A review of somatic games intervention for children with autism spectrum disorders

(overview essay)

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

Keywords: *children with autism spectrum disorders, somatic games, intervention, review*

1 Introduction

Autism spectrum disorder (ASD) is one of the fastest growing developmental disorders in the US with the Center for Disease Control (CDC) estimating that 1 in 68 children are diagnosed with ASD. According to the Diagnostic and Statistical Manual of Mental Disorders-fifth edition (DSM-V) published by the American Psychiatric Association in 2013, ASD is identified by two diagnostic markers: persistent deficits in social communication and social interaction, and the restricted, repetitive patterns of behavior, interests, or activities. With regard to these deficits, individuals caring for children and youth with ASD 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 Practices for Children, Youth, and Young Adults with Autism Spectrum Disorder. 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 individuals with ASD. "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 (Kandroudi, Bratitsis, 2013). Based on motion sensing, somatic games are video games operated through body movements, 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. The particular influence of digital games on children's learning has been cherished by American education expert Marc Prensky. He (2001) proposed that integrating digital games with education would achieve better learning outcomes. Because digital games constitute potentially powerful learning environments, and children are not receiving knowledge passively but participating in the activities very positively. Therefore, those digital games aiming at making children be producers of knowledge, can make their learning much easier, more enjoyable, and more interesting, and thus, more effective. Besides, many researches indicates that children with ASD may have an affinity for digital media and that these technologies may serve an important role in ASD intervention (Uzuegbunam et al., 2015). 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 firstly states that knowledge acquisition is derived from active experiences in the world. Then, embodied cognition theory also emphasises the formative role of embodiment, which is the way in which an individual's sensory-motor capacities enable him or her to successfully interact with the physical environment (Mademtzi, 2016). Later, more studies have suggested that body movements affect emotional processes, and affective and social communicative mediation apart from cognitive processes (Bianchi-Berthouze, 2013). With respect to children with ASD, previous studies have shown that there is a positive correlation between behavioral problems and lack of body movements. Thus, engaging in body movements will contribute to reduce their self-stimulatory behaviors, class destruction behaviors, and improve their body aptitudes, such as stamina, strength, and agility (Pitetti et al., 2007).

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

2 Methods

The aim of this study is to provide a complete and structured literature review of somatic games interventions for children with ASD. 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 ASD, (2) the research must examine the use of somatic games as an intervention tool for children with ASD, (3) the research must be an empirical study, not a theoretical one, and (4) the research can be retrieved online. Ultimately, 18 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	Duration of Intervention	Target Behaviors	Research Design
Blum-Dimaya et al. (USA)	2010	four children with ASD	PlayStation Move	Guitar Hero II™	15 minutes	imitative skills	a multiple-probe across participants design
Li et al. (Taiwan, China)	2012	three children with ASD aged 8 to 10	Webcam	Swimming Race Game	30 minutes	sensory integration	a quasi-experiment case study
Bartoli et al. (Italy)	2013	five boys with ASD aged 10 to 12	Kinect	(1) Bump Bash (2) Body Ball (3) Pin Rush (4) Target Kick (5) It's not what you think! Honest!	3 hours and 40 minutes	attention, emotion, and behavior	
Shoemaker (USA)	2013	eight children with ASD aged 4 to 11	Wii	(1) Just Dance 3 (2) Wii Sports (3) Mario Party (4) Just Dance for Kids	1hour	visual-motor coordination	a repeated measures quasi-experimental design
Hillier (USA)	2013	three boys with ASD aged 3 to 5	Wii	(1) Dora the Explorer Dance Video (2) Nickelodeon Dance (3) Zoo Adventures	2 to 3 minutes	engagement and peer interaction	a multiple baseline across participants design
Ferguson et al. (USA)	2013	six boys with ASD aged 7 to 11	Wii	Wii Sports Games	90 minutes	giving compliments, taking turns, and making a positive postgame comment	a multiple baseline across individuals design

Garzotto et al. (Italy)	2014	five boys with ASD aged 6 to 8	Kinect	Pixel Balance	10 minutes	imitative capability, body schema awareness, and social skills	
Bartoli et al. (Italy)	2014	ten children with ASD aged 6 to 8	Kinect	(1) Bubble Game (2) Space Game (3) Shape Game	30 minutes	selected attention, sustained attention, visual perception, motor coordination, and visual-motor coordination	a group-design
Zhu et al. (China)	2015	two children with ASD aged 9 to 10	Leap motion	Matching games	30 minutes	fine motor skills	an AB sequence design
Xu et al. (China)	2015	fifty-one children with ASD aged 3-19	Kinect	Rehabilitation games	30-40 minutes	self-care, mobility and sociability	a pre- and post-test experimental design
Bhattacharya et al. (USA)	2015	eighteen students with ASD aged 8 to 19	Kinect	Motion-based activities		engagement, social behavior, motor skills and coordination	
Uzuegbunam et al. (USA)	2015	three boys with ASD aged 7 to 12	Kinect	MEBook		greeting behaviors	a multiple-baseline single-subject study
Golden (USA)	2015	eleven boys with ASD aged 8 to 11	Kinect	(1)Crazy Sales (2)Save the hotdog	45 minutes	physical activity levels and executive function	a group-design
Mademtzi (UK)	2016		Kinect	Pictogram Room	15 minutes	sensory-motor skills	mixed a single-subject approach and a group-design approach
Lei et al. (China)	2016	one boy with ASD aged 11	Kinect	Catching game	15 minutes	motor skills	an ABAB sequence design
Lei et al. (China)	2017	four children with ASD aged 10 to 11	Kinect	Catching game	15 minutes	attention	an ABAB sequence design

Ge et al. (China)	2017	one girl with ASD aged 14	Kinect	Gesture Games: "Fruit Ninja" and "Big Adventure"	30 minutes	verbal skills, communication skills, peer relationship, interests	
Edwards et al. (Australia)	2017	eleven children with ASD aged 6 to 10	Kinect	Sports active video game	45-60 minutes	object control skills	a 2-group pre- and post-test experimental design

3 Review

The consoles of somatic games

Somatic games cannot 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 (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, 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). One of the existing studies applied the PlayStation Move, which 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. Most of the existing studies chose the Kinect, which is a motion sensing input device implemented by Microsoft Corporation in 2010. The device can detect user's 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; Kandroudi, Bratitsis, 2013). Using the Kinect sensor, children are engaged naturally, using hand and body gestures, in a playful learning experience where both body and brain stimulation are present and active. Thus, somatic games with kinect sensor can enhance participants' motivation and promote health-related fitness. 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. In addition to the three common motion sensor technologies above, some studies also applied other sensors, such as leap motion and the web camera (webcam). Leap Motion is a new gesture and position tracking system with the accuracy level of sub-millimeter (Zhu et al., 2015). Webcam is a kind of digital camera video monitor service terminals with an inbuilt web server by which people can monitor video, control remotely and manipulate PTZ. Li et al. (2012) proposed that webcam was similar to Kinect and was relatively cheaper. Taking into account the mutability of children with ASD, 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), Bartoli et al. (2014) and other researches designed their own games according to the characteristics and learning needs of children with ASD. 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 children with ASD (Bartoli et al., 2014).

Generally speaking, somatic games applied in the existing studies present several characteristics as the following. (1) task simplicity: considering children with ASD 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 children with ASD and to focus their attention and emotions on play rather than on understanding 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 ASD 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 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 both can be played in single player or in multiplayer mode. While in a 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 children with ASD, 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) different experimental designs: some researchers chose a group-design approach, while most utilised a single-subject design to see the effectiveness of the somatic games intervention. Single-subject design is one of the standard practices that can be used to examine the effectiveness of interventions based on the nature of the interventions and target behaviors (Uzuegbunam, 2015). In addition to that, interviews with the parents or teachers were also conducted in some researches to gather the qualitative data. In other words, mixed-methods design has been applied to provide better validity of the results. (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, children with ASD 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 ASD 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 choice of a different free choice activity available in the classroom after playing Wii game with their 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 children with ASD, 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 economy points (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. Golden (2015) gave the participant stickers every 2 minutes for feedback and additional encouragement if the child was lagging or was very intent in the game. 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 ASD 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 and the students possessed positive attitudes toward applying the game for training ASD 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 (2013) 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 ASD 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 ASD 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 the course 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 children with ASD. Besides, Edwards et al. (2017) also did not find any significant increase in object control skills following a 2-week intervention of playing Kinect Sports on the Xbox Kinect. They explained that the use of active video games (45-60 min, 3 times a week for 2 weeks) as a play-based intervention may not provide enough opportunity for children to perform the correct movement patterns to influence target skills. They suggested an active video game program may be more successful when used for a longer period of time or when incorporated in a therapy session within a structured environment, rather than for "play" in an unstructured in-home environment. However, they did find an improvement in ASD children's perceptions of their own motor skills, which could lead to positive active behavior.

4 Conclusions and Directions for Future Research

In this paper, we present a literature review of somatic games for children with ASD. Building on the encouraging findings from empirical studies, we suggest that somatic games, which incorporate body movements, may help to strongly motivate children with ASD to engage in vigorous exercise and be a powerful stepping-stone to develop 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 worthy to integrate somatic games into daily routines of children with ASD, 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, children with ASD always can not 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 their motivation and interests. Owing to the variability in ASD 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 configure the settings according to the individual needs and profile of each child. As some researchers proposed, the applied game categories, levels and terms should be personalized so the highest effect on child's progress could be achieved (Roglić, 2016). 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 not be 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, children with ASD 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 are 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 ASD 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 children with ASD. Additionally, it is necessary to provide a data analysis or visualization tools in 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. some 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 ASD are imperatively required in future.

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