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Onset patterns in autism: Correspondence between home video and parent report

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Abstract

Objective—The onset of autism is usually conceptualized as occurring in one of two patterns, an early onset and a regressive pattern. This study examined the number and shape of trajectories of symptom onset evident in coded home movies of children with autism and examined their correspondence with parent report of onset.

Methods—Four social-communicative behaviors were coded from the home video of children with autism ($n = 52$) or typical development ($n = 23$). All home video from 6 through 24 months of age was coded (3199 segments). Latent class modeling was used to characterize trajectories and determine the optimal number needed to describe the coded home video. These trajectories were

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then compared to parent report of onset patterns, as defined by the Autism Diagnostic Interview-Revised.

Results—A three trajectory model best fit the data from the participants with autism. One trajectory displayed low levels of social-communication across time. A second trajectory displayed high levels of social-communication early in life, followed by a significant decline over time. A third trajectory displayed initial levels of behavior that were similar to the typically developing group, but little progress in social-communication with age. There was poor correspondence between home video-based trajectories and parent report of onset.

Conclusions—More than two onset categories may be needed to describe the ways in which symptoms emerge in children with autism. There is low agreement between parent report and home video, suggesting that methods for improving parent report of early development must be developed.

Keywords

Autism; regression; onset; parent report

Introduction

The onset of behavioral signs of autism is usually conceptualized as occurring in one of two ways, an early onset pattern, in which children show abnormalities in social and communicative development in the first year or so of life and a regressive pattern, in which children develop typically for some period and then lose previously developed skills. The vast majority of children who experience a regression lose behaviors related to social interest and engagement, such as eye contact and response to name.[1–3] Some children also lose spoken language, although this is less universal.[4]

While the autism community has operated on a dichotomous onset classification model for many years, recent studies of larger cohorts, using multiple methods, suggest that two categories are insufficient to cover all the ways that symptoms emerge.[5] Some studies have described a “plateau” pattern, in which early development appears typical but then more advanced skills, such as language and joint attention, fail to develop.[5–8] Other studies have identified a mixed pattern, in which mild, non-specific early delays are followed by later regression.[3,8] The current study focuses on these definition and measurement issues, examining both the optimal number of onset classifications and correspondence between methods of defining onset.

The most common procedure for collecting information about early symptoms is parent report. A number of factors can influence report validity, including awareness of the child’s eventual diagnosis and knowledge of developmental milestones. Retrospective reports are subject to problems of memory and interpretation[9–10] and are especially problematic when precision in estimating event dates or frequencies is needed.[11–12] When people are asked to recall particular episodes, they often report them as having occurred more recently than they did, an error called “forward telescoping”.[13] This phenomenon has been described in investigations using parent report to study autism onset.[2]

Analysis of home movies of children later diagnosed with autism spectrum disorders (ASD) is another method to examine symptom onset. Video analysis is a labor-intensive, but more objective, procedure than parent report for collecting information about early development,[14] making it critical to understand the correspondence between the two methods. Given potential recording biases (e.g., tendency of parents to film positive behaviors), the approach taken in the current study was to focus on social-communication

behaviors that are typically present very early in life, rather than atypical or negative behaviors. If the analysis of serial video can document the presence of key social-communicative behaviors, such as eye contact and social smiling, early in life and then demonstrate a decline in frequency over time, we can be reasonably certain that a regression has taken place and that this was not due to a recording bias.

Two studies have already examined the correspondence between home video and parent report. One coded home video of first and second birthday parties of children with typical development or ASD.[15] Children whose parents reported regression demonstrated levels of joint attention and communication at 1 year that were similar to the typically developing infants and higher than the children with parent-reported early onset of symptoms. At 2 years, there were no differences between the two ASD groups, both of whom displayed significantly lower levels of social-communicative behaviors than the typically developing sample. Interestingly, all children with ASD, both those with and without parent-reported regression, showed worsening social gaze over the 12–24 month period. This study concluded that parent report of onset was generally valid, in that children with parent reports of regression did indeed lose skills over time. However, it also suggested that decreasing social and communication behavior occurred in many children who also had early symptoms, but was not reported by parents.

Another study[16] examined individual concordance between parent report and home video using the same coding system;[15] video was categorized as documenting loss (50% decline in a behavior over time) or no loss in language and non-language domains. Concordance between video and parent report was much higher for language than non-language loss (85% v. 49%). Inconsistent findings occurred most often when parents reported no loss in non-language areas. In two-thirds of these cases, parents reported no loss in behaviors like social gaze and social initiations, yet losses could be documented on video. This result is consistent with Werner and Dawson's finding that many children with parent-reported early onset autism in fact showed significant declines in social gaze on video between 12 and 24 months.[15]

One limitation of prior research is the use of observational data simply to evaluate the validity of preconceived onset patterns. Advances in statistical modeling provide the opportunity to empirically derive distinct onset patterns from longitudinal behavioral data with minimal *a priori* assumptions about what type and how many onset trajectories exist. Such a technique not only permits examination of the validity of traditional onset patterns, but lets the data itself dictate the categories.

The present study examined home movies from 75 children with either autism or typical development. The same social-communication coding system used in previous studies was employed,[15] but behavior was sampled much more densely, coding all video from 6 through 24 months of age. Latent class modeling was used to characterize the developmental trajectories of social-communication behavior in the children with autism.[17] Bayesian Information Criterion (BIC) was employed to compare competing models that included different trajectory numbers (e.g., traditional two-group model vs. three- or four-group models) and shapes (e.g., linear versus quadratic) to select the best fitting model. We then compared the categories derived from the latent class analyses of home video to parent report to examine correspondence between methods of classifying onset.

Method

Participants

Participants were enrolled at two sites: 59 from the University of California – Davis and 16 from the University of Colorado Health Sciences Center. The UC Davis sample was recruited from the M.I.N.D. Institute Subject Tracking System and local agencies serving individuals with developmental disabilities. The University of Colorado sample was recruited through ongoing studies of autism and the university subject pool. Participants fell into two diagnostic categories: children with Autistic Disorder (n = 52) and children with typical development (n = 23). The group with Autistic Disorder ranged in age from 23 to 59 months at the time of home video collection and behavioral assessments. They were free from other medical conditions (e.g., seizures, Fragile X syndrome) and had no visual or hearing impairments. Multiple diagnostic criteria were used to confirm the presence of autism. Each child 1) had been previously diagnosed with Autistic Disorder or Pervasive Developmental Disorder Not Otherwise Specified in the community, prior to referral to the study, 2) received a current clinical diagnosis of Autistic Disorder according to DSM-IV criteria by study personnel, and 3) met full criteria for Autistic Disorder on standardized diagnostic measures.[18]

The typically developing (TD) group ranged in age from 12 to 42 months at the time of study participation. All had normal hearing and vision and were free of significant medical or developmental concerns. None met criteria for ASD on any of the diagnostic instruments administered.

Measures

Autism Diagnostic Interview – Revised (ADI-R).[19]—The ADI-R is a standardized parent interview developed to assess the presence and severity of symptoms of autism. It provides an algorithm that reliably distinguishes children with Autistic Disorder from those with other developmental delays or typical development. Previous studies have shown good to excellent internal consistency reliability and discriminative validity across a wide age range. [19] All raters were trained to research reliability and maintained it throughout the project by double-scoring 20% of protocols and obtaining 85% agreement or better.

The ADI-R collects detailed information about the onset of symptoms. Question 4 asks about the timing of first symptoms. A score of 0 indicates that problems were present in the first 12 months, whereas a score of 1 or greater indicates onset of difficulties after the first birthday. To meet criteria for loss of language (Question 11), at least five words must have been used spontaneously, meaningfully, and communicatively for at least three months before being lost for at least three months. Later items collect information about losses in other domains (e.g., Question 25 pertaining to losses in social engagement, responsiveness, and interest). Responses to questions 4, 11, and 25 were used to classify parent report of onset (see Figure 1).

Autism Diagnostic Observation Schedule (ADOS).[20]—The ADOS is a semi-structured interaction that measures symptoms of autism. It provides an empirically derived algorithm that differentiates children with ASDs from those with other delays or typical development. Psychometric studies report high inter-rater reliability and agreement in diagnostic classification (autism v. non-spectrum). [20] Examiners were trained to research reliability, which was maintained at 85% by double-scoring 20% of protocols across the period of data gathering.

Mullen Scales of Early Learning (MSEL).[21]—The MSEL is a standardized developmental test for children ages birth to 68 months. Four subscales were administered: Visual Reception, Fine Motor, Receptive Language, and Expressive Language. The MSEL demonstrates strong concurrent validity with other developmental tests.[21]

Home video collection and coding procedures

All available video of the participant between 6 and 24 months of age was requested from families. It was transferred to DVD and chronologically segmented based on changes in the activity, date, and/or location of the video footage. Only segments containing at least one person, in addition to the participant, were coded to insure that there were partners available for the social and communication behaviors of interest.

Four social-communication behaviors that are typically present early in life (Table 1), and therefore have potential to show the kind of change over time that is relevant to onset, were selected from Werner and Dawson's[15] coding system. Coders unaware of group membership used Noldus: The Observer 5.0 software to record the frequencies of these behaviors in each video segment, with a time resolution of one half second (e.g., a behavior present for at least one half second was recorded as one frequency count of occurrence). Twenty percent of the segments were double-coded to ensure ongoing reliability, maintaining a minimum average intraclass correlation coefficient of .80 for each coder.

Once all segments had been coded, data were examined for outliers indicative of errors by plotting the incidence of each behavior by chronological age. Any data that were inconsistent with developmental principles (e.g. using phrases at 6 months) or represented extreme outliers (more than 3 standard deviations above or below the mean) were checked through visual inspection of the video. Any obvious errors were corrected through re-coding or eliminated from further analysis. This process resulted in 54 segments (1.7%) being discarded, yielding a total of 3199 video segments used in statistical analyses.

Onset group classification procedures

Participants with Autistic Disorder were classified into onset groups using two methods, empirical classification of the home movie trajectories and parent report.

Home video trajectory classification—Frequencies of the four coded social-communication behaviors were summed to produce a composite count. Because behaviors were coded over different time intervals for each segment, a rate was created by dividing this composite count by the length (in minutes) of the segment. The outcome of interest used in all statistical analyses was the number of social-communication behaviors per minute.

Group-based trajectory analysis was performed using the PROC TRAJ macro in SAS version 9.2.[22] This is an application of mixture modeling used to simplify longitudinal data by grouping similar individual trajectories into interpretable classes. This approach assumes the existence of latent subgroups and a given individual may follow a weighted mixture of several different trajectories. The model estimates the probability that a randomly chosen individual in the sampled population is a member of each identified group (i.e., the overall proportion of subjects who belong to a particular trajectory group), as well as the posterior probability of group membership (i.e., the probability for each individual of belonging to a specific trajectory group). PROC TRAJ assumes that individuals have only one measurement per period, recorded at regular intervals. Participants varied in the amount of video available at different ages, so to obtain a single measure to use for the trajectory model at each age, social-communication behaviors were averaged over 2 month intervals, resulting in one observation per child at months 7, 9, 11, 13, 15, 17, 19, 21, and 23. There

were no significant group differences in the amount of video available at any age (see Table S1).

Parent-report classification—The ADI-R was used to classify participants with Autistic Disorder into onset groups based on parent report. Following previously proposed algorithms, [5] the intersection of the responses to items 4, 11, and 25 was used to create four parent-report onset categories (see Figure 1).

Results

Home video trajectories

Latent class models were fit using linear and quadratic curves over time, with a range of 2 to 4 latent classes. Preliminary analyses showed that the quadratic trajectory terms were not justified, so only linear terms were kept in the models. BIC and Jefrey's scale of evidence were used to choose the best models.[17] Jefrey's scale of evidence is the exponentiated difference $e^{BIC1-BIC2}$ between the BIC values of two models (1 and 2) and can be interpreted as the ratio of the probability of 1 being the correct model to 2 being the correct model. Values greater than 10 are considered strong evidence for model 1, while values smaller than 0.1 are interpreted as strong evidence for model 2. The three trajectories model (BIC = −558.23) was strongly favored over both the two-group model ($e^{-558.23+560.91} = 14.6$) and the four-group model ($e^{-558.23+562.47} = 69.4$). The non-significant linear trend for one of the groups was dropped to produce the final model with three trajectories (BIC = −556.49). The approximate probabilities of these trajectories were estimated to be 38%, 39%, and 23% respectively.

In latent class analysis, each participant's trajectory is modeled as a mixture of all trajectories and posterior group probabilities are calculated for each individual. For our model, 50% of the participants had over 90% of their probability focused on a single trajectory. All the remaining participants had at least 75% probability concentrated on just two trajectory classes. When using posterior probabilities to classify participants, there were only 5 participants whose highest single posterior probability was below 50% and all were above 40%. This, along with the results of the BIC analyses, suggested that three trajectories (rather than two or four) best represented the patterns of change in social-communication behavior over time for these participants.

Using their highest posterior group probability, we classified the 52 participants with Autistic Disorder into three trajectories, TRAJ1 ($n = 20$), TRAJ2 ($n = 20$), and TRAJ3 ($n = 12$). To this sample we added the 23 typically developing children and reanalyzed the developmental trajectories of social-communication. A Generalized Estimating Equations approach was used since the coded behaviors were counts and the normal distribution was not applicable.[23] Because the data were overdispersed, the negative binomial distribution was employed to represent the distributions of behaviors. In models for count data, log of the mean (rather than the mean) is modeled as a linear combination of predictors. Because behaviors were coded over different time intervals for each video, the duration of the segment (in minutes) was log transformed and entered into the model as an offset. This resulted in a rate parameterization, in which the outcome of interest was the number of social-communication behaviors per minute and the regression coefficients represented the linear effect of the predictor variables on the log of the rate of behaviors. The model contained a main effect for diagnosis (with the TD group coded as the referent for comparison), a linear effect of time (measured in months, from the 6-month baseline) and the interaction between time and diagnosis. All analyses were implemented using PROC GLIMMIX in SAS Version 9.2.

This approach allowed us to test hypotheses about the baseline levels and rates of change in social–communication in the three autism groups relative to the TD group. Significant differences among the participants with autism would be expected in this analysis given that the dependent variable was originally used to identify trajectory group membership. Despite this tautology, post-hoc comparisons act as useful descriptors of each trajectory group. Figure 2 displays the trajectories estimated by the models, while supplemental Figure S2 displays individual trajectories for several participants in the ASD group.

At baseline, the TRAJ1 group displayed significantly lower social-communication than the TD group, while the TRAJ2 group had significantly more social-communication behaviors than the TD group and the TRAJ3 group had similar baseline levels to TD children (see Table 2). The TRAJ1 and TRAJ2 groups declined over time, with the TRAJ2 group showing a significantly more rapid decline. The TRAJ3 group showed a trend for slower growth over time compared to the TD group. At 24 months, all three autism groups showed significantly lower levels of social-communication than the TD sample. Post-hoc comparisons of the autism subgroups revealed no significant differences between TRAJ1 or TRAJ2 at 24 months, but both groups displayed significantly less social-communication than TRAJ3.

These trajectories correspond well with three previously described onset patterns and were labeled as such: TRAJ1 as Early Onset, TRAJ2 as Regression, and TRAJ3 as Plateau. There was no empirical support for a mixed onset group (demonstrating initial mild delays, followed by a significant skill regression) previously described in the literature.[3]

Correspondence between parent report and home video classifications

The ADI-R was used to create parent-reported onset types, as described in Figure 1. However, given the lack of support from the trajectory analyses for a mixed onset group, 8 participants with this parent-reported pattern were collapsed with those whose parents reported regression alone ($n = 16$). This resulted in three categories of parent-reported onset: PR_Early Onset ($n = 18$), PR_Regression ($n = 24$), and PR_Plateau ($n = 10$).

There was poor correspondence between onset classifications made by parent report and trajectory analysis of home videos. As seen in Table 3, a minority of participants were classified with the same onset type by both methods (kappa = .11, $p = .30$). Less than half of participants (9 of 20) whose home video displayed clear evidence of a major decline in social-communication behavior were reported to have had a regression by parents. Similarly, only 8 of 20 participants with evidence of early delays in social-communication and little evidence of skill decline on video were reported as having an early onset pattern by parents. Of the 10 parents who described a plateau in development, only 3 had home video trajectories consistent with such a pattern.

Group differences in current functioning

Table 4 summarizes demographic, Mullen, and ADOS scores as a function of onset classifications. Regardless of whether onset is classified by parent report or home video, there were few group differences in functioning level. Using either method of classification, the Plateau group generally performed at a higher level, as evidenced by non-significantly higher scores, sometimes as much as a full standard deviation, on the Mullen. Differences between the Early Onset and Regression groups were small and non-significant after Bonferroni adjustments (all p's > .05), whether the categories were defined by parent report or home video.

Discussion

The idea that early normal social and communication development are not necessarily a firm foundation for further social-communicative progress, but rather can be completely disrupted in the second year of life, has presented a theoretical and empirical challenge to those interested in early development. In order to begin to understand the phenomenon and its meaning *vis-a-vis* early social development, appropriate measurement and classification strategies are crucial. Recent questions about autism onset highlight the need for examining parent report, currently the primary source of information about very early development. The current study compared two procedures for defining onset, the common method of parent report versus discrete behavior measurement using home video. In contrast with previous studies, which used home video simply to evaluate the validity of preconceived onset patterns, the current investigation used statistical modeling to empirically derive the optimal number of distinct onset patterns apparent in the home video.

The first major contribution of this study concerns onset trajectories. Contrary to both traditional two-category definitions of onset and newer four category formulations, [5] latent class modeling suggested that three onset trajectories best fit the coded home video. The intercepts and slopes of these trajectories corresponded well with three previously described onset patterns: an early onset category displaying low levels of social-communication from early in life, a regression category displaying initial high levels of social-communicative behavior that declined over the first two years of life, and a plateau category displaying typical levels of social-communication in the first year, but failure to make expected developmental progress over time. A fourth parent-reported onset pattern has been described, exemplified by lower skills than the typical group at baseline, followed by significant decline.[3] This pattern was not defined via the latent class analyses, although the early onset group did show some decline in social-communication over time, a pattern previously described in the literature.[15] It is possible that, had the sample been larger, a distinct trajectory of this type might have emerged.

The onset pattern involving a developmental plateau (in which development progresses normally through most of the first year and then slows down without any frank skill loss) has only recently been described in the literature.[5–8] One contribution of the present study was to document this pattern as a distinct trajectory using home video analysis. Previous studies would likely have included such children in an early onset or no regression group. In the current study, fewer children displayed a plateau onset course (23%) than an early onset or regressive course (both 38.5%, which are relatively consistent with previous research). Further study of the plateau group is important to determine whether its later phenotype, outcome, or etiologies may differ from other onset types.

The pattern seen in the regression group involved a very unusual and novel feature. The children with regression displayed even higher rates of eye contact, social smiling, and communicative behaviors before the first birthday than did the group of young typical children participating in the study, demonstrated by the finding that the intercept of the regression trajectory was significantly higher than that of the TD trajectory. This was unexpected and conflicts with recent studies describing the development of many children with regression as atypical even prior to the losses.[2,3] It is, however, consistent with early studies of regression in which parents were “emphatic” in describing the normalcy of their child’s social development before the decline.[24] It is also consistent with a recent study that reported rapid early language development in children with regression, with the first word milestone achieved on time or, in some cases, early. [25] This may be a random finding and needs to be replicated before we attempt to interpret it, given its provocative nature. Further studies, particularly prospective investigations with larger samples, will be necessary to

determine whether this phenomenon is part of the regression phenotype and, if so, what it might mean.

The second major contribution of the present study was to examine the correspondence between the most widely used method for classifying onset, parent report, and the empirical trajectory classifications statistically derived from coded home video. Despite interviewing parents about their child's development only a year or two after the events in question (mean age of child at parent interview = 3.25 years), we found poor agreement between methods, with less than half of classifications derived from the ADI-R supported by trajectories identified through latent class analysis of home video. This would seem to disagree with two previous studies that reported somewhat better agreement between methods than we found, but procedural differences may account for the discrepant conclusions. One study[15] looked at group level correspondence (e.g., whether, as a group, children whose parents reported a regression showed a decline in behaviors on video); it is possible that a group level effect masked significant individual disagreements between onset classifications. The other study[16] found good agreement for language loss, but poor agreement for "other" regression (primarily social), which is consistent with the present findings that focused on social variables in the coded composite. Neither study used a statistical procedure like latent class analysis to categorize the underlying pattern of trajectories seen in the sample.

The finding of low concordance between video and parent report is consistent with a recent prospective study demonstrating that loss of social-communication behaviors was evident in many infants who were developing autism (demonstrated through video analysis of longitudinal standardized assessments), but was reported by only a minority of parents.[26] These parents astutely observed and reported early delays in their child's development, so it was not recognition of the child's problems that they failed to see. What few parents reported, although it was documented on both videotape and by structured examinations of the infant, was that most infants had experienced an early period of development in which communication and social skills were comparable to typically developing infants, followed by a sharp decline in these behaviors between 6 and 18 months of age.[26] This is similar to the 45% of participants in the present study whose parents did not report regression even though it could clearly be seen and empirically classified from videos collected in the home. This suggests that it may be difficult for parents to perceive and describe changing patterns of development occurring over many months during infancy, particularly when either 1) the period of normalcy is fairly brief and is followed by clearly atypical development or 2) an extended period of typical development slows and fails to progress in the second year.

The two main findings of the present study, the existence of more than two onset trajectories on home video and the low correspondence between classification methods, may explain some of the inconsistencies in the literature regarding the relationship between onset and prognosis. Previous studies comparing the developmental profiles of children with regressive and early onset autism have had mixed results. Some studies reported lower functioning in children with regression,[7,24,27,28] others found better outcomes for children with regression,[29] several reported no differences in developmental profiles,[4,6,30,31] and many found just one or two significant group differences out of multiple group comparisons.[32–35] The current study found no differences between onset groups on the Mullen and ADOS at a mean age of 3.25 years, regardless of the method of classifying onset. Consistent with other recent reports, [6] the Plateau group performed at a (non-significantly) higher functional level, no matter how onset was defined. On the Mullen, the Plateau group's scores approached one standard deviation higher on some subtests. They also displayed non-significantly lower ADOS scores according to both methods of classifying onset, as well as higher levels of social-communication behavior on home video. Since the present study raises significant questions about the use of parent interviews for

classifying onset, it is not surprising to see lack of agreement in the previous literature. Given the current data, the most accurate statement is that we do not know the relationship between patterns of onset and later developmental profiles or prognosis at this time.

There are several limitations to the present study that must be mentioned. The sample size was relatively small for a latent class analysis. It is possible that if more participants were included, evidence of additional trajectories may have emerged. Approximately 10% of the autism sample could not be characterized as clearly belonging to a single trajectory and showed relatively similar likelihood of belonging to multiple trajectories.

The present work has both specific methodological and broader scientific implications. These findings suggest that onset definitions will need to undergo further development, possibly expanding the number of categories from two to three or more. Alternatively, onset may better be considered dimensionally, as a continuum characterized by the amount and timing of regression.[26,36] At one end of the continuum might lie children who display loss of social interest very early (prior to six months of age), so that the regression is difficult to quantify using any method and the decline appears minimal. At the other end of the continuum lie children who experience losses of social interest and communication skills so late and so rapidly that the regression is easily quantified by any method and appears dramatic. Understanding whether onset is best represented categorically or dimensionally is critically important for etiologic studies, which have been hindered already by the tremendous heterogeneity of the autism phenotype.

At a practical, methodological level, these results indicate that the most commonly used method of classifying onset is flawed and must be improved, if future studies are to provide valid data on onset phenomena. Methods developed to improve parent report, such as the Early Development Interview[15] and the Regression Validation Interview,[37] could be employed in future studies to help parents remember early periods in their child's development that may be overshadowed by the clearly atypical behaviors that lead them to seek diagnosis. Later aberrant patterns of development likely stand out to parents because of their alarming nature, as well as their proximity in time to the interview and consistency with their child's current presentation. Several methods might be used in future studies to improve the validity of onset categorizations. Researchers might ask parents to review baby books and home video prior to interviews. Additionally, questions about early social development on interviews and questionnaires could be structured so that they provide more explicit examples of the kinds of behaviors that may be intact early in the lives of children with autism. We and others are exploring whether the use of video "standards" that provide parents with examples of typical and atypical behaviors improves the validity of parent report.

The present results might imply that retrospective data be abandoned in favor of prospective methods of studying onset. However, retrospective methodologies such as those employed in the current study provide important complementary data based on naturalistic observations collected longitudinally in the home prior to diagnosis. This kind of data is not compromised by artifacts that can be introduced, even in well-designed prospective studies, by measurement methods that may be less relevant or informative due to being performed in a laboratory setting. When findings converge across methods, as the present results do with prospective, laboratory-based investigations,[26] we come a bit closer to solving the puzzle of how early symptoms emerge in children later diagnosed with autism.

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	Loss of Skills	
	NO	YES
Symptoms present before 1st birthday	Early Onset (Early delays, no loss) Hindsight of symptoms in first 12 months (Q4=0) and No loss of language (Q11=0) and No loss of social engagement/responsiveness (Q25=0)	Mixed Onset (Early delays before loss) Hindsight of symptoms in first 12 months (Q4=0) and [Loss of language (Q11=1) and/or Loss of social engagement/responsiveness (Q25≥1)]
Symptoms not present before 1st birthday	Plateau (No early delays, no loss) Hindsight of no symptoms in first 12 months (Q4≥1) and No loss of language (Q11=0) and No loss of social engagement/responsiveness (Q25=0)	Regression (No early delays before loss) Hindsight of NO symptoms in first 12 months (Q4≥1) and [Loss of language (Q11=1) and/or Loss of social engagement/responsiveness (Q25≥1)]

Figure 1.
Parent report onset groups defined using ADI-R items

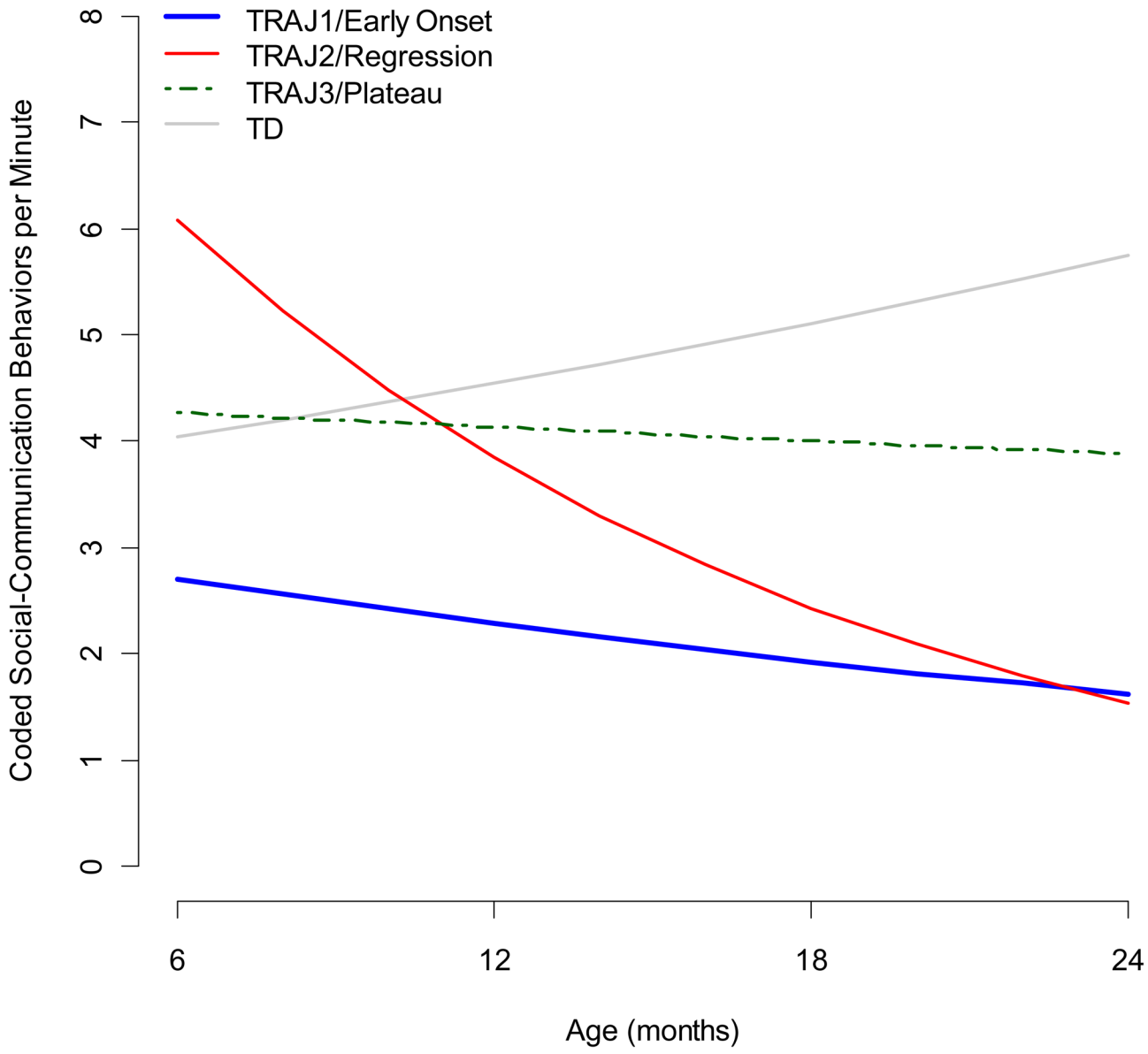

Figure 2.
Estimated social-communication trajectories from the generalized estimating equations model
Note:
Q = ADI question number; TRAJ = trajectory group.

Table 1

Social-Communication Behaviors Coded

Code	Description
Looks at People	Gaze is directed toward the face of another person.
Smiles at People	Smile (at least one corner of mouth must be clearly upturned) and/or laugh occurs when gaze is directed at another person.
Language	Child vocalizes using a non-word sound (sighs, coos, whines, cries, open vowels, consonant-vowel combinations), a distinct word or word approximation, or a two or more word combination.
Joint Attention	Child uses one isolated index finger to point for declarative (showing, sharing interest) or imperative (requests) purposes.

Table 2

Parameter estimates for the generalized estimating equations model predicting coded social-communication behaviors.

	Estimate (SE)
Estimated trajectory for TD group	
Baseline (6 months)	1.40 (.08)**
Linear change (per 3 months)	.06 (.03)*
Estimated difference between TRAJ1 and TD groups	
Baseline (6 months)	−.40 (.12)**
Linear change (per 3 months)	−.14 (.04)**
Estimated difference between TRAJ2 and TD groups	
Baseline (6 months)	.41 (.12)**
Linear change (per 3 months)	−.29 (.04)**
Estimated difference between TRAJ3 and TD groups	
Baseline (6 months)	0.05 (.14)
Linear change (per 3 months)	−.07 (.04)†

Note:

*$p < .05$,

**$p < .001$,

†$p < .10$

SE = standard error; TD = typically developing group; TRAJ = trajectory group.

Table 3

Correspondence between parent report and home video onset classifications

	Parent Report		
	Early Onset (*n* = 18)	**Regression (*n* = 24)**	**Plateau (*n* = 10)**
TRAJ Grouping			
TRAJ1/Early Onset (*n* = 20)	8	9	3
TRAJ2/Regression (*n* = 20)	5	11	4
TRAJ3/Plateau (*n* = 12)	5	4	3

Note: kappa = 0.11, $p = .29$

TRAJ = trajectory group.

Table 4

Characteristics of the sample as a function of onset classification method

	AUTISM						TD
	Parent Report			TRAJ Grouping			
	PR_Early Onset (*n* = 18)	PR_Regression (*n* = 24)	PR_Plateau (*n* = 10)	TRAJ1/Early Onset (*n* = 20)	TRAJ2/ Regression (*n* = 20)	TRAJ3/Plateau (*n* = 12)	(*n* = 23)
Gender							
Female	0 (0%)	5 (21%)	1 (10%)	1 (5%)	4 (20%)	1 (8%)	11 (48%)
Male	18 (100%)	19 (79%)	9 (90%)	19 (95%)	16 (80%)	11 (92%)	12 (52%)
Race/Ethnicity [a]							
Caucasian, non-Hispanic	11 (69%)	15 (62.5%)	9 (90%)	13 (65%)	12 (67%)	12 (67%)	18 (78%)
Other Race/Ethnicity	5 (31%)	9 (37.5%)	1 (10%)	7 (35%)	6 (33%)	6 (33%)	5 (22%)
Age at visit (years)	2.8 (0.8)	3.7 (0.8)	3.0 (0.6)	3.5 (1.1)	3.1 (0.7)	3.1 (0.7)	1.9 (0.7)
Mean Visual Reception T-Score[b]	31.1 (16.5)	27.1 (10.4)[†]	33.7 (9.2)[†]	27.9 (11.3)	30.7 (15.1)	31.9 (11.3)	57.6 (9.8)
Mean Fine Motor T-Score[b]	29.4 (9.7)	27.8 (13.1)[†]	38.4 (14.7)[†]	28.8 (10.1)	28.3 (9.2)	37.7 (19.1)	55.6 (7.8)
Mean Receptive Language T-Score[b]	26.6 (12.5)	22.9 (6.7)	30.7 (14.0)	23.3 (8.1)	25.1 (10.8)	31.5 (14.0)	55.1 (11.6)
Mean Expressive Language T-Score[b]	27.9 (13.2)	23.1 (5.4)	26.9 (13.9)	22.9 (4.3)	24.9 (10.0)	31.5 (16.7)	55.5 (11.7)
Mean Early Learning Composite[c]	62.9 (19.7)	56.2 (11.8)	66.7 (20.3)	56.8 (10.2)	59.6 (16.2)	68.0 (23.7)	111.8 (15.4)
Mean ADOS Communication + Social Interaction Total[c]	15.0 (3.7)[†]	16.8 (2.9)	17.5 (4.6)[†]	15.5 (3.0)[†]	17.5 (4.1)[†]	15.6 (3.7)	2.6 (2.1)

Note: Continuous variables are presented as mean (SD)

a, b, c Data missing for 2, 8 and 4 participants, respectively

[†] Autism subgroups with same superscript differ at $p < .10$ after Bonferroni correction

PR = parent report group; TRAJ = trajectory group; TD = typically developing group; ADOS = Autism Diagnostic Observation Schedule.