

Association between screen usage and two core symptom changes in children with autism during Covid-19: A Study in Italy

Yihan Luo^{1,3,*†}, Jiayi Cui^{2,4,*†}

¹College of Agriculture and Biology, Shanghai Jiao Tong University, Shanghai, 201100, China

²Department of Science, University of Toronto Scarborough, Toronto, M1C 1A4, Canada

³yihanluo71@gmail.com

⁴jiayi.cui@mail.utoronto.ca

*corresponding authors' e-mail: yihanluo71@gmail.com, jiayi.cui@mail.utoronto.ca

†These authors are co-first authors.

Abstract. As a result of covid-19, children with autism have experienced a substantial increase in screen time at home. This study delves into a dataset from Italy, exploring the impact of the severity of a child's doctor's diagnosis of autism on the child's choice of online activities and on the improvement of social interaction and behavioral problems. Results showed that television viewing was most strongly associated with these core symptoms, and that most children with varying severity of symptoms showed some improvement in social interaction and behavioral problems through watching TV.

Keywords: Autism Spectrum Disorder, screen time, lockdown, children, Covid-19.

1. Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental condition characterized by variations in brain structure and functioning. People with ASD often have problems with social communication and interaction, and restricted or repetitive behaviors or interests. ASD patients are not well adapted to reciprocal social development, and they have impairments in both verbal and nonverbal communication.[1] Compared to children, adults with ASD will have improved social interactions, better understanding of their own challenges, and greater ability to regulate themselves after a long period of experience and development.[1] Children with ASD have difficulty coping with daily life, especially social interaction and behavioral problems.[2] Barriers to social interaction make them visibly anxious and avoidant in social situations and unable to empathize with others and find it difficult to think differently, which cannot to develop social skills well.[1,3,4] In addition, about 50% of children with autism are also very likely to cause behavioral problems such as disobedience, aggression, and self-injury.[5,6] Moreover, during covid-19, conditions of prolonged lockdown environments and more difficult contact with the outside world are even more likely to affect children with ASD. Therefore, ASD children increased the amount of time they spent on electronic devices

during lockdown, and their parents allowed them to use this as a way to regulate and calm their emotions.[7] So, whether children with varying degrees of ASD tend to prefer one of these screen options and whether these screen options are effective in alleviating social and behavioral problems in children with ASD was the focus of our research.

There is a wide range of ASD-related research done in other literature on the relationship between ASD and other mental illnesses, the causes of ASD at the genetic, cellular, and other levels, and the influence of parents on children with ASD. Selten et al., discovered and confirmed that people with ASD have an increased risk of developing bipolar disorder.[8] Makinodan et al. studied the expression levels of Tumor necrosis factor-alpha in peripheral blood mononuclear cells in children with ASD and found that ASD patients had lower levels of tumor necrosis factor-alpha mRNA than normally developing children.[9] Besides, there are also a number of studies that have found that the parents of children with autism have a critical influence on them. Research shows that parents who are more knowledgeable or have more social connections are more likely to help moderate emotional and behavioral problems in children with ASD, and they are better able to provide resources and services for their children.[10] Furthermore, parents who engage in social and recreational activities are more likely to create a family atmosphere that values and encourages social participation, which in turn promotes the development and maintenance of an active social life for children with ASD.[11] It is also possible that the effects are reciprocal, i.e., the research also suggests that parents of children with less severe ASD have more time to develop their own knowledge, skills, or other technologies.[10] Nonetheless, there are fewer studies related to the covid-19 on children with ASD. Bacherini et al. mentioned that their limitation lies in the fact that they do not consider the social activities that take place online, especially since most of the activities during covid-19 were offline that became online.[10] Whether these studies explore the role of parental influence on children's social and recreational activities, or children's social relationships and recreational activities with their peers, most of these recreational activities refer to real-life recreations, such as exercise, family meals, et al. The amount of time many children with autism spent on screens increased dramatically during the covid-19, and online socialization is gradually becoming a social trend for today's young people. Some studies have found that most children with autism enjoy watching television and playing video games and using computers, but they haven't explored whether these online entertainment activities give positive feedback to children with autism.[12] Therefore, we looked at online socialization in children with ASD during the covid-19 and explored the effects of screen use on the symptoms of children with ASD. This area of research is very helpful in providing help for children with ASD in terms of trends in youth recreation patterns.

In this study, we analyzed a dataset consisting of 243 samples from Italy. The data was collected online and includes valuable information about autistic children and their parents during the Covid-19 pandemic. Our primary goal is to examine the influence of the severity level of autistic symptoms on the modifications of ASD symptoms during lockdown. According to the DSM-5, ASD is characterized by two primary symptoms: deficits in social communication and social interaction, and restricted and repetitive patterns of behavior, interests, or activities. For the purpose of this study, we have chosen one indicative symptom from each of these core domains, specifically, social interaction and behavioral difficulties, in order to examine fluctuations in symptomatology. Additionally, we aim to explore how the severity level affects the allocation of time to different activities at home. Through the identification of patterns, we aspire to establish a theoretical foundation for diverse treatment approaches for autistic children with varying levels of severity.

2. Methodology

2.1. Dataset description

This dataset was found through Google Dataset Search and is licensed under the CC0 1.0 Universal (CC0 1.0) Public Domain Dedication license. The researchers conducted an anonymous online Qualtrics survey, which was shared through social media (autism-related groups and pages on

Facebook, as well as WhatsApp) from May 15th to 30th, 2020. Participants who experienced the lockdown in Italy due to the Covid-19 pandemic read and signed a written consent form and explicitly agreed to participate in the study. In cases where a parent had multiple children with ASD, the parent was asked to report on one child only and filled out another survey for the other children. There was no monetary compensation for participating. The study was approved by the ethical committee of the Department of Neuroscience Imaging and Clinical Science of the University of Chieti-Pescara (Ethical approval number: DNISC2962) and was conducted according to the American Psychological Association guidelines in accordance with the 1964 Helsinki Declaration.[7]

2.2. *Main feature explanation*

The dataset contains three sections. The first part is the severity of autism symptoms diagnosed at the last doctor's visit to the child before the covid-19 epidemic. The doctor's diagnoses are autism symptom, language competences and cognitive function.

The second part is the eventual change in the core symptoms of ASD in children during covid-19, as documented by parents. Parents rated children's social interaction and behavioral problems using a 3-point Likert scale: improved (1), same (2), worsened (3).

The last part is a record of the time spent by the children on different activities at home during the covid-19. Activities recorded by parents included video games, playing with friends online, using social networks and watching TV.

2.3. *Statistical Analysis*

In the study, the missing data rate of the original dataset was calculated. For group 1 and group 2, the missing data rate was 0.00%, while for group 3 it was 2.23%, and for group 4 it was 2.67%. These relatively low rates of missing data indicate that the dataset can be deemed of good quality. In order to handle the missing data, we opted to remove all data rows that contained any missing values. As a result, the final sample size was 151.

The author performed exploratory data analysis (EDA) on the dataset. Firstly, missing values and outliers were addressed (The outliers were removed as they occurred when the questionnaire allowed values from 0 to 3, but there were instances of 6 and 7 in the dataset). By analyzing basic statistics and examining histograms for each column, it was discovered that data of the same type exhibited similarities in their distributions, while data distributions differed among various groups, suggesting a potential association among the variables. Given that the research dataset consisted of multiple features that needed associations among them to be handled, as well as multiple discrete categories for each feature, a multinomial model was selected. The dependent variables (Y) chosen were "social interaction" and "behavioral problems," and initially, a full-feature model was fitted. The objective was to examine the relationship between the change in symptoms (Y) and each X variable, to comprehend the influence of specific ASD symptom severity and time spent on specific activities. Subsequently, while keeping one value constant in "ASD diagnosis," "language competences," and "cognitive functioning," the data groups containing the fixed values were extracted. The variables "tv," "video games," "play with friends online," and "social networks" remained as X, while Y remained unchanged. This analysis aimed to investigate the inclination of children with a specific symptom to change ASD symptoms through each activity.

In this paper, our main focus is to study the correlation coefficients between each X variable and Y in the multinomial model, and evaluate the model based on the p-values obtained from the Likelihood ratio tests. The main focus is on the correlation coefficient signs between the "Improved" group and the "Worsened" group compared to the "Same" group. For the sign of the "Improved" group, "+" indicates a positive effect on improving variable Y, while "-" indicates a negative effect. The sign is reversed for the "Worsened" group, "+" indicates a positive effect on the worsening of variable Y, while "-" indicates no tendency to worsen Y. If the sign of a variable X is "+" for the "Improved" group and "-" for the "Worsened" group, it indicates a positive effect on improving Y and no tendency to worsen, indicating an overall improvement trend. Conversely, if the sign for the "Improved" group

is "-" and the sign for the "Worsened" group is "+", the result is completely opposite. If the signs for the "Improved" group and the "Worsened" group are the same, it indicates a stronger tendency towards "Same", meaning no change in symptoms. Type III tests show the significance of X variables at different levels of significance, based on the provided symbol coding for significance. If significant, it indicates a statistical relationship between the X variables and Y.

3. Results

3.1. Study Population

Table 1 shows the distribution of all characteristics in the dataset. Many children (the largest proportion) experienced a deterioration in social interaction during the epidemic, but stabilized in terms of behavioral problems. In this survey, 83.4% (n=126) of the respondents were male, and the majority (91.4%, n=138) of the guardians who completed the survey were mothers. Moreover, more than half of children (66.2% and 54.3%) spend no more than two hours a day watching tv and playing video games. Notably, most children (74.2% and 73.5%) do not choose to socialize online or play with friends online.

Table 1. Distributions of selected characteristics of the study population (N = 151).

Characteristics	Number	N	Percentage
Parents' Gender			
Mother	1	138	91.4
Father	2	13	8.6
Child Sex			
Male	0	126	83.4
Female	1	25	16.6
ASD Diagnosis			
Low symptoms	1	41	27.2
Medium symptoms	2	68	45.0
High symptoms	3	42	27.8
Language Competences			
No language	0	39	25.8
Single words	1	25	16.6
Short sentences	2	52	34.4
Complex sentences	3	35	23.2
Cognitive Functioning			
Low	1	27	17.9
Medium	2	71	47.0
High	3	53	35.1
Characteristics	Number	N	Percentage
Social Interaction			
Improved	1	50	33.1
Same	2	39	25.8
Worsened	3	62	41.1
Behavioral Problems			
Improved	1	51	33.8
Same	2	61	40.4
Worsened	3	39	25.8
TV			
Never	0	5	3.3
Sometimes	1	100	66.2

Table 1. (continued).

A lot of time	2	46	30.5
Video Games			
Never	0	29	19.2
Sometimes	1	82	54.3
A lot of time	2	40	26.5
Play With Friends Online			
Never	0	112	74.2
Sometimes	1	35	23.2
A lot of time	2	4	2.6
Social Networks			
Never	0	111	73.5
Characteristics	Number	N	Percentage
Sometimes	1	33	21.9
A lot of time	2	7	4.6

3.2. Social Interaction

Table 2 presents the coefficients obtained from fitting multinomial models to analyze screen time activities and modification of two core ASD symptoms during lockdown, considering different severity levels of ASD symptoms. The coefficients represent the magnitude of improvement or worsening of symptoms, relative to the reference coefficient indicating no change in symptoms.

In the full-feature model, improvements in social interaction are only associated with watching tv ($\beta = 0.52$, p-value = 0.0102). Although there are other variables with positive coefficients, they are not significant. We did not discuss the variables in the model that were coefficient with the same sign for both improvement and deterioration because it suggests that there was little change in this aspect of children's social interaction. We then re-modeled ASD diagnosis, language competence, and cognitive functioning by stratifying them separately.

We stratified the ASD diagnosis into three models, according to low, medium, and high. Compared to children who had no change in social interaction, the ASD children with low symptoms had a positive effect on the improvement of social interaction while playing video games ($\beta = 0.75$, p-value = 0.02451) and playing with friends online ($\beta = 1.14$, p-value = 0.06900), i.e., they are both helpful for improving social interaction. In medium symptomatic children, watching tv ($\beta = 0.62$, p-value = 0.01533) was positively associated with social interaction. For highly symptomatic ASD children, it is worth noting that watching TV (p-value = 0.001844) and using social networks (p-value = 0.038143) were significant with social interaction.

In the model which we stratified the language competence, for children with no language or can speak short sentences, there are no variables showing significance. Among children who could only speak single words and could speak complex sentences, although playing video games (p-value = 0.09299) was a little significant with social interaction in children with speaking single words, and watching TV (p-value = 0.002926) and playing video games (p-value = 0.003510) were significant with social interaction in children with speaking complex sentences, no variables were found to be very helpful in improving or worsening social interaction.

The last model we stratified the cognitive functioning. Children with low cognitive functioning had a positive effect on the improvement of social interaction only when they played video games ($\beta = 0.54$, p-value = 0.17079). However, it wasn't significant. Watching TV (p-value = 0.00944) and playing with friends online (p-value = 0.00313) were significant with social interaction in children with low cognitive functioning. And regardless of which activity children with medium cognitive functioning chose, social interaction tended to remain unaltered. Nevertheless, watching TV (p-value = 0.0004228) has a large significance with social interaction in children with medium cognitive

functioning. Besides, there were no variables significant on social interaction in children diagnosed with high cognitive functioning.

3.1. Behavioral Problems

In a full-feature model integrating behavioral problems with all other features, only watching TV ($\beta = 0.33$, p-value = 0.01312) tended to improve behavioral problems compared to children whose behavioral problems did not change. As with the model of social interaction, we do not discuss variables that maintain the same for behavioral problems.

In the model stratified for ASD diagnosis, using social networks (p-value = 0.08209) was a little significant in children with low symptoms. In contrast, for children with medium symptoms, watching TV ($\beta = 2.05$, p-value = 0.0005039) was positively associated with improvement in behavioral problems, while playing with friends online ($\beta = 1.02$, p-value = 0.0362091) was positively associated with worsening behavioral problems. Furthermore, there were no variables not only having a positive effect on improving behavioral problems in children with high symptoms, but also be significant. Watching TV (p-value = 0.01243) and using social networks (p-value = 0.06003) were a little significant in this type of children.

The second model is to stratify language competences. In this model, no variables had a positive effect to improve behavioral problems on children with no language or speak only single words. However, social networks ($\beta = 0.33$, p-value = 0.05612) promoting worsening behavioral problems in children who speak only single words. Moreover, for children who could speak short sentences, watching TV ($\beta = 0.966$, p-value = 0.04264) had the same positive effect on improving behavioral problems. Meanwhile, behavioral problems for children with complex sentences tend not to change. Watching TV (p-value = 0.01642) and using social networks (p-value = 0.07756) were a little significant in children who can speak complex sentences.

In the last model, we did not find any variables have a tendency to improve or worsen behavioral problems in children with low cognitive functioning or medium cognitive functioning since these variables were not significant in this model. Only watching TV ($\beta = 0.0466$, p-value = 0.008081) was inclined to ameliorate behavioral problems for children whose cognitive functioning is high.

Table 2. Coefficients of the multinomial models.

	Symptoms Change	ASD Diagnosis	Language Competences	Cognitive Functioning	TV	Video Games	Play With. Friends Online	Social Networks
Social Interaction								
Full-Feature Model	1 3	0.037 0.170	0.381 -0.004	-0.504 -0.085	0.519 -0.681	-0.003 -0.321	0.227 -0.030	-0.521 -0.299
P-value Significance		0.8590	0.1453	0.3510	0.0102 *	0.5172	0.8306	0.4413
A=1	1 3				-0.924 -1.541	0.754 -0.931	1.146 -1.372	-2.057 -1.195
P-value Significance					0.19935	0.02451 *	0.06900	0.13566
A=2	1 3				0.619 -1.370	-0.203 -1.006	-0.467 0.173	-0.766 -0.404
P-value					0.01533	0.13245	0.67774	0.39414

Table 2. (continued).

	Symptoms Change	ASD Diagnosis	Language Competences	Cognitive Functioning	TV	Video Games	Play With. Friends Online	Social Networks
Significance					*			
A =3	1				3.700	-0.469	0.856	10.341
	3				1.507	0.369	0.542	9.353
P-value					0.00184	0.48542	0.76294	0.03814
					4	6	2	3
Significance					**			*
L =0	1				-0.453	0.336	1.953	1.141
	3				-0.0560	-0.717	-1.056	-0.307
P-value					0.9489	0.5144	0.3024	0.4282
Significance								
L =1	1				-0.669	-1.412	9.313	-9.796
	3				-12.006	-2.360	9.363	-8.793
P-value					0.15844	0.09299	0.39105	0.38769
Significance								
	Symptoms Change	ASD Diagnosis	Language Competences	Cognitive Functioning	TV	Video Games	Play With. Friends Online	Social Networks
L =2	1				0.046	-0.011	0.567	-0.949
	3				-1.121	-0.243	-0.003	-0.774
P-value					0.2029	0.8517	0.7936	0.6204
Significance								
L =3	1				10.088	9.462	0.125	-0.275
	3				8.210	9.424	0.115	-0.124
P-value					0.00292	0.00351	0.99278	0.93975
					6	0	1	3
Significance					**	**		
C=1	1				-10.454	0.539	-10.912	0.0002
	3				-10.871	-0.877	-23.024	0.643
P-value					0.00944	0.17079	0.00313	0.87202
Significance					**		**	
C=2	1				2.291	-0.257	1.014	-0.738
	3				0.138	-0.746	1.102	-0.911
	Symptoms Change	ASD Diagnosis	Language Competences	Cognitive Functioning	TV	Video Games	Play With. Friends Online	Social Networks

Table 2. (continued).

P-value					0.00042 28 ***	0.34564 01	0.47564 01	0.36399 73
Significance								
C=3	1				0.366	-0.015	0.623	-0.472
	3				-0.317	-0.106	0.282	0.080
P-value					0.5874	0.9758	0.6504	0.6534
Significance								
Behavioral Problems								
Full-Feature Model	1	-0.235	-0.047	-0.365	0.328	0.260	-0.014	-0.295
	3	0.205	-0.131	-0.031	-1.026	0.006	0.398	-0.957
P-value		0.46968	0.85068	0.51202	0.01312 *	0.67048	0.64780	0.12310
Significance								
A =1	1				-0.500	0.809	-0.116	-0.258
	3				-0.856	-0.260	-0.964	-10.235
P-value					0.62673	0.14690	0.73796	0.08209
	Symptoms Change	ASD Diagnosis	Language Competences	Cognitive Functioning	TV	Video Games	Play With. Friends Online	Social Networks
Significance								.
A =2	1				2.050	0.246	-1.412	0.201
	3				-1.100	-0.453	1.019	-0.456
P-value					0.00050 39 ***	0.53770 76	0.03620 91 *	0.70910 83
Significance								
A =3	1				-1.167	0.069	0.157	-2.107
	3				-2.531	0.551	-0.080	-1.898
P-value					0.01243 *	0.65961	0.96076	0.06003
Significance								.
L =0	1				0.508	1.107	0.300	-0.331
	3				0.010	0.141	-1.150	-1.467
P-value					0.8375	0.4026	0.5022	0.4677
Significance								
	Symptoms Change	ASD Diagnosis	Language Competences	Cognitive Functioning	TV	Video Games	Play With. Friends Online	Social Networks
L =1	1				1.025	0.357	0.629	-14.324
	3				-8.096	-0.504	1.281	0.330

Table 2. (continued).

P-value					0.25253	0.72994	0.65944	0.05612
Significance								.
L =2	1				0.966	0.144	0.915	0.353
	3				-1.247	0.012	2.822	-0.558
P-value					0.04264	0.94593	0.05002	0.73123
Significance					*		.	
L =3	1				-1.300	0.610	-1.602	-0.792
	3				-2.751	0.677	-0.726	-1.719
P-value					0.01642	0.74763	0.18797	0.07756
Significance					*		.	
C=1	1				-0.120	0.205	-0.904	0.276
	3				-10.418	-1.683	-18.937	-19.481
	Symptoms Change	ASD Diagnosis	Language Competences	Cognitive Functioning	TV	Video Games	Play With Friends Online	Social Networks
P-value					0.3460	0.3030	0.4003	0.3939
Significance								
C=2	1				0.854	-0.018	-0.054	0.062
	3				-0.117	-0.008	0.914	-1.319
P-value					0.2257	0.9994	0.4822	0.1656
Significance								
C=3	1				0.047	0.156	0.430	-1.319
	3				-2.628	0.094	0.263	-0.888
P-value					0.00808	0.95983	0.79495	0.13326
Significance					1	6	6	4
					**			

Note: A represents ASD Diagnosis, L represents Language Competences, C represents Cognitive Functioning. Coefficients of 1 and 3 are relative to same symptoms (same=2). The significance codes used are: '***' for $p < 0.001$, '**' for $p < 0.01$, '*' for $p < 0.05$, '.' for $p < 0.1$, and '' for $p \geq 0.1$.

4. Discussion

In all our results above, we are contrasting improvement and worsening with the same. We did not discuss the variables in the model that had coefficients with the same sign for both improvement and deterioration because it suggests that there was little change in this aspect of children's social interaction. Here, we only discuss the cases where the signs are different. In the full-feature model, the correlation between the severity of symptoms in children with ASD and the improvement of symptoms was not significant, therefore we did not discuss this issue.

During the covid-19, children with ASD spent substantially more on screen-related activities. However, few studies have explored whether these online activities have a positive impact on children with ASD. In the full-feature model, only the activity of watching TV demonstrated a noteworthy association with children's social interaction and had a favorable impact. More specifically, among children diagnosed with moderate autism, watching TV had a significant positive effect on their social interaction. Parents of children with ASD can use television as an effective way to calm children,

prevent tantrums and control behavior.[13] Besides, playing with friends online and playing video games are more effective in improving social interaction for children whose ASD symptoms is low. The positive effects of social networks on children with ASD is not very significant. One reason is because they're socially inept. They have difficulty defining what a friend is and lack interest in the social world.^[11]

The study demonstrates that the amount of time children spent engaging in various screen activities during lockdown has a positive or negative impact on their behavioral problems and social communication and social interaction areas, depending on the severity of their ASD symptoms. In previous studies, the longer the children's exposure to screens during lockdown, the more severe the deterioration of core symptoms of autism.[7] High screen use may raise strong emotions and lead to cognitive fatigue,[14] which can lead to an increase in behavioral problems and restricted and repetitive behaviors, interests or activities.[15] However, in our study, we found a significant improvement in behavioral problems associated with watching TV in the full-feature model. Additionally, we observed a significant improvement in behavioral problems among ASD children with high cognitive functioning who engaged in watching TV. The escalation in screen time may also impose limitations on social interactions with family members,[16] which plays a vital role in the development of language, communication skills, and social-emotional abilities. Consequently, this may give rise to challenges in engaging effectively in social interactions.[17] It appears that the impact of screen usage on ASD symptoms is unidirectional. However, through our analysis, we have discovered that the influence of screen usage on ASD symptoms varies depending on the severity of the symptoms, resulting in a dual effect. For instance, for children with medium severity of ASD symptoms, watching TV has shown a remarkably evident improvement in their behavioral problems. However, engaging in online play with friends has been observed to worsen their behavioral problems. In addition, for children with high severity of ASD, watching TV does not significantly alter their behavioral problems, while it has a positive effect on children with moderate severity. Similarly, ASD children with weaker language abilities are more likely to receive positive effects from watching TV, which also indicates a contrasting trend. It would be urgent to study whether this phenomenon is due to the fact that children with milder symptoms are less susceptible to the effects, or if it is because they have stronger problem-solving abilities. This study arrived at different conclusions from previous research because we examined subcategories of ASD severity instead of making generalizations about a single core symptom.

However, the current study has its limitations. Firstly, the dataset was collected solely in Italy, thus constraining its generalizability and implying a regional bias. The alterations in ASD symptoms among children may be impacted by cultural traditions and parental caregiving practices. While parents do not cause a restricted, repetitive repertoire of behaviors and deficits in social-communication skills directly, impairments in social-relatedness can strain parent-child relationships and interactions and parental stress can have trans-actional effects that impede development.[18] Furthermore, it is important to consider the influence of age on ASD symptoms. Although the dataset used in this study does contain information on the ages of children, the limited sample size prevents it from being representative. As a result, this experiment does not evaluate the correlation between ASD symptoms and children's age.

5. Conclusion

To conclude, the impact of screen usage on children with Autism Spectrum Disorder (ASD) is dependent on the severity of their symptoms. By comparing the changes in symptoms of ASD children with different levels of severity, the study recognised the differences in the effects of different screen activities on their symptoms. Among the four types of screen activities, TV has the most significant impact on changing the symptoms of ASD children. While watching TV can have a positive impact on children with moderate ASD symptoms, high screen usage may worsen behavioral problems and limit social interactions. Social networks have the least impact on changing the symptoms of ASD children. This study utilizes a specific period of covid-19 and provides new ideas for studying treatment options

for children with ASD, it can also provide certain references and reminders for parents of children with ASD. However, the survey was limited to Italy, so the generalizability of the results of this study remains to be investigated, and future studies could expand the scope of the survey to make comparisons or explore in more depth the specific effects of watching TV on children with ASD.

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Yihan Luo and Jiayi Cui contributed equally to this work and should be considered co-first authors.

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