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Matching Law and Sensitivity to Therapist's Attention in Children with Autism Spectrum Disorders

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Abstract A social skills deficit is one of the core symptoms in children with autism spectrum disorders (ASDs) and has been hypothesized to be related to a deficit in social sensitivity. This study set out to investigate the social sensitivity of preschoolers with ASDs in an early behavioral intervention setting, using the generalized matching equation as an analytical tool. We evaluated how 14 children with ASDs, ages 3 to 5, allocated their appropriate social behaviors compared to their inappropriate and nonsocial behaviors, based on the attention of their therapists during early behavioral intervention. The objectives were to (a) measure the social sensitivity of participants using the generalized matching equation and describe the stability of this measure after 8 months of intervention and (b) evaluate the relationship between the parameters of the GME and the participants' level of functioning as measured by their intellectual functioning and severity of autistic symptoms. Seven of the participants significantly varied their appropriate social behaviors based on changes in the social attention of their therapists at the onset of intervention, and 3 more participants showed this pattern after 8 months of intervention. Changes in behavioral bias and social sensitivity after 8 months of observation were significantly correlated with some measures of functioning in the participants. The usefulness of the matching law as a tool for measuring social sensitivity in this population, and its clinical applications, is discussed.

Keywords Autism Spectrum Disorders · Matching law · Social behaviors · Social attention

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A social skills deficit is one of the core symptoms in children with autism spectrum disorders (ASDs), along with a language deficit and restricted interests (American Psychiatric Association 2000). Early intensive behavioral intervention (EIBI) has been widely studied and accepted as the most effective treatment to remediate these symptoms in children with ASDs (Eldevik et al. 2009, 2010; Makrygianni and Reed 2010; Reichow and Wolery 2009; Virués-Ortega 2010). While EIBI programs have well-documented success in areas that can be taught through discrete trial teaching, such as preschool tasks (see Rivard and Forget 2012), the teaching and measuring of social skills remains one of the most challenging areas for EIBI clinical practitioners (Kelley et al. 2010). EIBI efficacy research has mainly focused on outcomes based on standardized tests, such as intellectual functioning (intellectual quotient [IQ]) and adaptive behaviors (Kelley et al. 2010), while the broad territory of social skills remains an area in need of further research.

One of the challenges of conducting social skills research is determining how to separate the broad social deficit into specific, measurable elements. One such element that has been isolated, however, is the notion of social sensitivity (see Forget and Rivard 2010). *Social sensitivity* can be defined as children's sensitivity to social reinforcement contingences that they encounter in their daily environments, that is, how much children change their social behaviors as a function of changes in the reinforcement rates associated with those behaviors (Forget and Rivard 2010). Various authors have hypothesized that social deficits are related to deficits in social sensitivity (see Hochmann 2009; Lovaas et al. 1967), yet this relationship has not been extensively studied.

To address this gap in research, we aimed to measure the extent to which children with ASDs are sensitive to changes in social contingences in their environments. Specifically, we focused on their sensitivity to the changes in attention of adults in an early intervention environment, as this has direct

implications for the strategic use of adult attention not only in improving social behaviors but also in generating other types of learning gains. Existing tools used to measure social behaviors in this population are often standardized tests that provide a general measure of individual social competencies on the basis of norms established from samples of children with ASD. However, such tools are limited in their abilities to measure the dynamic relationship between children with ASDs and those who interact with them. To our knowledge, no standardized tool exists to measure social sensitivity in children with ASDs. As such, we suggest a procedure for investigating social sensitivity using direct observation and the generalized matching law as an analytical tool.

Herrnstein's matching law, or the simple matching equation (Herrnstein 1961, 1970), can be used to measure the way an organism distributes its behaviors between two or more concurrent sources of reinforcement (de Villiers 1977). The equation is

$$B1/[B1 + B2] = R1/[R1 + R2].$$

In this equation, the frequency of one response ($B1$) compared to the frequency of another response ($B2$) depends on the reinforcement rate associated with it ($R1$) and the reinforcement rate associated with the other response ($R2$).

The generalized matching equation (GME; Baum 1974) is a development of the first equation and shows that the relationship can be described with a simple linear relation if the factors are expressed as ratios and then changed into natural logarithms. This equation is

$$\log(B1/B2) = a\ \log(R1/R2) + \log\ b,$$

where the two new parameters are the level of sensitivity to changes in reinforcement (a) and the behavioral preference for one of the alternative behaviors (b). The slope of line a measures sensitivity to concurrent reinforcement programs, or how much the behavior ratios change given a change in the reinforcement ratio (Baum 1974; Reed et al. 2006; Shull 2005). Parameter a, sensitivity, measures the dynamic movement of the line. The y-intercept of line b, bias, measures the behavioral bias for one of the responses (Pierce and Epling 1983).

When the rate of behavioral change adjusts itself to any change in the relative reinforcement rate, the slope of line a equals 1, and there is strict matching. If the rate of behavioral change is slower than the change in relative reinforcement rate, the slope is less than 1 and there is *undermatching*. Finally, when the rate of behavioral change is faster than the change in relative reinforcement rate, the slope is higher than 1 and the phenomenon is called *overmatching*. In his study of 103 data sets from 23 different studies, Baum (1979) found that the slopes of a frequently deviated from 1.0 and, after statistically assessing these deviations, concluded that a slope in the range of 0.90 to 1.11 can be considered approximate matching.

The matching theory provides a thorough model to explain behavior under natural conditions where humans are presented concurrently with a range of response choices (Mace et al. 1990). Authors that have used the matching law to investigate the behavior of people with developmental disabilities and ASDs have principally focused on the allocation of problem behaviors (Borrero and Vollmer 2002; Borrero et al. 2010; Myerson and Hale 1984; Symons et al. 2003). To our knowledge, there are no studies published in English that have used the matching law to describe the social sensitivity in young children with ASD during early behavioral intervention.

Some studies published in French have employed the matching law to study the social sensitivity of children with ASDs (Duval and Forget 2005; Poirier and Forget 1997; Rivard and Forget 2006). Poirier and Forget (1997) used the GME to investigate the degree to which children with ASDs matched their appropriate behavior with the social attention of their teachers. They separated the participants into three subgroups, based on their diagnostics and their levels of functioning, defined by severity of autistic symptoms. The first group was composed of five children with a low level of functioning (low intellectual functioning and higher severity of autistic symptoms), the second group was composed of three high-functioning children (higher intellectual functioning and lower severity of autistic symptoms), and the third group included three children with Asperger syndrome. When the data were grouped by the three separate profiles, the first group presented a pattern of undermatching, the second group of strict matching, and the third group showed a pattern of maximization. Poirier and Forget proposed that this heterogeneity in matching patterns could be used as a different measure of the continuum of social deficits in children with autism spectrum disorders.

These studies demonstrate that children with ASDs present a wide variability in sensitivity to social attention and serve as a starting point for further research into the social sensitivity patterns of children with ASDs. To our knowledge, there have been no studies that have used the matching law in the context of early intervention for preschool-age children with ASDs, or more precisely, that have described the allocation of children's social behaviors based on the social attention of their therapists in intervention environments. As such, our first objective was to describe the participants' sensitivity to their therapists' attention using the generalized matching equation (GME) and to evaluate the stability of this sensitivity after 8 months of intervention. Our secondary goal was to expand on the research of Poirier and Forget (1997) and use the GME to examine the relationship between children's social sensitivity and levels of functioning. We were interested in investigating this relationship in terms of continuous measures rather than in terms of diagnostic categories. To this end, the second

objective was to evaluate whether there were relationships between the different parameters of the GME and the participants' levels of functioning, as measured by their verbal, performance, and full-scale IQs, as well as their severity of autistic symptoms.

Method

Participants

The participants were 14 children with ASD ages 3 to 5 years who were starting an EIBI program at a public service agency in Quebec, a French-speaking province of Canada. The primary language of all participants was French, and this was the language of instruction in the EIBI program. The parents of all children beginning the EIBI program were solicited for the study. The principal researcher and the coordinator of the EIBI program met individually with each family to explain the research project and procedures and informed them that their participation would not have any affect on their services in the EIBI program. Eighty-eight percent of parents gave informed consent authorizing their child to participate. Table 1 describes each participant's gender, comorbid problems (described next), full-scale IQ, severity of autistic symptoms, and number of observation sessions. Each participant's diagnosis of ASD was confirmed by a multidisciplinary team that included a child psychiatrist. One of the participants (participant 5) met the criteria for a diagnosis of Asperger syndrome, as confirmed by his score on the Gilliam Asperger's Disorder Scale (GADS; Gilliam 2001). Nine of the participants had no associated comorbid conditions, while three had problem behaviors in comorbidity with their diagnosis of ASD (participants 8, 9, and 10). Three participants (9, 10, and 12) were undergoing clinical evaluations to determine other comorbid diagnostics, due to their developmental history, patterns of behaviors, or physiognomy (e.g., fetal alcohol syndrome).

Setting

Because the intensity of interventions in this study was less than 20 h per week, we refer to the program as Early Behavioral Intervention (EBI), rather than EIBI. Observation sessions for the study occurred during the participants' regular EBI program sessions. The program was conducted independent of this research; that is, we were not involved in the development of the program and had no control over the program goals, training of therapists, and so forth. The program was based on the EIBI of Lovaas (1987) and primarily consisted of discrete trial teaching. The participants received an average of 14.5 h of intervention weekly.

The intervention sessions were delivered in a private room in each participant's kindergarten, with a 1:1 therapist-to-participant ratio. Each participant had two different therapists over the course of the intervention program: a principal therapist who facilitated 2/3 of the total number of sessions and another one who facilitated 1/3 of the total number of sessions. All therapists received specialized training in ASDs and in EIBI as part of their employment with the agency. The therapists were blind to the research objectives, and they conducted

Table 1 Participant Descriptions and Number of Sessions

Participant	Gender	Comorbid problems	Full-scale IQ	CARS	Number of sessions	
					Time 1	Time 2
1	M		45	44.0	7	6
2	M		60	36.0	7	7
3	F		68	30.0	6	7
4	M		111	25.0	7	0
5	M	Asperger syndrome	117	22.5	7	7
6	M		51	38.0	7	7
7	M		67	34.0	7	6
8	M	Problem behaviors: oppositional behaviors	NA	36.5	7	7
9	M	Suspected genetic syndrome, problem behaviors: oppositional behaviors	NA	36.5	7	6
10	F	Suspected fetal alcohol syndrome, severe feeding problem	57	37.5	7	6
11	M		44	44.5	7	7
12	M	Intellectual Disability	44	31.0	7	7
13	M		79	31.0	7	6
14	M		NA	48.5	7	7

Intellectual quotient measures were not gathered for participants 8, 9, and 14 due to parental refusal. *CARS* Childhood Autism Rating Scale (CARS; Schopler et al. 1988)

their sessions according to each child's specific program goals in the same manner as when observation sessions were not occurring. During observation sessions, a research observer sat in the corner of each participant's room and filmed the sessions with a handheld video camera. The research observers did not interact with the therapists or participants in any way during filming.

Procedures

Two periods of observation sessions were carried out to record the EIBI sessions in order to subsequently code the social behaviors of participants and therapists. Each period contained seven 60-min sessions. The first observation period (T1) took place over the first 7 consecutive weeks of the EIBI program (1 h of observation per week), and the second observation period (T2) took place 8 months later, also over 7 weeks. Most participants were observed for seven sessions in each observation time; however, due to different constraints in the clinical environment, some were observed for fewer sessions. Participant 3 was observed only six times during the first observation period, due to being sick for over a month after the sixth observation session. In the second observation period, only six observation sessions were completed for participants 1, 7, 9, 10, and 13. This was due to the fact that at that point in the intervention program, these participants began to be prepared for their transitions to school by being integrated slowly into the kindergarten context and fading the 1:1 sessions. Finally, we have no data for participant 4 in T2, due to a technical problem that resulted in the loss of the videotaped observation sessions for T2. In total, participants 2, 5, 6, 7, 8, 11, and 14 were observed for 840 min, with 5,040 intervals compiled; participants 1, 3, 9, 10, 12, and 13 were observed for 590 min with 4,680 intervals compiled; and participant 4 was observed for 420 minu with 2,520 intervals compiled. Table 1 displays the number of sessions per participant for the two periods of observation.

The measures for the severity of autistic symptoms and the intellectual functioning were collected during the second month of intervention.

Data Collection

Social Behaviors All observation sessions were filmed and subsequently coded in a laboratory setting by research assistants. The 15 research assistants were undergraduate students in psychology who had received an average of 60 h of training, which included video training. They achieved an interobserver agreement (IOA) score of at least 85 %, with a second observer, on practice videos before starting to code the actual research videos. The practice videos contained examples of 60-min 1:1 intervention sessions. The IOA was calculated in an interval-by-interval (5 s) agreement measure for the social behaviors of the children and the consequences delivered by the adults in the practice videos. Agreement was considered for an interval if all behaviors observed during the interval were coded the same by the two observers.

The assistants coded the behaviors of the participants and the therapists. Target behaviors were documented during fixed intervals of time, with 5 s of observation followed by 5 s of data collection. The target appropriate social behaviors (*B*1) for the participants were response to a demand (verbal or nonverbal response to a requested behavior), refusal of a demand (appropriately refused to follow a demand), maintaining an interaction (maintained a social exchange initiated by the therapist), and initiation of an interaction (initiated a social exchange in an appropriate manner with the therapist). The target inappropriate behaviors (*B*2) for the children were self-stimulation (e.g., repetitively moving a body part, repeating vocalizations), self-injury (e.g., biting, face slapping, head banging), aggression toward others (physical aggression against the therapist, such as hitting, kicking, biting), aggression against materials and/or physical environment (making a physical attempt to alter the materials in the environment), other inappropriate activities (inappropriate behaviors following a demand by the therapist not included in any of the previous categories, e.g., if the therapist instructed the participant to sit and he instead walked around the room), oppositional behaviors (active and repetitive opposition to a demand, e.g., screaming "no!" loudly and repetitively after a demand by a therapist) and nonsocial behaviors (not engaging the therapist in any way).

For the purpose of the analysis, therapist attention was the targeted reinforcer for appropriate behaviors (*R*1) and inappropriate behaviors (*R*2). All forms of the therapists' behaviors that provided attention to the participants were counted, including social reinforcers (e.g., giving verbal praise, thumbs up), material reinforcers (e.g., giving a toy or edible), reprimands (e.g. "you need to listen to me"), demands (e.g., "pass that to me"), and general attention (e.g., visually or aurally attending to the behavior of the participant). The consequences noted were not exclusive and could follow the behaviors in any combination (St. Peter et al. 2005). If there was no attention from the therapist, the observers coded it as either absent (the therapist was not present in the room), proximity (the therapist was in the room but not attending to the participant, e.g., taking notes), or timeout (where attention was deliberately not given as part of a time-out protocol). All consequences were considered contiguous because they occurred no more than 5 s after the target behavior. The therapists, being blind to the purposes of the research study, were not given special instructions regarding how to deliver attention to the social behaviors of the participants. The consequences they delivered to the participants' social behaviors were those occurring naturally within the framework of the EIBI program

and were based on preference assessments completed for each participant at the start of the program.

For this study, a second independent observer observed 29 % of the total observation sessions for each participant, and the agreement scores ranged from 81 to 90 %. As in the training sessions, the IOAs were calculated for the targeted behaviors of the participants and the consequences were delivered by their therapists during a 60-min intervention session, in an interval-by-interval (5 s) agreement measure. Agreement was considered if all behaviors during an interval were coded the same by the two observers. Interobserver agreement was calculated as the total number of agreements divided by the number of agreements plus disagreements, and expressed as a percentage.

Severity of Autistic Symptoms and Intellectual Functioning The Childhood Autism Rating Scale (CARS; Schopler et al. 1988) was used to determine the degree of severity of autistic symptoms. The CARS gives a score of 15 to 60 to classify the severity of symptoms, with 60 indicating extreme symptoms. The Gilliam Autism Rating Scale (GARS; Gilliam 1996) was also used to get an autism quotient on a scale from ≥69 to ≤131 (extreme scores).

The participants' intellectual functioning was evaluated using the Wechsler Preschool and Primary Scale of Intelligence (WPPSI-III; Wechsler 2002) for children ages 2.6 to 7.3 years. The WPPSI-III uses various indicators: The ones chosen for the study were verbal IQ (VIQ), performance IQ (PIQ) and full-scale IQ (FSIQ). Intellectual functioning was measured for 11 participants; 3 participants (8, 9, and 14) were not tested with the WPPSI-III due to parental refusal.

Data Analysis

For objective 1, descriptive statistics were derived for each participant's frequencies of appropriate social behaviors ($B1$) and inappropriate and nonsocial behaviors ($B2$), as well as the frequencies of reinforcement delivered by the therapists for those behaviors, that is, attention for appropriate social behaviors ($R1$) and attention for inappropriate and nonsocial behaviors ($R2$). These statistics were derived for both observation periods (T1 and T2) for each participant. These rates were then analyzed using the generalized matching equation (GME), with each of the seven sessions analyzed as a block (molar data). Two independent observers performed each analysis, in order to ensure that there were no mistakes in the calculations. This analysis provided descriptive data for each participant's sensitivity and bias. Each participant's variance accounted for (VAF) was also derived for each time period. Paired t tests were used to measure the changes in sensitivity, bias, and VAF between T1 and T2. This stability was not systematically studied as it would be in a rigorous experimental analysis of stability with specific criteria. It consisted of a single repetition of an observational assessment to verify whether the parameters changed over time and, if so, how.

For objective 2, Pearson correlations were conducted between the parameters of the GME (VAF, sensitivity, and bias) in T1 and the participants' scores on CARS, GARS, and WPPSI-III subtests (VIQ, PIQ, and FSIQ). Correlations were also conducted between the changes in the GME parameters between T1 and T2, and the severity and intelligence measures.

Results

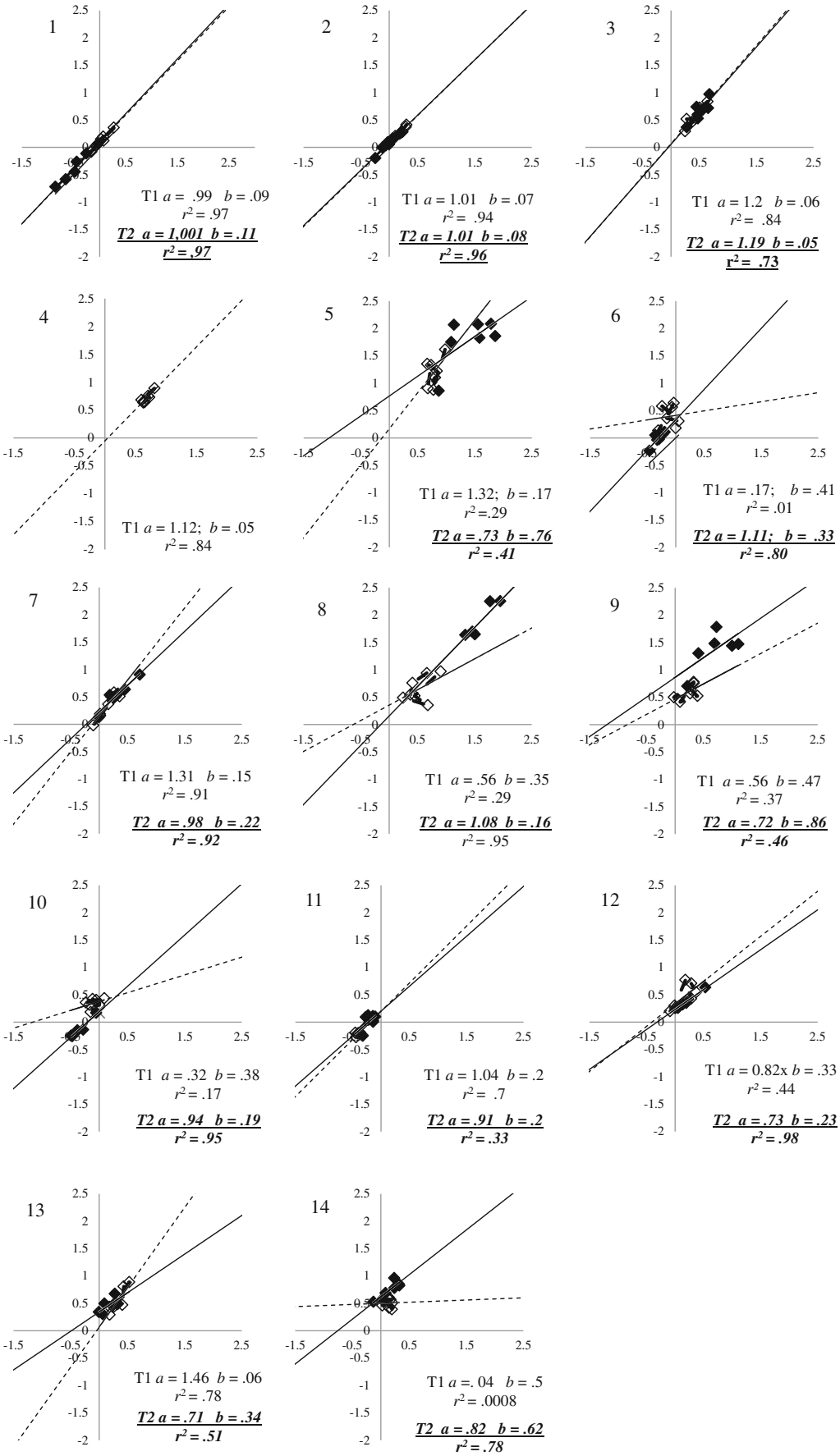
Matching Patterns

Figure 1 presents the data for the two observation periods (T1 and T2) and displays the log response ratios (appropriate social behaviors/[inappropriate + nonsocial behaviors]) plotted against the log reinforcement ratios (attention for appropriate social behaviors/[attention for inappropriate + nonsocial behaviors]) for each participant. Each point represents data for one of the seven 60-min observation sessions. The data represented by the blank squares are from the first observation period, and their slope is indicated by the dashed line. The data represented by the filled squares are from the second observation period, 8 months later, and their slope is indicated by the solid line.

The analysis of the data for T1 showed that participants' sensitivity ranged from 0.04 to 1.67, with a mean of 0.96. Accepting results within the range of 0.90 to 1.11 as matching, five participants (3, 4, 5, 7, and 13) overmatched, three participants (1, 2, and 11) matched strictly, one participant (12) undermatched, and five participants (6, 8, 9, 10, and 14) showed no matching. In T2, sensitivity ranged from 0.71 to 1.19, with a mean of 0.92. The two observation periods did not show a significant change, $t(12)=-0.23$, $p=0.82$, and the data did not vary together ($r=0.20$). However, there were qualitative differences in the patterns of matching: Two participants (3 and 6) overmatched, six participants (1, 2, 7, 8, 10, and 11) strictly matched, one participant (14) undermatched, and four participants (5, 9, 12, and 13) showed no matching.

The participants' bias in T1 ranged from 0.05 to 0.50, with a mean of 0.23, indicating that the participants did not show negative bias in favor of inappropriate behaviors. The participants' bias in T2 ranged from 0 0.05 to 0.86, with a mean of 0.32. As in T1, none of the participants presented a negative bias in favor of inappropriate behaviors. Bias data were not significantly different between the two time periods, $t(12)=1.09$, $p=0.30$, and the data did not vary together ($r=0.50$).

Figure 2 presents the VAF of the data for both time periods. In T1, the VAF ranged from 0.01 to 0.97, with a mean of 0.54. As in Reed (2009), we considered VAFs equal to or greater


1
T1 a = .99 b = .09
r² = .97
T2 a = 1,001 b = .11
r² = ,97
2
T1 a = 1.01 b = .07
r² = .94
T2 a = 1.01 b = .08
r² = .96
3
T1 a = 1.2 b = .06
r² = .84
T2 a = 1.19 b = .05
r² = .73
4
T1 a = 1.12; b = .05
r² = .84
5
T1 a = 1.32; b = .17
r² = .29
T2 a = .73 b = .76
r² = .41
6
T1 a = .17; b = .41
r² = .01
T2 a = 1.11; b = .33
r² = .80
7
T1 a = 1.31 b = .15
r² = .91
T2 a = .98 b = .22
r² = .92
8
T1 a = .56 b = .35
r² = .29
T2 a = 1.08 b = .16
r² = .95
9
T1 a = .56 b = .47
r² = .37
T2 a = .72 b = .86
r² = .46
10
T1 a = .32 b = .38
r² = .17
T2 a = .94 b = .19
r² = .95
11
T1 a = 1.04 b = .2
r² = .7
T2 a = .91 b = .2
r² = .33
12
T1 a = 0.82x b = .33
r² = .44
T2 a = .73 b = .23
r² = .98
13
T1 a = 1.46 b = .06
r² = .78
T2 a = .71 b = .34
r² = .51
14
T1 a =. 04 b = .5
r² = .0008
T2 a = .82 b = .62
r² = .78

◀ **Fig. 1** Data for Participants 1–14 for the two observation periods from the generalized matching equation. *Note*. Time 1 (T1): *blank square* and *dashed line*; Time 2 (T2): *filled square* and *solid line*; *a* = slope (social sensitivity); *b* = y intercept (bias); r^2 = variance accounted for (VAF)

than 50 % to be acceptable indices of matching. With this criterion, seven children (1, 2, 3, 4, 7, 11, and 13) had a VAF higher than 50 %, indicating that they matched their appropriate social behaviors to their therapist's attention. Seven participants (5, 6, 8, 9, 10, 12, and 14) had a lower VAF and therefore did not match their appropriate social behaviors to their therapist's attention. Participant 5 was the only one who had a low VAF but a high slope. For this participant, social attention may have had an impact, but not in a regular, systematic, or predictable way.

In T2, the VAF varied from 0.33 to 0.97 and 10 of the 13 participants (1, 2, 3, 6, 7, 8, 10, 12, 13, and 14) had a VAF higher than 50 % (Fig. 2, bottom). The group mean was 0.75. Compared to the first observation period, three more participants matched their appropriate social behaviors to their therapist's attention. The two observation periods were statistically comparable, $t(12)=2.02$, $p=0.07$, but did not vary together ($r=0.05$).

Relationship Between the Parameters of the GME and the Participants' Level of Functioning

The second part of this study sought to investigate whether the measures of VAF, sensitivity, and bias at T1 were correlated with the participants' severity of autistic symptoms and IQ measures. This part of the study also examined if changes in those parameters, between T1 and T2, were correlated with the severity of autistic symptoms and IQ.

The participants' scores ranged from 22.5 to 48.5 on the CARS and 64 to 117 on the GARS. The two participants (4 and 5) who did not score significantly for autistic symptoms on the CARS had a significant result on the GARS (52, 72), which detects the symptoms for higher functioning profiles of ASD. Participants' scores ranged from 44 to 117 for FSIQ, 52 to 111 for VIQ, and 53 to 121 for PIQ.

The correlations are shown in Table 2. The three GME parameters at T1 were not significantly correlated with the severity or IQ measures. Significant correlations were found between the changes in sensitivity from T1 to T2 and the participants' CARS scores ($r=0.57$, $p<0.05$). Significant correlations were also found between the changes in bias from T1 to T2 and FSIQ ($r=-0.9$, $p<0.05$), VIQ ($r=-0.87$, $p<0.05$), and PIQ ($r=-0.81$, $p<0.05$).

Discussion

There is a great need for more early intervention research on the social and communication behaviors of children with ASDs, as these, along with adaptive behaviors, are the most resistant to intervention (Kelley et al. 2010). We set out to

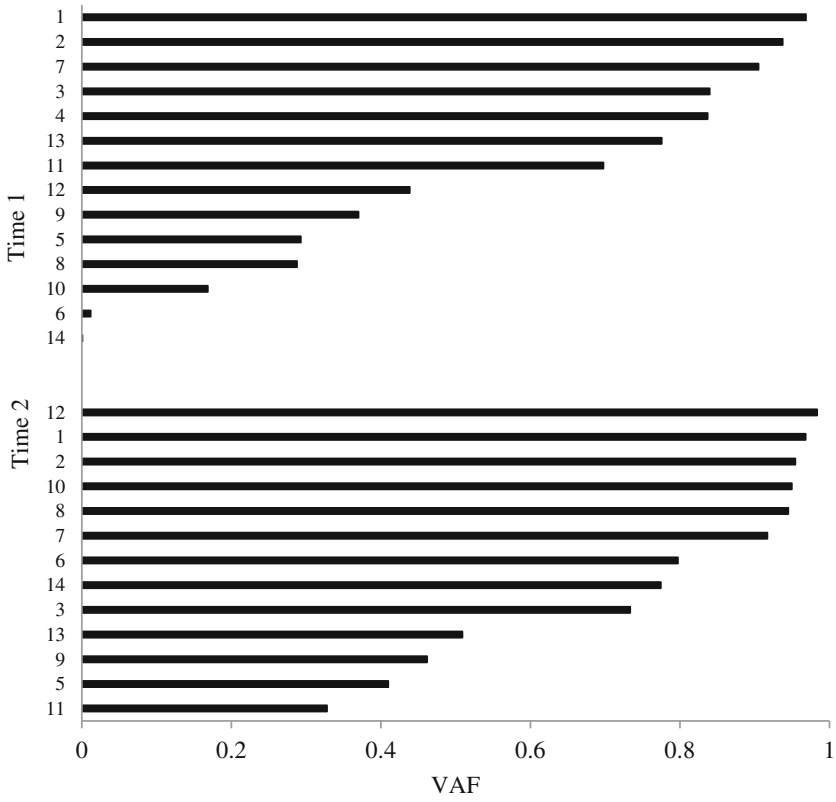


Fig. 2 Variance Accounted For (VAF) for each participant, for the two periods of observation

Table 2 Pearson Correlations Between the GME parameters (at T1 and in the Difference between T1 and T2) and the Participants' Scores on CARS, GARS, and WPPSI-III

GME parameter	CARS	GARS	FSIQ	VIQ	PIQ
GME measures at Time 1					
VAF	−0.21	−0.23	0.02	−0.06	−0.02
Social sensitivity (*a*)	−0.5	−0.5	0.29	0.17	0.25
Bias (*b*)	0.49	0.49	−0.51	−0.44	−0.45
Difference between GME measures at Time 1 and Time 2					
VAF	0.20	0.21	−0.2	−0.12	−0.01
Social sensitivity (*a*)	0.57*	0.5	−0.49	−0.36	−0.43
Bias (*b*)	0.41	0.52	−0.9*	−0.87*	−0.81*

CARS Childhood Autism Rating Scale (CARS; Schopler et al. 1988), *GARS* Gilliam Autism Rating Scale (GARS; Gilliam 1996). *FSIQ* full-scale intellectual quotient, *VIQ* verbal intellectual quotient, *PIQ* performance intellectual quotient; from the Wechsler Preschool and Primary Scale of Intelligence (WPPSI-III; Wechsler 2002)

*$p<0.05$

contribute to this effort by investigating the social sensitivity of children with ASDs in an intervention setting, using the GME as an analytical tool.

The primary objective of this study was to investigate how young children with ASDs adjusted their appropriate social behaviors based on the attention of their therapists in an EIBI setting. The use of the GME allowed us to not only analyze the degree that the participants matched their appropriate behaviors to therapist attention but also describe the individual factors of sensitivity and behavioral bias that played a role in this matching.

In the first observation period, the GME was a good predictor of the variations in appropriate social behaviors for seven participants. That is, half of the participants varied their appropriate social behaviors as a function of their therapists' attention, with VAFs higher than 50 %. It is interesting to note that these seven participants presented more classical profiles of autism than the other participants; that is to say, these individuals did not have associated intellectual disabilities or other comorbid conditions. Many of them presented with high results on intellectual scales. Of the seven participants who had VAFs lower than the acceptable cutoff of 50 %, three were undergoing clinical evaluations to establish diagnoses of genetic or postnatal syndrome (e.g., fetal alcohol syndrome), six had very high frequencies of vocal and motor self-stimulation or challenging behaviors (e.g., severe eating problems), and one had a diagnosis of Asperger syndrome. These participants may have presented a different pattern of matching because of their developmental particularities, problem behaviors, or pervasive self-stimulation behaviors.

In general, the VAF was congruent with sensitivity, which may have helped the social sensitivity analysis by adding information about the participant's capacity to vary his or her behaviors in relation to social attention. The only incongruent data were for participant 5 in T1, who had a VAF below 50 %, yet a high slope and demonstrated overmatching. According to Poirier and Forget's data (1997), children with Asperger syndrome may present a profile of no matching and may maximize sources of reinforcement. Participant 5 did show significant results on the GADS, which detects the symptoms of Asperger syndrome.

Clinically, these data have significant implications, foremost, that many children on the autism spectrum do vary their appropriate social behaviors in response to the social attention of others, so the management of social attention in early intervention programs should be planned rigorously. In a related study, Rivard and Forget (2012) targeted the verbal behavior of the same participants in the same clinical environment and demonstrated that on average, 30 % of the verbal behaviors emitted by the participants were not followed by attention from the therapists. The results of the present study underline the importance of responding to such initiations with attention: Since many children with ASDs are sensitive to social attention, it may serve to reinforce these initiations.

In addition, understanding the level of social sensitivity of individuals in an early intervention program is integral to properly choosing effective reinforcement. For a child with a high VAF, therapists could potentially use only social reinforcement, whereas for a child with a low VAF, therapists would need to pair social reinforcement with material reinforcers.

The data showed that none of the participants presented a bias in favor of inappropriate social behaviors or nonsocial behaviors. All of the participants presented a bias in favor of appropriate social behaviors. These data suggest that in the absence of social reinforcers, children with ASDs prefer to act appropriately in structured situations. For the purposes of intervention, these data also signify that it is important to distinguish social competencies from social sensitivity, and to understand that children who have lower social competencies or who do not exhibit spontaneous social behaviors may still be sensitive to the social attention of their caregivers.

The VAF, social sensitivity, and bias were statistically stable over time. This finding has implications for the strategic planning of social reinforcement discussed above. The stability suggests that an approach used at the beginning of an intervention program, based on initial measurement of sensitivity, should remain appropriate throughout the treatment. For example, if a participant showed strong matching and had a high VAF at the onset of treatment, the choice to use social attention as a main reinforcer should continue to be a strong choice further into the treatment. However, this finding needs to be studied further and with a larger sample size, as there were some qualitative changes in social sensitivity and behavioral bias over time; more participants had VAFs higher than 50 % and higher biases after 8 months of intervention.

The second objective of this study was to explore whether the degree of matching related to the participants' severity of autistic symptoms and levels of intellectual functioning. The rationale behind this objective was to build on Poirier and Forget's (1997) work, which found significant relationships between social sensitivity and levels of functioning when participants' data were analyzed in distinct groups of level of functioning. We were interested to see if a relationship existed when analyzed along a continuum of functioning, rather than distinct groups. However, social sensitivity and bias were not significantly related to the participants' severity of autistic symptoms or levels of intellectual functioning. This finding may be explained by the fact that the participants in this study were younger and that this relationship occurs in older children, around 7 years old, whose profiles are better discriminated with language measures and whose educational settings are different. These results may also demonstrate that our measures of functioning (CARS, GARS, and IQ) are more representative of the cognitive, language, and ritualized behavior components of autism than of the social aspect of autism.

Though these correlations were not found to be significant, the significant correlations between the *changes* in social sensitivity and bias and the measures of functioning have significant implications. The change in social sensitivity between the two observation periods was significantly correlated with the participants' CARS scores: After 8 months of intervention, participants with more severe autistic symptoms were the ones who showed increases in social sensitivity. The changes in bias between observation periods were significantly correlated with measures of IQ. At the onset of intervention, the participants with higher functioning profiles had lower biases in favor of appropriate social behaviors; that is, they had a lower tendency to act appropriately in the absence of social reinforcers. After 8 months of intervention, these participants' bias increased. These two results highlight the importance of pairing social attention with other forms of reinforcements for children across the spectrum. Future research with a greater number of participants should be conducted in order to further explore these correlations.

This study exhibits some limitations. First, we were unable to obtain the intellectual functioning scores for three participants due to parental refusal. In terms of methodological limits, one limitation to the study was that it did not include a functional analysis method to evaluate whether the coded responses of the therapists actually served as reinforcers. In addition, the stability of the matching parameters over time should be examined more rigorously, using a systematic procedure. One issue that was not analyzed in this study was the interlocking nature of the social interactions between the participants and their therapists, as was proposed by McDowell and Caron (2010) in their study of the interlocking nature of verbal behaviors. That is, the impact of the participants' behaviors on the feedback attention of their therapists was not analyzed, and those two variables were certainly not independent, despite the fact that attention management was outlined in the intervention plan.

There is a great need for more research on the social skills deficits in children with ASDs, and we sought to contribute to this effort by investigating the notion of social sensitivity through the lens of the GME. While many studies exist that use the matching law to investigate problem behaviors in children with ASDs, we used it to investigate these children's appropriate social behaviors, as a means of better understanding their social sensitivity. The contributions of this study are primarily clinical, demonstrating that many children with ASDs indeed do vary their social behaviors based on social attention of others and, therefore, there is a need for social attention to be strategically planned in early intervention settings. This study also highlights the possible relationships between bias, sensitivity, and various levels of functioning, and the need for further research to be conducted in this area.

This study also has some methodological contributions to the literature on children with ASDs, as it is one of the few studies that utilize the matching law as an analytical tool to measure social sensitivity in this population. This is especially relevant since, to our knowledge, no tools exist to measure social sensitivity in children with ASDs. The use of the matching law in this specific area would benefit from future research into how the levels of analysis of the matching equation can affect its measurements of sensitivity.

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