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Prospective, Blinded Exploratory Evaluation of the PlayWisely Program in Children with Autism Spectrum Disorder

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The purpose of the study was to explore a low-cost intervention that targets an increasingly common developmental disorder. The study was a blinded, exploratory evaluation of the PlayWisely program on autism symptoms and essential learning foundation skills (attention, recognition, and memory skills) in children with a diagnosis of autism, autism spectrum disorder (ASD†), pervasive developmental disorder – not otherwise specified (PDD-NOS), and Asperger syndrome (AS). Eighteen children, 1 to 10 years of age, were evaluated using the Childhood Autism Rating Scale, Second Edition (CARS2); the PlayWisely Interactive Test of Attention, Recognition, and Memory Skills; Autism Treatment Evaluation Checklist (ATEC), and the Modified Checklist for Autism in Toddlers (M-CHAT). There were significant treatment effects for the PlayWisely measure on the Yellow Sets that examine recognition; Purple Sets that examine brain region agility and early memory skills; Blue Sets that examine phonemic awareness and recognition; and for the Total Sets, with a similar trend toward improvement in the Green Sets that examine perception and Red Sets that examine attention. No other measures reached statistical significance. The results suggest that PlayWisely can improve recognition, brain region agility, phonemic awareness, letter recognition, and early memory skills in ASD. It was observed by the parents, coaches, and study investigators that the children who were less than 3 years of age showed improvements in autism symptoms; however, the group was too small to reach statistical significance. Future studies are needed to see if this intervention can mitigate autism symptoms in very young children with ASD.

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†Abbreviations: ASD, autism spectrum disorder; PDD-NOS, pervasive developmental disorder – not otherwise specified; AS, Asperger syndrome; ATC, Autism Treatment Center; CARS2, Childhood Autism Rating Scale, Second Edition; ATEC, Autism Treatment Evaluation Checklist; M-CHAT, Modified Checklist for Autism in Toddlers; APA, American Psychiatric Association; IRB, Institutional Review Board; HIPAA, Health Insurance Portability and Accountability Act.

Keywords: autism, autism spectrum disorder (ASD), essential learning skills, intervention

INTRODUCTION

Autism Spectrum Disorder and Early Intervention Issues

Autism spectrum disorder (ASD) is defined by qualitative impairments in both communication and social interaction and in restricted, repetitive, and stereotyped patterns of behavior, interests, and activities [1]. ASD can range in clinical symptoms from severe to mild among individuals diagnosed with autistic disorder (autism), pervasive developmental disorder – not otherwise specified (PDD-NOS), or Asperger's syndrome (AS) [2,3].

There has been a dramatic rise in ASD in the past two decades [4-6]. Currently, 1 in 50 children are affected with ASD, according to the Centers for Disease Control [7], and according to the Autism Society, autism is now considered to be of epidemic proportions. During the 1990s, other disabilities increased by 16 percent, while autism increased by 172 percent. More recently, an evaluation of the autism prevalence rate recorded from 1997 through 2008 shows an even greater increase. Boyle et al. [4] found that the percentage change in the prevalence of ASD was 289 percent during that time period. The number of children with developmental disorders in the United States is now 1 in 6 children, driven predominately by the increase in ASD [4].

The rise in the prevalence of autism prompted the American Academy of Pediatrics (AAP) in 2007 to issue a report stating that all children must be screened for autism at 18 months and 24 months of age. Furthermore, the AAP report stated that children who show signs of autism should start intervention as quickly as possible and that early intervention is crucial in helping these children.

However, it also is clear that affordable, cost-effective interventions are needed. Low- and middle-income families do not have access to many cutting-edge therapies because they are not covered by Medicaid and other insurance providers and are unaffordable for these families to pay out-of-pocket. Therefore, studies to examine cost-effective interventions in ASD are needed.

Evidence shows long-distance underconnectivity between brain regions in ASD [8]. Although it is argued that not all areas of the brain in ASD are affected equally [8], evidence from sensory processing studies show that all of the different sensory modalities are affected [3], suggesting that the matter of connectivity involves multiple areas of the brain. Subsequently, stimulating connections between the brain regions is especially important. Brain underconnectivity in ASD is thought to contribute not only to the sensory processing issues, but also to the lack of "central coherence," or the lack of ability to bring together separate information into a single, coherent concept, potentially making the world more difficult to understand. Therefore, interventions are also needed for young children with ASD in order to rebuild neural and sensory pathways.

PlayWisely, an interactive program originally developed for neurotypical infants, toddlers, and preschoolers, was designed to stimulate connections between the major brain areas (bringing together touch, sound, visual, and proprioceptive stimuli) and integrate different attribute-processing areas. It encourages these connections through combined progressive perceptual, cognitive, and motor exercises that coordinate sensory and cognitive systems, ultimately targeting the connections that affect a child's ability to attend, recognize, recall, and react.

Because PlayWisely is a card-based system, it is affordable even for middle- and low-income families. Compared to many currently available therapies and interventions in ASD, PlayWisely is considerably less costly. The following section describes the PlayWisely program.

THE PLAYWISELY PROGRAM

With the use of a flash card system, the PlayWisely program works to stimulate and strengthen the connections of the brain to increase attention span, recognition, speed of response, eye-hand coordination, fine and gross motor skills, and scope of vision. PlayWisely seeks to train the neural circuitry responsible to detect, process, and coordinate accurately, defining and analyzing data for achieving successful learning. The neurosensory and processing skills included in the method are: focus and eye teaming (eyes working together to attend appropriately), tracking (smoothly following stimuli directionally within the visual field), signal identification (the ability to attend to one piece of data to the exclusion of others), JND (just noticeable difference of stimuli), acuity (keenness of perception), discrimination (differentiation of stimuli), directionality (awareness of positions and orientations of stimuli), sensory property coordination (recognizing that motion, sounds, and sights are intimately linked, allowing us to create expectations regarding the objects and actions of our world), SIP (speed of information processing), pattern recognition (the ability to organize data and detect meanings), and brain region interconnectivity (intertwining the specialties of the brain areas to process certain attributes that together enhance interpretation of our world).

PlayWisely purposefully engages the brain's navigational systems for gaining a child's attention and stimulating early learning. For learning, PlayWisely has developed a next generation flash card system that incorporates a performance algorithm of defined learning modules cradled within the rhythm, positioning, and directional motion of the choreography of the flash card presentation. The constant rhythm, repositioning, and directional motion help focus a child's attention. The visual cortical system possesses distinct data processing pathways referred to as the "where" stream (processes location, orientation, and directional motion of attended data) and the "what" stream (processes the fine features and attributes of attended data). The system's goal is to exercise coordination of these pathways, believing they are essential for clear data collection, efficient processing, and clarity of perception. Children with autism have compromised visual processing capabilities, and the PlayWisely system seeks to strengthen neural pathways from the earliest levels of detection and processing through to a clear perception.

The choreography of the flash card system purposefully engages the "where" stream and "what" stream of visual cortical wiring to develop coordination of visual processing systems as well as enhancing the length (quantitative aspect) of attention. The specific learning modules embedded into the flash card system combine clearly defined and matching auditory and visual input for each card shown within a specific time threshold. Combined with eye muscle tracking and focusing required for each card "flash," the system is also exercising coordination of sensory input (coordinating timing of auditory, visual, and kinesthetic inputs).

Exercising coordination of auditory, visual, and kinesthetic input to "arrive" in the perceptual mechanism simultaneously is critical for optimal sensory integration and clarity of perception. Children with autism often suffer with sensory integration disorders. The card system is designed to purposefully exercise sensory integration skills with the intensity and repetition necessary to positively impact development. The flash card system builds information incrementally from card to card until the child begins to intuit the rules of the game and becomes aware of an emerging pattern that ends in learning a new concept. The method coordinates sensory input while learning modules are presented to enhance qualitative aspects of attention. The system uses unique and specially designed "performance algorithms" that alternate attribute recognition processed in different brain regions. For instance, a color module, number module, then a language module are consistently interchanged. These patterned modules within each algorithm are designed to provide the mental gymnastics necessary for exercising pathways between brain regions. Children with autism often demonstrate difficulty with flexibly moving from one processing area to another. The repetitive intensity and choreography of the flash card delivery embedded within the specially designed "performance algorithms" engages attention, recognition, and memory while building awareness of new concepts. The final embodiment of the PlayWisely flash card system consists of eight separate card categories, flashed with a unique

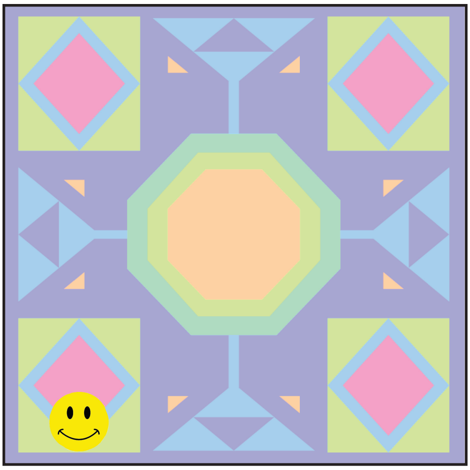

Figure 1. An example of a "Find It" card with a complex background.

Figure 2. A child points to a specified object on a "Find It" card within a complex background.

choreography of position and directional motion, and contains specific matching auditory and visual stimuli on each card to achieve a particular performance goal. The speed of output, asking a child to point or express what they have been learning verbally (if possible) in a timely manner is the final goal of the card system training. Each separate card set provides the child an opportunity to visually point (if non-verbal or communicative), point, or verbally interact with specific cards. Assessments are made based upon appropriateness of "looking" or attending, answering correctly, and interacting in a timely manner. The cards themselves are two-dimensional images on a flat surface; however, what makes them unique and come alive in this program are the motions that link the "psychological moments" into meaningful patterns.

The interaction works because images are carefully constructed and classified/categorized unambiguously using a performance algorithm of repeating sections. Attention is enhanced by isolating the difficulty of the perception. Using a blank background, we reduce the ambiguity of the image perceived. The image is then moved directionally within the visual field, which prompts reflexes within the visual system to follow the image and remain attended. Using sensory property coordination to enhance recognition, the system combines unambiguous visual input with matching verbalization and tone of verbalization and card motion (stimulating kinesthetic pathways) simultaneously to enhance recognition. The repeating algorithms enhance anticipation and memory skills for the visual/cognitive system much like a dance for the motor system or a song for the auditory system.

One sequence within the program, for example, exercises focusing attention and inhibition processes by having children search for an object on cards where the backgrounds become progressively more complex (Figure 1 shows an example of a "Find It" card with a complex background, and Figure 2 shows a child pointing to a specified object on a "Find It" card within a complex background). Even young children quickly learn to search the cards visually, taking longer to search with more distracters. They progress to searching visually and then pointing to the target picture, and they further progress to anticipating where the target will appear on the subsequent cards. As children progress, the coach will move the cards horizontally and vertically, such that the exercise will also require tracking. Depending on the child's verbal ability, the child may be asked to point and say "hi" to what they are pointing at, e.g., "Hi, happy face." Thus, children exercise and use multiple brain systems at the same time, e.g., visual search abilities, visuo-motor coordination, language, and memory.

The purpose of the study was to examine the effectiveness of the PlayWisely program on autism symptoms and essential learning foundation skills (attention, recog-

Table 1. A summary of the participants.

Descriptive Information	Summary (n = 18)
Sex/Age	
Male/Female (ratio)	12/6 (2:1)
Mean Age in Years ± Std (range)	5.9 ± 2.4 (1-10)
Mean Year of Birth ± Std (range)	2004 ± 2.3 (2001-2010)
Race (n)	
Caucasian	39% (7)
Hispanic	28% (5)
Asian	5% (1)
Mixed	28% (5)
Autistic Disorder Characteristics	
Mean CARS2 Score ± Std (range)	36.3 ± 8.1 (22.5-57)
Mean Total ATEC Score ± Std (range)	67.6 ± 22.7 (9-97)
Regressive (n)2	61% (11)
Non-Regressive (n)	39% (7)
Autism (n)	50% (9)
Autism Spectrum Disorder (n)	22% (4)
PDD NOS (n)	22% (4)
Asperger's (n)	6% (1)

ATEC = Autism Treatment Evaluation Checklist; CARS2 = Childhood Autism Rating Scale, Second Edition

nition, and memory skills) in children with a diagnosis of autism, PDD-NOS, ASD, or AS.

METHODS

Participants

Eighteen children with a diagnosis of autism, PDD-NOS, ASD, or AS participated. This was based on a prior, formal diagnosis that each child had. The children were 1 to 10 years of age and had a Childhood Autism Rating Scale, Second Edition (CARS2) score > 22.5. For CARS evaluation, a total score of about 25 is considered to be the minimum cutoff CARS score for an ASD diagnosis. However, the cutoff in this study was set at > 22.5 to include one child with AS. This was because the targeted treatment from the PlayWisely program is appropriate for children who range from severely affected to mildly affected. The children were prospectively recruited from the community by using flyers and word of mouth. All of the children lived in the greater Dallas Metroplex area. After explaining the study and obtaining informed consent from the parent(s), each child was evaluated using the CARS2. For the one child in the study who was 1 year of age, the Modified Checklist for Autism in Toddlers (M-CHAT) was completed. The participants were not starting, changing, or stopping another therapy, intervention, or medication. Children who met the age, diagnosis, and CARS2 score criteria and who were not starting, changing, or stopping another therapy, intervention, or medication were included in the study. See Table 1 for the demographics (Table 1 includes the 18 children whose data was included in the final statistical analysis). It is important to note that the diagnoses listed above for the participants was based on the diagnosis that each child was given prior to the study; however, in this study, when "ASD" is used, sometimes it is in reference to the whole group, e.g., in the Title and in the Discussion section.

Study Location and IRB Compliance

The study was conducted at the Autism Treatment Center (ATC; Dallas, Texas). The study protocol received Institutional Review Board (IRB) approval from Timberlawn Psychiatric Research Foundation (Dallas, Texas).

All parents signed a consent and Health Insurance Portability and Accountability Act (HIPAA) form, and all received a copy. The study complied with the American Psychological Association ethical standards in the treatment of participants and in obtaining informed consent. Children remained in the presence of a parent at all times while participating in the study assessments and treatments.

Initial Evaluation

Parents brought their child to the ATC for an initial evaluation. Information about the child's diagnosis and treatment history was obtained. Children who met the inclusion criteria were then enrolled, and an appointment for the pretreatment evaluation was set up.

Design and Procedure

The study was originally designed as a crossover study, in which initially approximately half the children were to receive treatment (PlayWisely) and half the children were to receive usual care (or wait) for 3 months. Then, after 3 months of treatment, the group that was waiting started treatment and the group that was receiving treatment stopped. The children were randomized by the flip of a coin into Group 1 (treatment) or Group 2 (wait or usual care). Nine children were randomized to Group 1, and eight were randomized to Group 2.

All of the children were given a baseline assessment. Assessments took 30 to 40 minutes each and included 20 minutes of PlayWisely and 10 minutes of floor play with a parent. All assessments were videotaped. Then Group 1 began treatment, and Group 2 began the wait period. One child in Group 1 dropped out in week 2 due to not having adequate transportation. After 24 treatment sessions, Group 1 (eight children) was reassessed. Group 2, which had been waiting, was also reassessed. At that time, Group 2 included six children because two dropped out of the study during the study wait period. After the assessments were completed, Group 2 began treatment. Because of the four dropouts from the study, four new children were assessed and began treatment as a part of Group 2. Then Group 2, which consisted of 10 children, was reassessed after 24 sessions.

Treatment

The PlayWisely intervention was administered to each child for 30 minutes two times per week for 3 months. The sessions were individually administered by one of two PlayWisely coaches.

Wait Period or Usual Care (UC)

Usual care is defined as commonly encountered regular practice or procedure. In the Dallas area, common care is generally speech, physical, or occupational therapy. All therapies or medications were held constant throughout the study participation. If the child experienced a change in therapy or medication during the study, he or she no longer qualified.

ASSESSMENTS AND MEASURES

Clinician-Rated Measures (Blinded)

The blinded assessments in this study were completed using the videotaped assessments. The autism measure CARS2 and the PlayWisely assessment measures were completed by investigators who were "blind" to the diagnosis, severity, and the grouping of the participants. Neither were they involved with the treatment or management of the study in any way, and thus did not know of the child's treatment status.

Clinician-Rated Measures (Unblinded)

For the one child who was 1 year of age, the M-CHAT was completed.

Parent-Rated Measure (Unblinded)

Parents were asked to complete the ATEC. Parents were not blinded to their child's treatment status.

Childhood Autism Rating Scale, Second Edition (CARS2)

The CARS is a well-established measure. The CARS is a 15-item behavioral rating scale developed to identify autism as well as to quantitatively describe the severity of the disorder [9]. The CARS has also been used successfully to measure treatment effects in ASD [10]. The items are: 1) Relating to People; 2) Imitation; 3) Emotional Response; 4) Body Use; 5) Object Use; 6) Adaptation to Change; 7) Visual Response; 8)Listening Response; 9) Taste, Smell, and Touch Response and Use; 10) Fear or Nervousness; 11) Verbal Communication; 12) Nonverbal Communication; 13) Activity Level; 14) Level and Consistency of Intellectual Response; and 15) General Impressions. Each item is scored from 1 (no pathology) to 4 (severe pathology) in .5 intervals. A total score of 15 to 29.5 is considered non-autistic; a score of 30 to 36.5 is considered mild to moderate autism; a score from 37 to 60 is considered moderate to severe autism [9]. For CARS evaluation, a total score of about 25 is considered to be the minimum cutoff CARS score for an ASD diagnosis [11].

The internal consistency reliability alpha coefficient is .94; the inter-rater reliability correlation coefficient is .71; and the test-retest correlation coefficient is .88 [9]. CARS scores have high criterion-related validity when compared to clinical ratings during the same diagnostic sessions, with a correlation of 0.84 ($p < .001$) [9]. Other comparisons, based on information from records, parent interviews, and non-structured clinical interviews with the child, report a correlation coefficient of 0.80 ($p < .001$). Independent reports on the validity of the CARS indicate a high validity [12-14].

PlayWisely Interactive Test of Attention, Recognition, and Memory Skills

The scoring for this part of the study was accomplished by having a PlayWisely expert (coauthor, AMV) view the pre- and post-treatment videotapes of the study participants. Six interactive card sets were used to assess the child's attention, recognition, and memory skills. These interactive card sets all require varying degrees of brain area interconnectivity and coordinated function. The following describes the specific learning areas that the card sets represent:

Red Sets. The red sets are for developing and exercising essential visual field navigation skills and for promoting the quantity and quality of attention skills.

Yellow Sets. The yellow sets are the pre-math sets and present the unifying characteristic of amounts increasing and decreasing to enhance recognition of the basic attributes of shape, size, color, and number.

Green Sets. The green sets are for exercising coordination of sensory property attributes essential for quality perception. These sets are also used to develop auditory processing and vocal output.

Purple Sets. The purple sets are also known as the Subject Sets and are designed to exercise brain region agility and early memory skills.

Blue Sets. The blue sets are the ABC (alphabet) sets. These sets are designed to promote phonemic awareness, letter recognition, and early memory skills.

Since the PlayWisely card system was created to maximize development of early attention, recognition, and memory skills, the study focused on these elements to evaluate program participants. The assessment focuses on measuring length of attention, clarity of perception (recognition), and appropriate responses coming from a memory of anticipated performance.

A scoring guide was created that assigned points based on the participants attention to, interaction with, and recognition of the different sets of cards presented during each session. Using the scoring guide, each session was reviewed, and points were assigned based on the performance of each participant. The greater the attention, interaction, and signs of recognition displayed during the session, the greater the number of points the child would receive for that category.

Autism Treatment Evaluation Checklist (ATEC)

The ATEC, designed by the Autism Research Institute, is a one-page form designed to be completed by parents, teachers, or others who see the individual's behavior on a regular basis [15]. It consists of four subtests

Table 2. Description of the baseline measurements by time period and treatments (Mean + SD).

Measurements	Period					Total
	Baseline	3 month evaluation		6 month evaluation		
	Treatment	Treatment		Treatment		
	No TX	No TX	Treated	No TX	Treated	
ATEC Speech-Test-BL	12.44 ± 7.08	10.50 ± 3.94	13.42 ± 8.21	13.38 ± 8.28	9.60 ± 3.65	12.44 ± 6.95
ATEC Sociability - Test-BL	15.44 ± 6.76	19.33 ± 7.71	13.50 ± 5.58	11.50 ± 5.21	19.00 ± 8.57	15.44 ± 6.63
ATEC Sensory - Test-BL	16.33 ± 5.93	19.17 ± 6.59	14.92 ± 5.30	14.75 ± 6.14	17.40 ± 5.55	16.33 ± 5.82
ATEC Physical-Test-BL	21.89 ± 9.49	23.33 ± 6.80	21.17 ± 10.79	20.00 ± 13.08	22.20 ± 6.94	21.89 ± 9.31
ATEC Total - Test-BL	67.28 ± 23.28	72.50 ± 21.14	64.67 ± 24.75	62.25 ± 29.53	68.20 ± 20.49	67.28 ± 22.84
CARS2-BL	35.97 ± 9.03	35.00 ± 7.74	36.46 ± 9.91	36.31 ± 11.29	34.00 ± 8.21	35.97 ± 8.86
Test Score-BL: 1. Red Sets	31.22 ± 23.20	42.67 ± 25.89	25.50 ± 20.49	20.13 ± 21.31	43.20 ± 28.91	31.22 ± 22.75
Test Score-BL: 2. Yellow Sets	34.17 ± 22.91	41.33 ± 20.68	30.58 ± 23.98	29.25 ± 28.39	44.80 ± 21.09	34.17 ± 22.48
Test Score-BL: 3. Green Sets	12.06 ± 5.06	14.33 ± 5.09	10.92 ± 4.85	10.25 ± 5.95	14.80 ± 5.54	12.06 ± 4.96
Test Score-BL: 4. Purple Set	22.72 ± 16.96	29.33 ± 13.78	19.42 ± 17.96	19.38 ± 20.13	31.00 ± 14.71	22.72 ± 16.64
Test Score-BL: 5. Blue Sets	18.89 ± 14.36	29.50 ± 14.99	13.58 ± 11.16	16.00 ± 12.83	33.60 ± 12.44	18.89 ± 14.09
Test Score-BL: 6. Total	119.06 ± 74.12	157.17 ± 72.69	100.00 ± 70.00	95.00 ± 82.50	167.40 ± 76.29	119.06 ± 72.71

TX = treatment

designed to measure the effects of treatment in persons with autism. The items are: 1) Speech/Language/Communication (14 items); 2) Sociability (20 items); 3) Sensory/Cognitive Awareness (18 items); and 4) Health/Physical/Behavior (25 items). The internal consistency reliability of the measure is high (.94 for the Total score) [15]. Many studies have successfully used the ATEC to measure treatment effects in autism [16,17].

Modified Checklist for Autism in Toddlers (M-CHAT)

The M-CHAT consists of 23 yes/no items that assess the child's attainment of developmental milestones [18]. Items address issues important in autism such as social relatedness, communication, pretend play, imitation, interaction, eye contact, response to name, interests, basic skills, and behavior. It is usually parent/caregiver completed. It is considered an instrument for the early detection of autism. A child either passes or fails the M-CHAT. A failed score is indicative of markers for autism. Criteria for failure of the checklist is failing either two or more critical items or failing three or more items. The internal reliability for the M-CHAT is adequate for the checklist as a whole (α = .85) and the critical items (α = .83). The M-CHAT has a sensitivity of .87, specificity of .99, positive predictive power of .80, and a negative predictive power of .99 [18]. This measure was completed by a Co-PI on the child less than 2 years of age.

STATISTICAL ANALYSIS

Descriptive statistics such as mean, standard deviation for continuous variables, number, and percentage for categorical variables were used to describe the results at the baseline, 3-month, and 6-month evaluations. The assessments analyzed for baseline, 3-month, and 6-month evaluations were the CARS2, the ATEC, and the PlayWisely Interactive Test of Attention, Recognition, and Memory Skills. To evaluate the treatment effect over the evaluation period (time), a mixed random effect model was utilized, which included the outcome as the dependent variable. The model's fixed effects were treatment, evaluation pe-

Table 3. Description of the baseline measurements by time period and treatments (Mean + SD).

Measurements Difference from Baseline	Period				Total
	3 month evaluation		6 month evaluation		
	Treatment		Treatment		
	No TX	Treated	No TX	Treated	
ATEC Speech -Test 1	-0.33 ± 2.07	-1.42 ± 2.39	-6.00 ± 7.39	-3.80 ± 4.32	-1.76 ± 4.02
ATEC Sociability -Test	-0.83 ± 6.65	-3.17 ± 4.47	-6.63 ± 8.40	-5.60 ± 6.88	-2.53 ± 5.48
ATEC Sensory -Test	-1.33 ± 3.56	-2.25 ± 3.19	-8.13 ± 8.37	-5.80 ± 5.36	-2.63 ± 5.02
ATEC Physical/Behavioral -Test	-0.67 ± 4.72	-1.00 ± 9.25	-12.75 ± 18.12	-3.40 ± 8.20	-2.76 ± 9.81
ATEC Total -Test	-3.33 ± 11.50	-9.50 ± 18.09	-36.13 ± 43.96	-18.60 ± 22.96	-10.53 ± 24.06
CARS2	-3.00 ± 3.42	-5.46 ± 5.39	-4.19 ± 4.35	-4.40 ± 3.58	-2.84 ± 4.12
Test Score: 1. Red Sets	2.33 ± 2.42	14.25 ± 14.25	17.13 ± 11.34	9.40 ± 10.95	7.53 ± 11.29
Test Score: 2. Yellow Sets*	8.17 ± 10.96	16.25 ± 18.46	13.50 ± 14.46	20.00 ± 9.22	9.22 ± 13.70
Test Score: 3. Green Sets	-0.67 ± 4.27	5.42 ± 5.81	5.38 ± 6.65	2.00 ± 3.94	2.33 ± 4.95
Test Score: 4. Purple Set*	4.00 ± 4.69	9.58 ± 8.69	7.63 ± 6.76	15.20 ± 7.92	5.63 ± 7.60
Test Score: 5. Blue Sets*	2.00 ± 14.04	14.67 ± 20.66	1.88 ± 3.44	12.60 ± 14.42	5.43 ± 13.37
Test Score: 6. Total*	15.83 ± 27.01	60.17 ± 42.64	45.50 ± 29.87	59.20 ± 28.06	30.14 ± 37.51

TX = treatment. Measures that showed significant treatment effects are noted with an asterisk (*).

riod, and treatment-time interaction. The random effect was the child. JMP by SAS 10.0 was utilized for all statistical analysis, and a two-sided p-value < 0.05 was considered statistically significant in the present study.

RESULTS

Table 2 is a description of the baseline measurements by time period and treatments. Table 3 shows the measurement difference scores from baseline by time period and treatment (Mean + SD). There was significant treatment effect on the PlayWisely measure on the Yellow Sets ($p = 0.0250$); Purple Sets ($p = 0.0143$); Blue Sets ($p = 0.0223$); and for the Total Sets ($p = 0 .0117$), with a similar trend toward improvement in the Green and Red Sets. No other measures reached statistical significance.

DISCUSSION

Results showed a statistically significant improvement on the yellow, purple, and blue sets with a similar trend in the green and red sets. The total for the card sets was also significant. No other measures used in the study showed statistically significant treatment effects. The other measures examined autism symptoms.

The results suggest that PlayWisely can improve recognition, brain region agility, phonemic awareness, letter recognition, and early memory skills in ASD. As mentioned in the Introduction, PlayWisely was designed to stimulate connections between the major brain areas (bringing together touch, sound, visual, and proprioceptive stimuli) and integrate different attribute processing areas. Because evidence shows long-distance underconnectivity between brain regions in ASD, stimulating connections between the brain regions is important. The results from this study suggest that PlayWisely may be able to stimulate brain connections in autism because of improvements measured in recognition, brain region agility, phonemic awareness, letter recognition, and early memory skills. Without brain data, it is not clear that connections were strengthened with PlayWisely; however it is a possible explanation.

It was observed by the study investigators that the youngest children in the study showed improvement in autism symptoms; however, this was not observed in the older children. For example, in the child that was 1 year of age, the M-CHAT decreased from failing four critical and eight noncritical to failing one critical and four noncritical, suggesting considerable improvement. This measure was unblinded, and so some bias would need to be considered. However, the improvement was also noted by the parents, coaches, and study investigators. Future studies using the younger children only may be able to measure improvement in autism symptoms. In the current study, there were not enough of the younger children to have a large enough sample to achieve statistical significance.

By improving recognition, brain region agility, phonemic awareness, letter recognition, and early memory skills in ASD, the program may have the potential to help children with ASD learn by improving essential learning foundation skills and to better understand their world. Interestingly, in the qualitative evaluations, several parents in the study reported that their child appeared to be more aware of their surroundings.

The program is a highly interactive, fast-paced, fun, family-based program, and the children appear to enjoy it. It can be used with children who are mild to severe because the PlayWisely program is designed to determine and adjust to a child's individual level. The program is designed to be presented in a calm, positive way with a repetitive and consistent delivery that is critical to learning for a child with autism. If a child has difficulty with a card, there are no wrong answers; the coaches just progress to the next card.

Evidence suggests that the PlayWisely program has the potential to be another intervention and tool to be used with children with ASD at a lower cost than many current alternatives. The cost of this program is estimated to be less than 10 percent the cost of currently available alternatives, making the program affordable for even low income families. As mentioned in the Introduction, 1 in 50 children are affected with ASD.

There were three observations that the investigators noted from this exploratory evaluation. First, it was observed that the youngest children (less than 3 years of age) and children who have regressed seemed to show the most improvement. Second, the treatment time needs to be longer than 3 months (about 4 months), because the children started to show the most improvement at 3 months. Third, even the most severely affected child responded to the PlayWisely program, however, it took longer to engage them in the program initially.

STUDY LIMITATIONS

The main study limitation was the small sample size. Measures that trended toward improvement, but were not statistically significant in this study, e.g., Green Sets and Red Sets, may have reached statistical significance with a larger sample size. Because four participants who dropped out of the study were later replaced and the replacements were then incorporated and treated in Group 2, not all study participants were randomized. No *a priori* information was available to be used in the initial design of the study as to what would work best. Observations from this study revealed several ways in which the study could have been designed better, such as a longer treatment time of at least 4 months, selecting for a younger population of children with autism and ones who had regressed. The main study strength was that the study was blinded. The raters were given videotapes for the assessments in which there was no information about the child's treatment status.

CONCLUSION

The results from this study suggest that PlayWisely may be able to stimulate brain connections in autism because of improvements measured in recognition, brain region agility, phonemic awareness, letter recognition, and early memory skills. By improving recognition, brain region agility, phonemic awareness, letter recognition, and early memory skills in ASD, the program may have the potential to help children with ASD learn and better understand their world. The qualitative data collected that showed that the children who were less than 3 years of age improved in autism symptoms may have important implications and reinforces the importance of early intervention to mitigate autism symptoms in children. Future studies are needed to see if this intervention can mitigate autism symptoms in very young children with ASD.

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