Role of Serious Game in Improving Self-care Ability: One Case Study on Autistic Children

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Abstract: Background: It has been confirmed that serious games improve the social and cognitive abilities of autistic children, while there is little research on their effectiveness in enhancing the self-care skills of these children. This study aims to explore and verify whether training based on serious games can effectively improve the self-care abilities of autistic children. Subjects and Methods: Based on autistic children's needs for personal dressing skills, 3 12-year old autistic children of similar intelligence were selected for teaching intervention with the theme of "personal dressing"via the animation demonstration of social stories in the originally developed serious game. A single-participant & cross-participant multiple-baseline experimental design was employed to observe and record the participants' behaviors including adjusting dress according to the occasion, changing shoes based on activity needs, and

dressing or undressing according to temperature and weather conditions. Quantitative analysis of C-statistics, and qualitative analysis of visual check, were conducted in the study. Results: The results showed that for target behavior 1, the Z-values in C-statistics for the three participants were 1.93, 3.53, and 1.28, respectively; for target behavior 2, the Z-values were 2.45, 2.6, and 1.88, respectively; and for target behavior 3, the Z-values were 3.7, 2.12, and 3.06, respectively. Eight out of the nine data points showed significant differences in C-statistics ($P<0.05$), with one data point potentially not showing significance due to the unfamiliarity with the serious game operation. The Z-values during the maintenance period did not see significant differences, indicating good maintenance of intervention effects. The study results indicate that all three participants showed varying degrees of improvement in the three target behaviors related to dressing adjustments after the intervention, and the intervention effects were well-maintained.Interviews with parents, teachers, and the participants themselves revealed that the serious game was well-liked by the autistic participants and meanwhile positively influenced their compliance. Conclusions: This study not only confirmed the effectiveness of serious games in enhancing the self-care abilities of autistic children, but also explored the positive impact of integrating the social storytelling and participatory design on the intervention effects of serious games.
Keywords: Autistic Children, Serious Game, Dressing Adjustment, Social Story, Self-Care Ability.

1. INTRODUCTION

Self-care ability refers to one's ability to take care of himself/herself in drinking, eating, dressing, going to toilet, cleaning, etc. It also involves individual basic life skills and survival ability, and the basis for individual independent development and one's adaptation to social environment .The ultimate goal of special education is to enable children with special needs to live independently, take care of themselves and master basic life skills and develop good habits.Research shows that autistic children suffer obvious defects in social skills, as well as severe challenges in taking care of themselves (Panceri et al., 2021). The lack of self-care ability brings autistic children great difficulties in adapting themselves to society, thus triggering a negative impact on their study, employment, self-confidence and life quality(Das et al., 2017).In addition, the lack of autistic children's self-care ability may lead to more serious social problems, like family financial difficulties, the deterioration of parents' physical and mental health, poor marriage relationship, the increase of siblings' life pressure, the restriction of family social and life activities, and even social shame.In the existing research, scholars have used intervention strategies including job analysis, visual strategy, reinforcement strategy and social story telling to help improve autistic children's life skills like going to the toilet, washing hands,

dressing, ironing clothes, cooking lunch and self-cleaning. Some researchers experimented with social story telling, video teaching and social work intervening (Rodrigues et al., 2017). However, these strategies are effective only when teachers and parents invest a lot of time and energy, and the teaching intervention is mainly aimed at individuals instead of groups. To meet this challenge, a variety of intervention methods and strategies were proposed and practiced. In recent years, digital interventions with serious game as the representative showed their potential in improving autistic children's social skills (Perkins & Berkman, 2012). Serious game does not take entertainment as its main purpose, but adopts the gaming form that educates players amid entertainment, allowing users to receive information during the game playing and obtain new personalized, interactive and interesting learning experience (Barajas et al., 2017). It is designed based upon the characteristics of autistic children preferring interactive visual learning. Compared with traditional intervention methods, it has the characteristics of flexibility, entertainment, motivation, and repeatability (Jung & Sainato, 2015). With the focus on combining educational goals with game mechanisms, the serious game can be adjusted in time according to the characteristics and needs of learners. Its interactivity, repetition and continuous feedback can help stimulate users' learning motivation. With the characteristics of low cost, high popularity and convenient use, it provides a safe and interesting learning environment for autistic children, helping them practice and acquire social skills in simulated social situations and better interact with others in real life (Hassan et al., 2021). Serious games break the limitations of learning time and space, thus greatly reducing the cost of individualized teaching. With the help of Internet, the comprehensive sharing of teaching resources can be achieved in serious games (Kokol et al., 2020). Empirical research shows that serious game intervention can be well used to improve autistic children's social skills, cognition, and self-care abilitities (Liu et al., 2019). For example, game participation logic improves their learning interest. A central goal of serious game is to achieve both educational and rehabilitation goals through learning in games. They no longer passively accept various knowledge, instead, actively participate in the game using social skills, thus fully mobilizing their initiative (Vallefuoco et al., 2022). In addition, the game's narrative attributes reduce users' cognitive difficulty by transforming the process of achieving educational and rehabilitation goals into a progressive narrative. Moreover, games can be easily operated in a repeated manner, thus reducing the workload of teachers and parents (Pennazio & Fedeli, 2019): serious games can provide repeatable

instructions in a flexible environment, and autistic children can be trained repeatedly in the classroom or at home. Meanwhile, the Internet provides an enabling environment for the full sharing of teaching resources (Noor et al., 2012). In existing research, Teoh, Kang et al. used serious games to teach autistic children bathing steps and independent bathing skills respectively. In other studies, serious games are used to improve self-care abilities including learning to shop in the supermarket, understanding the use of money, taking public vehicles, and using the toilet independently. These studies have all witnessed positive intervention effects (Kurniawan et al., 2018). As a high-level skill in self-care skills, personal dressing adjustment skill is an important one. This skill is shown in the "Assessment of Functional Living Skills", "Social Life Ability Scale for Infants-Junior High School Students", and other scales. Autistic children show deficiencies in dressing adjustment skills in daily life and are overly dependent on parents or teachers. As a result, they are ridiculed by others, and their health, and life quality are severely affected. On this basis, this study with three autistic children as the participants, developed and applied the serious game with the theme of "dressing adjustment", and explored a new intervention method that is economical, effective and suitable for both individual and collective teaching, by adopting the single-participant & cross-participant experimental design, so as to improve autistic children's self-care ability. To some extent, this study fills the gap in the development and application of serious games in China, explores the intervention method of combining serious games with social story telling and other teaching strategies, and discusses the effect of the intervention method on the autistic children's self-care ability, providing data support for relevant empirical research and a new perspective for the study on autistic children's self-care abilities.

2.RESEARCH DESIGN AND METHODS

2.1 Participants

This study selected three autistic children from a special education school as participants, with selecting criteria as followed: (1) Those who are diagnosed with autism spectrum disorder; (2) Those who can identify different clothes, such as short-sleeved shirts and trousers; (3) Those who frequently fail to dress and undress according to the temperature changes; (4) Those whose visual attention can last for over 3 minutes; (5) Those who are able to understand simple instructions; (6) Those who are

recommended by teachers and whose participation gets informed consent of parents. The specific information is as followed: Participant C, male, 12 years old, was measured with 52 of Wechsler's IQ, and 36 of score in Children Autism Rating Scale (CARS). He can distinguish different clothes; identify common weathers and seasons under prompts; speak passively; understand simple instructions; and maintain attention for 2 minutes at most. Participant P, male, 12 years old, was measured with 58 of Webster's IQ, and 33 of score in CARS. He can distinguish different clothes; identify common weathers and seasons; speak actively; understand simple instructions; and maintain attention for over 3 minutes. Participant Z, male, 12 years old, was measured with 62 of Wechsler's, and 32 of score in CARS. He can distinguish different clothes; identify common weathers and seasons; speak actively; understand simple instructions; and maintain attention for over 3 minutes.

2.2 Research Tools

2.2.1 Design and Development of Serious Games Based on Social Story Telling.

In the study, a serious game was designed based on social story telling with Unity as the engine, and the Android or PC as the application platform. The game can be played in class or at home with the assistance of teachers or parents. Evidence-based experiments abroad have proved that social story telling is a scientific and effective intervention method for autistic children's education and rehabilitation characterized by visual support (Karal & Wolfe, 2018). Based on the personal life experience of these children, this method describes different social situations or social concepts through brief and individualized stories (Bryan et al., 2017). The social story telling has a unique writing standard, and its integration with other methods represents the main trend of its application, for example, the combination of social story telling with picture book design and animation design. The integration has witnessed good intervention effect in many studies (Chen et al., 2020). Therefore, before the serious game begins, an animated teaching video with social stories as the script is presented for 2 minutes and 6 seconds. The demonstrator of the animated video is a little boy (animated character), whose image is designed based on the textbook for intellectual development published by People's Education Press. The dressing knowledge and application of different seasons, occasions, weathers and temperatures are presented through language description and corresponding pictures (Anagnostopoulou, 2019). Animation script based on the writing standard of social stories, involved

both descriptive and indicative sentences. Scripts and videos were watched and confirmed by the individual training teachers and head teachers of the participants to ensure the effectiveness of the teaching materials (Safi et al., 2022). The game part was designed with the theme of dressing knowledge. Based on the participant's existing dressing adjustment ability and the teachers' analysis, 4 learning tasks were selected. Task 1: Point out the clothing suitable for winter, summer, spring and autumn; Task 2: Choose clothing suitable for different occasions (school, home); Task 3: Find shoes suitable for sports; Task 4: Adjust clothing and shoes according to different weathers and temperatures. The game levels were designed based on 4 learning tasks as shown in Table 1. A game of increasing difficulty with elementary, intermediate and advanced levels set around teaching tasks. Each level of the task consists of three levels as shown in Table2.

Table 1(a): Content, operation and feedback of serious games with 4 tasks

Task	Presented content	Operation content	Operation feedback	Feedback interface
Task 1		Choose two pictures where the characters wear the right clothes in summer and winter respectively.	If it is right, you will get a five-pointed star and enter the next level. If it is not right, you can not enter the next level. Instead, you need to choose to play it again or watch the corresponding short video.	 
Task 2	  	Choose 1 from 3. Choose the right school uniform with a red scarf and drag it towards the boy. Click on the little boy wearing a raincoat on rainy days. Choose to take off your raincoat and wear a school uniform on sunny days.	If you are right, you will get a five-pointed star and enter the next level. If it is not right, you can not enter the next level. Instead, you need to choose to play it again or watch the corresponding short video.	Be the same as the above

Table 1(b): Content, operation and feedback of serious games with 4 tasks

Task	Presented content	Operation content	Operation feedback	Feedback interface
Task 3	  	Choose 1 from 4. Choose the right school uniform with a red scarf and drag it towards the boy. Click "+" to add clothes for the little boy in the supermarket where the temperature is very low. Click "-" to reduce clothes for the little boy in the outdoor environment where the temperature is very high.	If it is right, you can get a five-pointed star. If it is not right, you can not enter the next level. Instead, you need to choose to play it again or watch the corresponding short video.	Be the same as the above

Table 2(a): Each level is distinguished by 3 levels of difficulty

Content	Game level	Presented content	Operation content	Operation feedback	Feedback interface
Learning Video	Cognitive Teaching Approach		Video watching. Click on the top right corner to pause the video as needed.	Automatically jump to the game interface in the end.	
Elementary Game	First Level		Choose two pictures where the characters wear the right clothes in summer and winter respectively.	If it is right, you will get a five-pointed star and enter the next level.	
				If it is not right, you can not enter the next level. Instead, you need to choose to play it again or watch the corresponding short video.	

Table 2(b): Each level is distinguished by 3 levels of difficulty

Content	Game level	Presented content	Operation content	Operation feedback	Feedback interface
Intermediate Game	First Level		Choose two sets of summer and winter clothes in 20 seconds.	If it is right, you will get a five-pointed star and enter the next level. If it is not right, you can not enter next level. Instead, you need to choose to play it again or watch the corresponding short video.	Be the same as the above
Advanced Game	First Level		Match three different seasons with corresponding clothes within 20 seconds.	If it is right, you will get a five-pointed star and enter the next level. If it is not right, you can not enter the next level. Instead, you need to choose to play it again or watch the corresponding short video.	Be the same as the above

In the game, lessons were drawn from Bloom's taxonomy of educational objectives and SOLO (Structure of the Observed Learning Outcome) classification of learning achievements (Ahmad & Hussin, 2017). Based on the social story telling and autistic children's abilities, primary, intermediate and advanced games were designed, so as to know, deeply understand and apply the educational rehabilitation goals respectively. In the collective teaching, teachers can make personalized choices based on the actual situation of autistic children, and the types of games are mainly right-and-wrong games and games of chance. The game difficulty was mainly distinguished by changing scenes, increasing the number of game characters and limiting the time of passing game levels (Haring et al., 2018). For example, the intermediate game involving more pictures, people and scenes poses higher requirement for student's attention compared with the primary game involving less pictures, people and scenes. Priority was given to training autistic children to be better able grasp the game rules in different situations, and finally achieve the educational and rehabilitation goals (Henriksen, 2013). The game concept diagram is as shown in Figure 1.

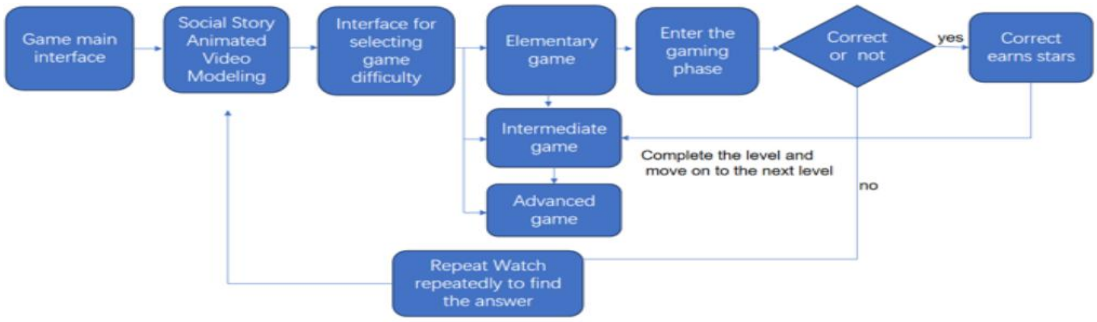

Figure 1: Game design framework diagram.

2.2.2 Characteristics of Serious Game Design in the Study

This serious game has four main features: The combination with social story method: social story method is combined with the design of serious game, and the animated video will be demonstrated before autistic players start playing the game (Jeekratok et al., 2014). Individualization: primary, intermediate and advanced game levels were designed to let autistic children make personalized choices according to their realities (Vallefuoco et al., 2022). Context-based learning: the serious game includes the social contexts of each learning goal that autistic children are familiar with, like school, family, supermarket, etc. These enable autistic children to practice repeatedly in different backgrounds (Terlouw et al., 2020). Structured learning design: in the design of serious game, structured learning activities of three levels were included: learning theme (guidance), animation video demonstration (guidance), game breakthrough (practice) and feedback (reward and prompt). Amid structured learning, when players fail to pass the game level, repeated video demonstration and indicating words will appear (Tang et al., 2019).

2.2.3 Dependent Variable Scoring Table

Two versions of "Dressing Skills Scoring Table" were compiled to record the behavior of the participants when they need to make dressing adjustments and to record the question answering accuracy in games. The table is used in life situations and serious game interventions respectively. Both tables are scored on a scale of 0-1, with 1 indicating that wearing, taking off and changing clothing are made appropriately, and 0 suggesting that no adjustment is made or the adjustment is incorrect for the former (recording of participant behaviors); 1 indicating a correct choice is made in the interactive question answering of serious game, and 0 suggesting a wrong choice is made for the latter (recording of question answering adjustments). If the number of times that the teachers think participants need to respond is divided by the number of times when participants

respond correctly, the accuracy of the participants' target behaviors can be obtained.

2.2.4 Intervention Loyalty Inspection Table

In order to ensure the consistency between the actual intervention process and the planned process, the study compiled the intervention loyalty inspection table to check the implementation process of the intervention procedure. The table involves the intervention place, procedure, intervention game equipment, as well as the prompts and recording methods in the intervention process.

2.3 Experimental Design

This study adopted a cross-participant multiple baseline design, and the whole study included three periods: baseline period, intervention period and maintenance period. Three participants entered the baseline period at the same time, and then baseline data were collected, and continuous observation was conducted for at least 4 times. When a certain participant had a stable baseline reaction at the earliest (According to the design requirements of the single-participant experiment, at least 4 data points were needed to guarantee a stable state.), the intervention period came. When the intervention behaviors of the first participant became stable and the baseline period of the second participant remained stable continuously, the second one entered the intervention period. When the intervention behaviors of the second participant became stable and the baseline period of the third participant remained stable continuously, the third one entered the intervention period. When the participants' C statistical scores remained stable in each stage and there were significant differences between stages, the intervention marked an end and the maintenance period came. Three participants entered the maintenance period in turn within one week after the intervention. In this study, visual analysis and C statistics were adopted to quantify the target behaviors. In visual analysis, an analysis made based upon graph data, the trend, trend stability, level range, level change and more were sorted out in each stage and between different stages in baseline period and treatment period according to the number of times the participant's target behavior occurs. C statistics, also called statistical test of simplified time series, can make up for the deficiency of visual analysis. After the data in a certain period are substituted into the formula,the Z value can be obtained. This value can help define whether the baseline period contains a stable path; evaluate the differences between the slope trends of the baseline period and the

treatment period; and explain whether a significant difference occurs statistically. When the statistic C gets close to 0, it means that the data of time series are close to the average, and the data of time series show no obvious change. When the statistic c is close to 1, it means that the observation value of time series is on the rise. When the statistic c is far away, it means that the observation value of time series shows a downward trend. When the confidence interval is 95%, and the value of Z is 1.64, obvious difference exists regardless of the sample size.

2.3.1 Independent Variable and Dependent Variables

The independent variable of this study represents serious game intervention, including social story telling through animation video and serious game training. Based upon the basic ability and self-care needs of the participants, this study took the dressing adjustment skills that the participants are less likely to have in their daily life as the dependent variable. Specifically, these skills include wearing red scarf according to the occasion, changing sports shoes according to the needs of activities, as well as dressing and undressing according to the temperatures and weathers. The setting of the target behaviors is shown in Table 3.

Table 3: List of operation definitions of target behaviors.

Behavior	**Operation definition**
Behavior 1: Adjust the Dressing According to the Occasions	It refers to wearing a red scarf at school.
Behavior 2 Change Shoes According to the Activity Needs.	It refers to their willingness to change sports shoes before breaktime activities and sports and health classes.
Behavior 3: Put on and off Clothes According to the Temperatures and Weathers.	It refers to wearing raincoats and rain boots in rainy days, wearing ordinary clothes and shoes in the classroom, and increasing or decreasing coats according to indoor and outdoor temperature changes.

In order to avoid the practice effect, some measures were taken in the research design. The answer options of serious games are presented randomly; the data related to dependent variables are collected based on the needs of daily teaching; and no specific time and place are arranged. The teaching content and implementation of teachers excluding the head teacher are not affected by intervention. In addition, to avoid mutual interference between participants, they are not allowed to be present in the place where data are collected.

2.3.2 Data Collection Methods

The collected data involve quantitative data and qualitative data. The former includes the data of dependent variables and the data about the answering accuracy in the intervention process. The latter includes children's self-evaluation and social validity evaluation of parents and teachers, as shown in Table 4.

Table 4: List of operation definitions of target behaviors.

Data	Collectors, Collecting Situations and Methods	Recording Mode	Processing and Presentation Manner	Collection Purpose
Changing Data of Dependent Variables	Researchers and class advisers observe in different occasions like classroom, playground and individual training room.	The number of times when the participant's behaviors are right and not right.	When the accuracy is calculated, the visual analysis and c statistics are applied.	To learn the participants' dressing behaviors in their life situations before and after the intervention.
To Investigate the Accuracy of Participants in Serious Games.	The researcher observes in a training room	Question answering accuracy in the steps of different game levels during the intervention period.	Table display of accuracy	To learn the acquisition process of dressing knowledge before and after the participants participate in serious games.
Participants' Self-Evaluation	Participants are graded as each intervention marks an end in a training room.	The participants' love for their own games is recorded.	It is presented in the form of text description.	To learn whether the participants like serious games.
Social Validity	The researcher investigates participants' parents and class advisers.	It is recorded in text.	It is presented in the form of text description.	To learn the generalization effect of intervention research.

2.4 Research Place and Time

The experimental sites include a training room, a classroom, a playground and a simulated supermarket in a special education school. In the intervention period, one researcher studied one participant in training room,classroom,playground and more. There was a desk and two chairs in the training room. To ensure that the intervention would not affect the daily study and life, the intervention was set at the lunch break when the participants had free time.

2.4.1 Research Procedures

2.4.1.1 Baseline Period

In daily life, the number of correct and incorrect times when participants made dressing adjustments without any prompts was observed and recorded, and the accuracy rate was calculated. There were sports and health classes on Mondays, Thursdays, and Fridays, giving more opportunities to observe whether participants changed sports shoes; several rainy days a week also increased the need to put on and take off raincoats; for the part about changes in ambient temperature, if there was no suitable natural condition, the air conditioning temperature would be set.

2.4.1.2 Intervention Period

The process of serious game intervention included two stages: animated video and serious game. In the animation video teaching stage, the researcher played the demonstration animation and paused and explained at any time based upon the participants' response. At this stage, after Q & A was made to ensure the participants indeed understood the general content, they would enter the next stage. In the serious game stage, the researcher guided the participants to participate until they could understand the meaning of game level and play independently. When the participants' accuracy reached above 60% in the primary stage, they could enter the intermediate stage, and when their accuracy reached above 60% in the intermediate stage, they could enter the advanced stage. The collected data in the intervention period include the recording of the intervention process, participants' daily behaviors and the feedback from teachers and parents. The contents recorded in the intervention process include the accuracy and the number of times when the animated video was watched.

2.4.1.3Maintenance Period

After the intervention ended, the participants were observed in the maintenance period. Data were collected by the researcher and teacher 4

times for each participant. The collected data came from participants' daily behaviors and feedback from teachers and parents.

2.4.2 Reliability and Validity Analysis

2.4.2.1 Consistency of Observers

Since the study took a long time and the data analysis was very complex, 25% of the data of each participant were selected randomly at different stages of the intervention for observer consistency testing. Before the inter-rater consistency reliability was calculated, the researcher at the first place explained the observation points and behavioral evaluation criteria of participants' activities; the number of participants' behaviors was recorded as a rehearsal in the video on the condition that participants did not interfere with each other. The inter-observer consistency reliability was calculated using a formula. When the inter-observer consistency reached 90%, formal observation and recording would begin. The observer consistency coefficients of the three participants were 92%, 92.5%, and 95% respectively, and the overall observer consistency was 93.17%.

2.4.2.2 Intervention Loyalty

In the study, the first author observed the three intervention processes of each participant; and the "Intervention Loyalty Inspection Table" was used to conduct a fidelity test. The loyalties of participant C, participant P, and participant Z were respectively 87%, 90%, and 92%.

2.4.2.3Social Validity

A semi-structured interview was conducted with one of main caregivers including parents, head teachers, and personal training teachers. Whether children talked about or their behaviors showed love for serious game teaching, and whether there were changes in the target behaviors, etc., were observed. When the participants were investigated, based upon the participant's cognitive level, the study adopted the method of pointing one finger at an emoticon stickers ranging from a smiling face to a crying face or the method of scoring 1-3 points, and the participants were asked to explain when necessary.

3. RESEARCH RESULT

3.1 Analysis on Changes in Interventions of Serious Games

The changes in target behavior 1 of the three participants are shown in Figure 2. It should be pointed out that the data for target behavior 1 is

special. The basis for data collection is whether to make dressing adjustment according to changes in the occasion, and only two types of data: 0% and 100% are here, resulting in large fluctuations in visual analysis. During the baseline period, all three participants showed the lowest 0 times. During the intervention period, the levels ranged from 0 to 100%, with average levels of 75%, 95% and 100% respectively. The overlap percentages between the baseline period and the intervention period for these three participants were 20%, 25%, and 0% respectively. The inter-stage C statistical results showed that there was an obvious difference for participant P (Z=1.93, P<.05) and participant Z (Z=3.53, P<.05). Although participant C (Z=1.28, P>.05) did not see obvious significance and the data showed instability, the average value improved greatly from 0% to 75% in the intervention period and maintenance period. There was no obvious difference in the C statistics of the three participants from the intervention period to the maintenance period, and the average values for these three were 75%, 83%, and 100% respectively, indicating that the intervention effect still exists to a certain extent.

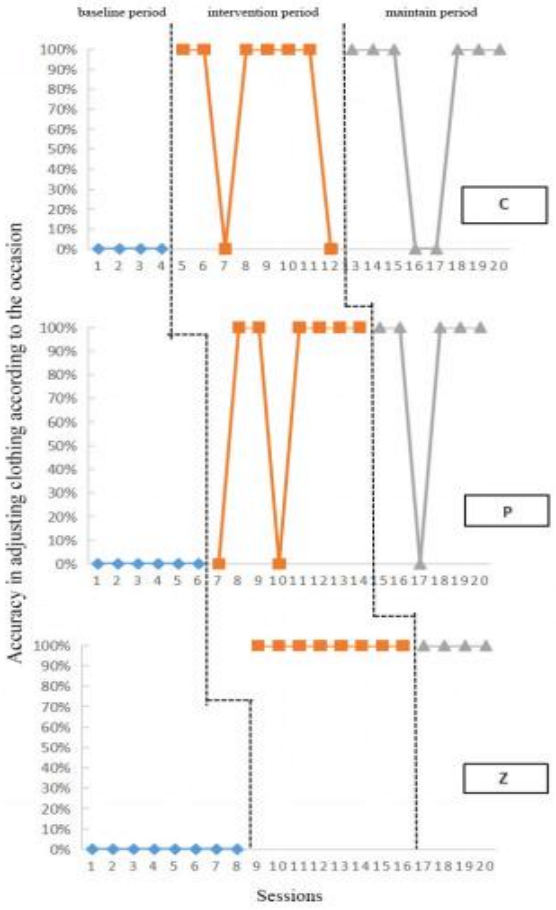

Figure 2: Visual analysis diagram of behavior 1

The changes in target behavior 2 of the three participants are shown in Figure 3. From the baseline period to the intervention period, participant

C (Z=2.45, P<.05), participant P (Z=2.6, P<.05), and participant Z (Z=1.88, P<.05) all witnessed significant difference. All three participants saw 0 times during the baseline period, and they even had the habit of having physical exercises wearing slippers. However, after the intervention, there were obvious differences in data. The average values were 66%, 81.25%, and 84% respectively; the level ranges were 50%-100%, 50%-100%, 75%-100%; and the overlap percentages were all the same - 0%. During the maintenance period, participant C still maintained an upward trend (both trend stability and level certainty reached 75%). Participants P and Z showed instability in trend and level, but there was no obvious difference in C statistics.

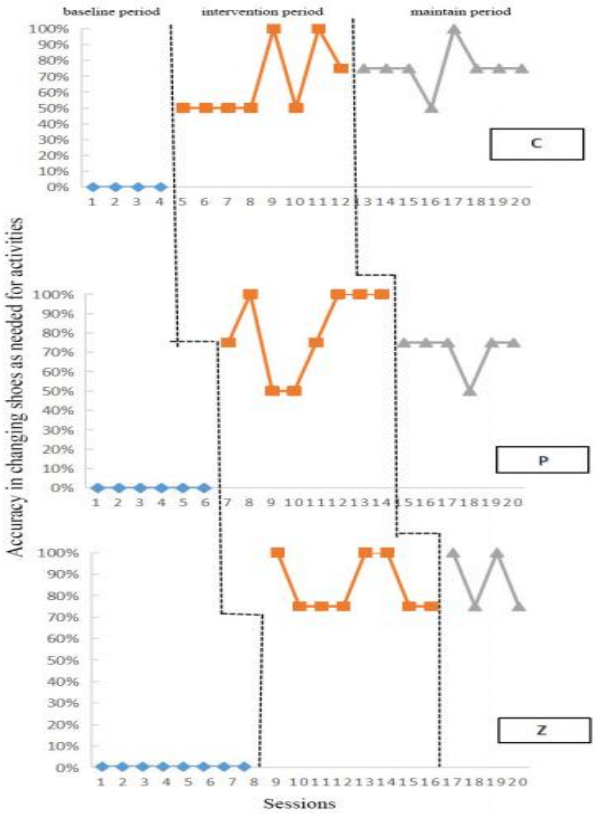

Figure 3: Visual analysis diagram of behavior 2

The changes in target behavior 3 of the three participants are shown in Figure 4. From the baseline period to the intervention period, C statistics showed that participant C (Z=3.7, P<.05), participant P (Z=2.12, P<. .05) and participant Z (Z=3.06, P<.05) witnessed obvious differences. Participants P and Z had 50% of the target behaviors for 2 and 3 times during the baseline period, because they wore raincoats with the reminder and assistance of their parents and took initiatives to wear off raincoats after arriving in the classroom. However, neither of them actively increased and decreased their coats due to temperature changes. The level ranges of participants during the intervention period were 5%-75%, 50%-100% and

75%-100% respectively. The overlap percentages between the intervention period and the baseline period were 0%, 12.5%, and 0% respectively. During the maintenance period, participant C showed an unstable downward trend, while participants P and Z maintained average values of 75% and 87.5%. The overlap percentage from the intervention period to the maintenance period was 100%, and the C statistics did not see obvious difference.

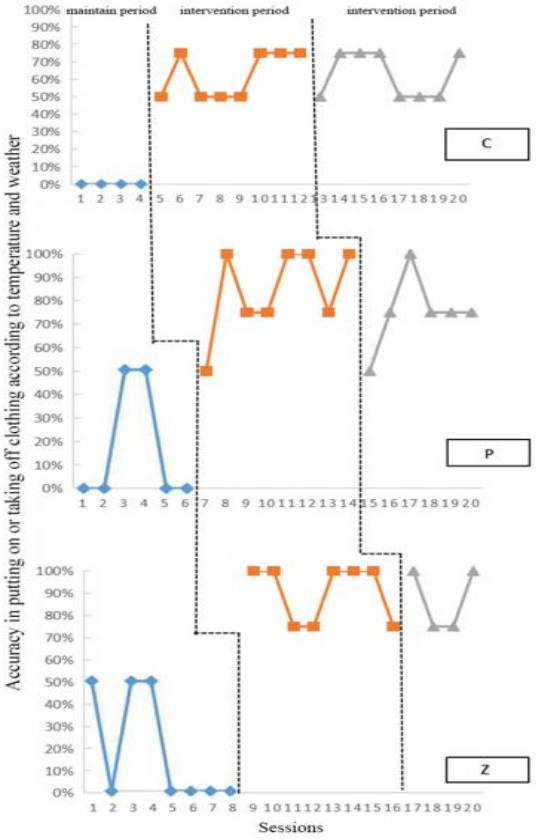

Figure 4: Visual analysis diagram of behavior 3.

3.1.1 Analysis on Answering Feedback in Serious Games

Table 5 shows the accuracy of the three participants at primary, intermediate, and advanced levels in serious games. Findings are as followed: (1) Consistent with the literature-based findings of Li et al., serious game intervention has a better intervention effect on autistic children with high cognitive levels than those with poor cognitive levels (Li et al., 2023). Participant C has relatively low intelligence, which is reflected in the fact that in the early stage, he failed to enter the advanced stage due to low accuracy. The accuracy of participant C was lower than that of participants P and Z; only the target behavior of participant C has a less obvious statistical result in terms of dependent variables. (2) Video review helps achieve teaching results.

There are differences in review times among the three participants, with less for participant Z and more for participant C. But overall, it can be seen that video review can provide good support for autistic children

Table 5: Feedback of autistic students on the completion of serious games in the intervention period.

Partici-Pants	Sessions	1	2	3	4	5	6	7	8
C	Elementary	60%**	60%*	80%*	60%	80%	80%	80%	100%
	Intermediate	50%***	62.5%***	62.5%**	75%*	87.5%	100%	100%	100%
	Advanced		42.3%***	71.4%**	71.4%	85.%	85.7%*	100%	100%
P	Elementary	80%*	80%	100%	100%	100%	100%	100%	100%
	Intermediate	75%**	75%*	87.5%	87.5%	100%	100%	100%	100%
	Advanced	57.1%***	71.4%*	71.4%	100%	85.%	100%	100%	100%
Z	Elementary	80%*	80%	100%	100%	100%	100%	100%	100%
	Intermediate	75%**	75%*	87.5%	100%	100%	100%	100%	100%
	Advanced	85.7%*	85.7%	100%	100%	100%	100%	100%	100%
F	Elementary	60%**	60%**	80%*	80%	80%*	80%	100%	100%
	Intermediate	50%***	62.5%**	62.5%**	75%*	75%	87.5%	100%	100%
	Advanced		42.3%**	71.4%**	85.7%*	85.7%	100%	100%	100%
M	Elementary	80%*	80%	80%	100%	100%	100%	100%	100%
	Intermediate	62.5%**	75%*	75%	87.5%	100%	100%	100%	100%
	Advanced	57.1%**	71.4%**	71.4%*	85.7%	85.7%	100%	100%	100%
L	Elementary	80%*	80%	100%	100%	100%	100%	100%	100%
	Intermediate	75%*	87.5%	87.5%	100%	100%	100%	100%	100%
	Advanced	85.7%*	85.7%	100%	100%	100%	100%	100%	100%

Note: 1. The intervention start time varies for each participant; 2. There are 5 feedback points for elementary and 8 feedback points for intermediate; Advanced has 7 feedback points; 3. When the accuracy is below 60%, do not enter the following level; 4. * means reviewing the corresponding teaching video once.

3.1.2 Analysis of Social Validity

There are three findings based on interviews with parents and teachers as well as investigation on the participants.

First of all, the three participants all showed a love for serious games. The teacher observed that the three participants took the initiative to participate in the teaching of serious games from the second intervention. In particular, participants Z and P expressed their willingness to become the first participant for serious games every time they saw the researcher. The participants themselves gave the highest score to their liking for serious games. Secondly, the three participants saw changes of different degrees in the target behaviors. The head teacher pointed out that before exercising, participant C needed the teacher's reminder, "There will be recess activities in a while!", while the other two participants did not need such reminder. Two participants took the initiative to talk about serious games when they went home and mentioned that they wanted to make changes. The parents of participant P pointed out that he had changed significantly. "After arriving home, he changed his shoes more actively than before, and he would take an initiative to wear a red scarf when going to school." In addition, teachers discovered the advantages of serious game teaching from a professional perspective and applied it to teaching management. The head teacher in the class room believed that timely feedback from serious games, together with school token rewards, has a great promotion effect on children. Personal trainers thought that the language of animated videos in serious games is concise and easy for children to learn. The characters and situations appearing in the game are very close to real life, making it easy for children to apply what they acquired from serious games to real life.

4. DISCUSSION

This study used serious game teaching intervention to effectively improve the dressing adjustment skills of three participants. One target behavior of participant C showed no obvious difference in C statistics from the baseline period to the intervention period, while other target behaviors saw obvious differences in visual analysis and C statistics. In terms of the maintenance effect of the target behaviors, the three participants were able to apply the behaviors they acquired in the game to their daily life. Participant C needed indirect reminder, while the other two did not need reminders from the teacher. The research result, together with research results of the foreign studies mentioned above, is consistent with the use of somatosensory games to improve the daily living skills of autistic children in the PEDI scale. Different from previous research, this study

originally developed a serious game that matches the teaching theme, and innovatively added an animated demonstration video with a social story as a script before the serious game playing. In the study, the advantages of previous serious game interventions were absorbed, and even some breakthroughs were made here. The study is an attempt to create a new intervention method combining social story telling, video demonstration and serious game. Its features and advantages are summarized as followed:

4.1 Serious Game Effectively Promoted Autistic Children's Dressing Adjustment Skills

This study used serious game teaching intervention to effectively improve the dressing adjustment skills of three participants. Only one target behavior of participant C did not see obvious difference in C statistics from the baseline period to the intervention period. All the other target behaviors saw obvious improvement in visual analysis, and the C-statistic results also witnessed obvious differences. It can be seen from the maintenance effect of the target behaviors that, the three participants were able to apply the behaviors in serious game to daily life. Only participant C needed indirect reminders, and all the other participants did not need reminders from the teacher. The research result is consistent with the previous research results(Perkins & Berkman, 2012). ,that is, serious game intervention can improve the life skills of autistic children.

4.2 Integration of Social Story into Serious Game can Effectively Improve Intervention Effect

The serious game originally developed in this study innovatively integrates social story and animation videos. It is a new "integrated" intervention method combining social stories, video demonstration methods and serious games. This method can be applied not only to case teaching, but also to collective classroom teaching in Chinese special education schools (Quirmbach et al., 2009). Animated videos designed based upon social stories take full consideration of children's language understanding and acceptance abilities. Social stories are written with a little boy as the first person and more descriptive sentences than indicative sentences are used as Gary suggested, with the ratio of descriptive sentences to indicative sentences reaching above 2:1, making the teaching content more acceptable to children (Pineda et al., 2008). During the intervention process, concise and easy-to-learn language inspires autistic children to frequently repeat sentences on their own, strengthening and consolidating their ability to speak such language. Meanwhile, social stories

written based on real dressing needs are more conducive to children's understanding, association and application of what they acquired into practice (Terlouw et al., 2020). For example, the animation of "wearing short sleeves in summer and long sleeves in autumn" is designed based on the real weather. When children have difficulty in constructing the connection between different seasons and clothing, teachers will remind children to take a look at what they are wearing today, and help them associate and acquire the dressing rules. The social storylines in animated videos, such as wearing a raincoat and rain boots when it rains, putting on a coat when the classroom is cold, are consistent with the dressing scenes designed in the serious game to maximize children's acquisition and their potential to apply what they learned into their real life.

4.3 Participatory Design has Important Influence on the Intervention Effect of Serious Games

This study involved a team of autism research experts, game designers, teachers, and parents in all aspects of the study, including the design of serious games, the design and implementation of intervention, and the testing of intervention effectiveness. First of all, existing research points out that "participatory design" allows game developers to create solutions together with user stakeholders, thus users' needs can be better met Following this principle, during design and development, a series of interviews were conducted with the parents and teachers of the participants. Based on knowledge about the participants and daily teaching needs, the game design team constructed and compiled social stories that met the participants' cognitive needs. The preliminary version of the game was designed to solve the participants' daily problems in dressing adjustment. In the early stage of serious game application, an iterative version was designed based on the collected opinions and feedback. "Participatory design" greatly improved the effectiveness of serious game interventions, and helped to establish informative and efficient feedback loops between the real world and game development.

4.4 Research Limitation and Suggestions for Future Research

4.4.1 Research Limitation

This study shows that serious game intervention has significant effects on the dressing adjustment skills of autistic children, and can be widely used in future interventions. When specific intervention research is conducted, the following aspects can be considered: In terms of the participant selection, this study selected participants in the same class to facilitate the collection of data materials, but it will also lead to mutual

influence between participants to a certain extent, so it is recommended to select participants from different classes; In terms of the intervention design, a control group can be set up to better prove the effectiveness of serious games; During the intervention process, the teaching progress has been slowed down for participants with weak cognitive abilities, but teaching scaffolding can be added to more fully help participants understand the game content.

4.4.2. Future Research Suggestions

This study used a cross-participant multiple baseline design to intervene on three autistic children, but there are still shortcomings. Future research on the use of serious games for autism intervention can be further improved from the following aspects: In terms of research content, priorities can be given to other skills beyond self-care ability to further verify the effectiveness of serious game intervention.; The game carriers including mobile terminals like mobile phones, computers, and tablets can be replaced by somatosensory games, robotics, and virtual games. Although mobile terminals are convenient, virtual reality technology or the combination of serious games and somatosensory games can provide more diverse stimulation and more fun for autistic children. In game design, a module design that automatically records evaluation scores can be added to make the game more universe. In terms of application fields, most current studies are conducted in school environments or professional institutions. It's found from the study that parents are also willing to join the research, and a certain degree of home-school cooperation may lead to more effective intervention results.

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