with somatic games selected or developed, some other research conducted other activities in addition to somatic games. For example, in an attempt to verify the functional relationship between Wii game and peer interaction, children in the study of Hillier (2013) were directed to make a choiceof a different free choice activity available in the classroom after playing Wii game withtheir peers. Likewise, Ferguson et al. (2013) allotted the participants 15 minutes of free time at the end of the intervention, in which they could play other games the participants brought from home or have access to other games on the Wii console. (4) effectively use of reinforcements: as the positive reinforcement is the most effective way to enhance the initiative of the autistic children (Peng, 2014), existing studies applied plentiful reinforcements. For example, Bartoli et al. (2014) gave a positive final reward (e.g., an applause or a golden cup) to participants if they finished the game. Ferguson et al. (2013) reinforced each participant with verbal praise and token economypoints (could be exchanged for tangible rewards, e.g., Legos, sunglasses, Pokémon trading cards) when they showed the following behaviors: following directions, participating in group discussion, and demonstrating the target skills. Analogously, Garzotto et al. (2014) showed a 3-second video reward once the children successfully accomplished the activity, for the sake of gratifying and encouraging them.

The effectiveness of the intervention

Empirical studies focused on autistic children's motor skills (e.g., balance, visual-motor coordination), cognitive skills (e.g., imitative capability, body awareness), and social skills (e.g., attention, emotion, peer interaction). And majority of them hold quite positive intervention effectiveness. For instance, Li et al. (2012) analyzed three subjects'biological change on heart beat, blood pressure, and temperature, with the observation records about limb coordination, concentration focus time, tempo accommodation, and game performance, finding positive changes on vision, hearing, motor senses, and overall coordination of limbs. In addition, depending on the feedback, the teacher andthe students possessed positive attitudes toward applying the game for training autistic students' sensory integration. Bartoli et al. (2013) found an increase of selective and sustained attention in all children and their difficulties on interaction and anxiety were decreased according to three participants' changes before, during, and after the treatment. Combining with three participants' data in baseline and intervention, Hillier (2013) held the belief that they demonstrated increased rates of peer interaction. At the same time, Hillier conducted an interobserver reliability assessment through training two assistants to simultaneously and independently code the sessions. Besides, the researcher provided a survey on the ease and effectiveness of the intervention to the classroom teachers to measure the social validity of the study. Ferguson et al. (2013) also indicated that participants exhibited improved performance in giving compliments, taking turns, and offering a positive postgame comment, and each participant made significantly fewer negative comments toward his peers and group clinicians after the intervention. Furthermore, these behaviors were found to generalize to other stimuli (i.e., different video games and actual sports). On the basis of the global weighted score, Garzotto et al. (2014) revealed that games successfully contributed to autistic children's imitative ability, body awareness, and social skills. Bartoli et al. (2014) compared the evaluation between the initial and the final time of the treatment group, finding that motion-based touchless games have a learning potential for autistic children's attention, integration of motor and visual skills.

Very few studies did not show significant data change. For example, Shoemaker (2013) found that the Nintendo Wii did not improve visual-motor coordination, visual perception or motor coordination in Hispanic children with autism according to the data before and after the treatment. The researcher summarized several problems that might have affected the internal validity of the study. First, this study utilized a pre-post test design, potentially resulting in test-retest effects. This would mean that any changes that might have occurred could have been a result of practice effects. Second, only one measure (The VMI) was administered to assess for each construct, which means there was not convergent validity for each construct being measured. Third, during the initial pre-test period, many of the participants did not know the researchers, resulting in evaluation apprehension which may not have been present during the post-test where they knew the researchers. Forth, the assessment procedures and interventions were administered at different times of the day and different times of the year for different participants. Some participants completed the assessment and intervention over thecourse of summer break, while others completed the intervention during the school year.This could have resulted in History effects. Fifth, the children played the games with the assistance of their families, which means that the amount of support may have affected the results as well. Nevertheless, regardless of the unremarkable data changes, the researcher reported that all children appeared to enjoy the games, and each child developed their own favorite games or activities with each game, which confirms the potential of somatic games to motivate autistic children.

Conclusions and Directions for Future Research

In this paper, we present a literature review of somatic games for children with autism. Building on the encouraging findings from empirical studies, we suggest that somatic games, which incorporate body movements, may help to strongly motivate autistic children to engage in vigorous exercise and have the potential for developing their key skills, such as cooperation, attention, and imitation, thus leading to better life. Given that the children and the teachers or the parents possess positive attitudes toward somatic games, and the low-cost full-body tracking devices such as the Wii or Kinect will be widely available for schools and homes, we suggest it is essential to integrate somatic games into daily routines of children with autism, so as to be favorable for them. Meanwhile, it is noteworthy that excessively or inappropriately use of somatic games may hurt children, such as ankle sprain, which makes it vitally important to apply somatic games reasonably and properly in the future.

As we all know, autistic children always cannot maintain appropriate attention time, and lots of body movements in somatic games may lead to burnout after novelty, making it very crucial to develop multifarious games to arouse and maintain autistic children's motivation and interests. Owing to the variability in autistic children's interests, it is not practical to develop custom-tailored games for each child's particular interests. However, it may be possible to provide a customization mechanism in these games to allow teachers and parents to edit according to each child's characteristics. At the same time, it is also vitally important to make a more diverse game design to keep children's interests and avoid boredom caused by tedious play. Furthermore, it could notbe better if the game would be set with multiple modes, in which decisions between single player and multiplayer mode can be made according to different intervention goals. Especially, in the multiplayer mode, autistic children have more chance to interact with peers and then will lead to better results in improvement of their social skills, such as cooperation and social interaction. Moreover, games with multiple difficulty levels is also needed to meet the needs of different children and boost their enthusiasm and motivation to participate in games more vigorously. Thus, we believe that making games fun and having multiple modes and difficulty levels might be the first reasonable step towards motivating the children. What's more, seeing that children with autism typically have fear of difficulty, the number of steps required to operate the game should be minimized, with the aim of making it easier for autistic children (Weng et al., 2012). Additionally, it is necessary to provide a data analysis or visualization toolsin these games which presents the progress and development of the children's skills (Zakari et al., 2014).

In addition to the games, the experimental design of future interventions should be elaborated rigorously. Some existing studies paid more attention to the selection or design of the games, but ignored the experimental design of the intervention. For example, Garzotto et al. (2014) described the goals and the characteristics of the game in detail, whereas skipped over the procedures and results of the intervention. Two other studies even did not mention their experimental designs. In fact, rigorously experimental design will not only affect the persuasiveness of the results, but also be convenient for replicable studies in the future. Therefore, while valuing the game design,future studies should also emphasize the rigorousness of the experimental design of the intervention, making the intervention results more convincing. Additionally, it would be beneficial for future research to report the reliability and validity of the intervention. Few existing studies verified their reliability and validity of the intervention, which makes it unclear whether the target skills would be generalized to other contexts or not. As is known to all, reliability means the credibility of the results, and validity refers to the availability of the findings. They are very important standards to verify empirical studies, undoubtedly related to the dependability and authenticity of the findings. As a consequence, future studies with more accurate and reliable data about the reliability and validity should be conducted.

While research on the benefits of somatic games are encouraging, and given the shortcomings of existing studies, more strict research on the somatic games as an intervention to facilitate various vital skills of children with autism are imperatively required in future.

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