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Early Screening for Autism Spectrum Disorders: Update on the Modified Checklist for Autism in Toddlers and Other Measures

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ABSTRACT. Early intervention for autism spectrum disorders necessitates early detection. This need has led to widespread agreement across disciplines that screening is critical in very young children. Two screening issues are highlighted in this review. *Level* of screening refers to the type of sample: Level I is defined as an unselected sample, and Level II consists of selected children already identified as being at risk for a developmental disorder. *Breadth* or scope of screening refers to the range of difficulties the screening tool attempts to identify: broad screening instruments identify multiple range of developmental difficulties, whereas disorder-specific tools focus on a single disorder or class of disorders. Broad developmental instruments reviewed include the Parents' Evaluation of Developmental Status and the Ages and Stages Questionnaires; autism-specific tools reviewed include the Checklist for Autism in Toddlers, the Modified Checklist for Autism in Toddlers (M-CHAT), the Pervasive Developmental Disorders Screening Test, Second Edition, and the Screening Tool for Autism in Two-year-olds. The development of the M-CHAT, a Level I and Level II screening instrument, is described, and current research and clinical use of the M-CHAT are reviewed, including description of the structured follow-up interview which reduces the false-positive rate of the parent-report M-CHAT. *J Dev Behav Pediatr 27:111–119, 2006.*

BACKGROUND AND DEVELOPMENT OF THE MODIFIED CHECKLIST FOR AUTISM IN TODDLERS

Autism spectrum disorders (ASD) are pervasive disorders of development affecting as many as 1 in 170 births.[1–4] Children with autism display a triad of symptoms characterized by impairments in social interaction, communication deficits, and restricted, repetitive, and stereotyped patterns of interests and behaviors (*DSM-IV*[5]). Those with Pervasive Developmental Disorder, Not Otherwise Specified (PDD–NOS), show deficits in social interaction and at least 1 of the other 2 domains and are typically less impaired than children with autism. ASD was originally defined based on the presentation of symptoms in older individuals, which has presented difficulties for researchers and practitioners attempting to detect ASD in the first years of life.

Despite the various challenges that surround the current definition of autism, there is a pressing need for early intervention,[6,7] which necessitates early identification of an ASD.[8,9] Review of the current literature suggests that children who receive early intervention services by age 3 years show significant developmental gains.[10–12] More precisely, children with autism who develop language and symbolic play before age 5 years are more likely to be enrolled in a regular classroom and to show pronounced improvement in communication,[13–15] developmental skills,[16] and language skills[17] relative to children who are nonverbal at age 5 years. Furthermore, early intervention attenuates the severity of ASD-associated deficits (e.g., impaired communication and deficits in social relatedness) that interfere with subsequent development.[18–20]

Although general awareness of ASD is increasing and evidence for its early manifestations in the first 2 years of life is accumulating through research using multiple methodological approaches, most children with ASD are not identified clinically at a very early age.[21–24] Retrospective analysis of videos recorded by parents of children who are later diagnosed with an ASD has identified early markers of the disorder in the first year of life;[25–27] although these articles found markers of group differences, it is not known whether these behavioral markers can identify ASD prospectively. Other research has focused on identifying early indicators of ASD in children younger than 2 years through case studies of children at risk[28,29] and

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parental reports.[30,31] More recently, research has focused on infants and toddlers who have older siblings already diagnosed with an ASD.[32] Younger siblings of children with ASD are at an increased risk of developing ASD compared with the general population.[33] Together, retrospective and prospective studies concur that deficits in the social-communicative domains (protodeclarative pointing [i.e., pointing to indicate interest],[1] joint attention,[34–36] pretend play,[37,38] response to voice,[14] response to name,[32,35,39] aversion to social touch,[25] poorly coordinated or lack of gaze for social communication,[39] and imitation[32,40–42]) constitute risk indices and suggest that measuring such domains is pivotal for the early identification of ASD.[16,36]

The preceding review suggests the presence of a constellation of symptoms specific to ASD that may be among the first to be detected by parents. However, studies suggest that many parents do not express concern regarding their children's development until the second year of life,[43–45] and children are not typically seen by a professional for a formal autism diagnosis for several months or longer.[43–45] Moreover, the expression of parental concerns to primary care physicians does not necessarily expedite a referral for diagnosis and management.[46] Increased awareness among primary caregivers is critical for reducing the age of referral to a specialist who might diagnose ASD.[47]

Screening in Toddlers

Given the importance of early detection and intervention in promoting better long-term outcomes for children with ASD, a multidisciplinary consensus panel supported by the American Academy of Neurology and Child Neurology Society[48,49] and endorsed by the American Academy of Pediatrics, among others, has recommended that pediatric primary care providers incorporate standardized developmental screenings within the developmental surveillance occurring during well-child care visits. Furthermore, in 2001, the American Academy of Pediatrics released a policy statement[50] highlighting the need for primary care physicians to use developmental surveillance and screening to identify those children at risk for an ASD. This goal has been supported by others in the field as well,[51,52] although challenges to screening have been identified.[53] Two key issues that arise when discussing screening are the level of screening and the breadth of screening.

Level I screening instruments are used to identify children at risk in the general population, whereas Level II screening tools identify risk for ASD among a selected group of children already considered to be at increased risk (e.g., a referred clinical sample with a variety of developmental concerns, younger siblings of children diagnosed with ASD). Level I instruments are most likely to be used by primary care physicians. The scope of Level I screening necessitates a brief format, given that they are administered to a large sample, most of whom are not at risk for developmental delay (DD). Level II screening tools are typically more time consuming, but are only used with a subset of children already identified as being at increased risk for DD. Level II screening instruments are often used by professionals other than general practitioners and can include both parent report and observation by the professional. Some screening tools are designed for use both for Level I and Level II screenings.

The second important issue regarding screening is the breadth or scope of the screening. Broad developmental screening aims to identify a wide range of developmental difficulties, whereas disorder-specific screens target a specific disorder or class of disorders. The advantage of broad screening is efficiency; it is cost- and time-effective to screen for multiple conditions with a single tool. However, the sensitivity of broad screening as a means of detecting ASD requires further study.

Pediatric primary care providers are often the only professionals interacting with preschoolers on a continuous basis. They also represent a trusted source of information for parents. These practitioners would benefit from instruments that facilitate screening this age group for both ASD and broader DD.

Existing Broad Developmental Screening Tools

The provision of an exhaustive list of broad developmental screening instruments is beyond the scope of this review. More comprehensive reviews on the subject are recommended to the reader.[45,54] However, 2 widely disseminated tools will be described here briefly. The Parents' Evaluation of Developmental Status[55] (PEDS) contains 10 questions: 2 are open-ended, asking about parental concerns regarding their child's development, and 8 are domain-specific (e.g., language and motor skills) questions, asking parents to respond ''yes,'' ''no,'' or ''a little'' and elaborate with comments. The PEDS is designed to screen children from birth to 8 years old. The Ages and Stages Questionnaires[56,57] (ASQ) consist of 11 different screening questionnaires to be used with children aged 4 to 60 months; parents report on development of specific skills by responding ''not yet,'' ''sometimes,'' or ''yes'' and are also asked to note general concerns.

Psychometric properties are adequate for both the PEDS[55] and ASQ,[57] although, to date, psychometric data regarding their ability to detect ASD specifically have not been published. In several studies using large ethnically and economically diverse samples, the PEDS showed sensitivity ranging from 74% to 79% and specificity of 70% to 80% across a broad age range. According to the ASQ technical manual,[56] sensitivity was found to be at least 72% for all ages except 4 months (51%) and 20 months (65%), and specificity was at least 81% for all age groups.

Evaluation of the psychometric properties for broad developmental screening instruments, such as the PEDS and ASQ, considers detection of all developmental delays, rather than specific developmental disorders such as ASD. Broad screening is critical for the identification of a wide range of risk factors in toddlers; however, there are limited data on whether general screening instruments such as the PEDS and the ASQ have high sensitivity specifically for the identification of children at risk for an ASD. The need

to maximize sensitivity for ASD is balanced against the practical need for optimal efficiency, that is, to incorporate as few screening tools as possible into well-child visits. Therefore, evaluating the ASD-specific psychometric properties of broad screening tools such as the PEDS and the ASQ is critical. Future research is required to further investigate this issue.

Autism-Specific Screening Tools

Three autism-specific screening instruments that have been designed for use in a Level I population are the Checklist for Autism in Toddlers[58,59] (CHAT), the Modified Checklist for Autism in Toddlers[60,61] (M-CHAT), and the Pervasive Developmental Disorders Screening Test, Second Edition[62] (PDDST-II). The M-CHAT and PDDST-II have also been developed as Level II screening instruments, and the Screening Tool for Autism in Two-year-olds (STAT)[16,63] is designed specifically as a Level II instrument.

The CHAT[58] consists of 9 parent-report items (see Appendix A, items 1–9) and 5 items observed by home health visitors or other health professionals (eye gaze, following point, pretend play, pointing on request, and constructional play). Initial research using the CHAT identified 10 children with autism at 18 months from a sample of approximately 16,000 toddlers, and diagnoses were confirmed at 3.5 years.[59] However, follow-up when the children were approximately 7 years old identified 50 children with autism and 44 with PDD–NOS, resulting in a sensitivity of 20% to 38% for autism, depending on whether the high-risk (n = 10 children identified) or medium-risk (n = 19 children would have been identified) scoring was used.[1] It is important to note that the original CHAT study identified autism and did not attempt to detect ASDs, but reported findings of PDD–NOS in the follow-up sample. Only 2 false-positive cases were identified at 18 months, suggesting that the CHAT is a highly specific screening instrument for autism.

The primary goal of the M-CHAT[61] (see Appendix A) was to identify children at risk for any ASD, not just autism. The M-CHAT retained the 9 parent-report items from the CHAT and added 14 additional items, based on a survey of the literature and clinical judgment. The observation section was eliminated, in part due to feasibility issues in the US health care system. The removal of the observation items was also supported by the literature suggesting that parent-report is more accurate than a brief observation by a professional, particularly in a setting where a child may be anxious or behave in an atypical manner, such as the pediatrician's office.[64] Preliminary results from the M-CHAT[61] reported combined findings from 2 groups of toddlers, aged 16 to 30 months: children seen by their pediatricians for routine checkups (n = 1122; Level I) and those referred for early intervention due to language and other developmental delays (n = 171; Level II).

Six critical items were identified from the 23 items on the M-CHAT, based on discriminant function analysis (DFA) with the first 600 participants. The critical items were (in descending order): (7) protodeclarative pointing, (14) response to name, (2) interest in peers, (9) bringing things to show parents, (15) following a point, and (13) imitation. Children who failed any 3 of the 23 total items or 2 of the 6 critical items were categorized as at risk for ASD.

Completed M-CHATs were scored by the authors, and parents were contacted for a telephone interview (see Appendix B for sample items) if the child's M-CHAT score indicated risk for an ASD (failure of 2 critical items or any 3 items). Telephone interviews were completed by graduate and undergraduate students trained to follow the structured format. The interview, which is concrete and easy to use, is designed to clarify the items failed by eliciting details of the presence or absence of behaviors and frequency of the behaviors and requires parents to provide specific examples of the behaviors. Children who continued to be at risk after the telephone interview (using the same scoring criteria as the M-CHAT) were invited for a developmental evaluation assessing cognitive, language, motor, play, adaptive, and social functioning; diagnoses were provided if appropriate. All families received specific recommendations for intervention.

After administration of the M-CHAT, children were categorized into 4 groups (see Fig. 1 for a flowchart of screening procedures): (1) passed the screening (n = 1161), (2) passed telephone follow-up interview and not evaluated (n = 74), (3) evaluated and identified as showing language or global delays (n = 19), and (4) evaluated and diagnosed with autism or PDD–NOS (n = 39). It is notable that, in this sample, 56% percent of children who are found to be at risk based on the initial screen were not followed up beyond the telephone interview, because the children no longer showed at-risk scores on the M-CHAT telephone interview. This suggests that eliciting details and examples of the child's behaviors from parents reduces the false-positive rate of the M-CHAT screen and is a critical follow-up to the initial parent-report M-CHAT.

The 4 categories (children not followed up, those who received the telephone interview but not an evaluation,

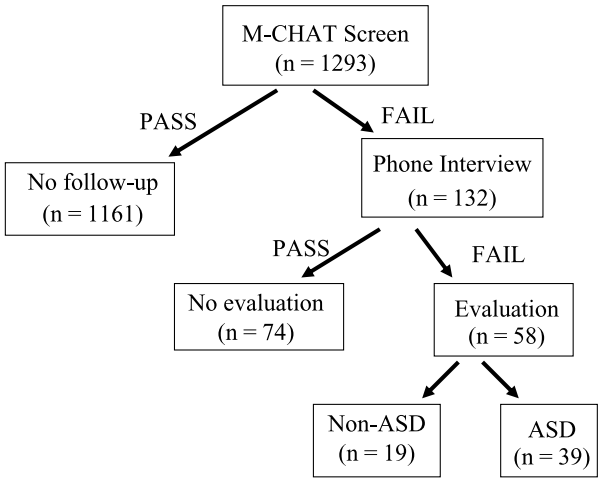

FIGURE 1. Flowchart of screening procedure in Robins et al.[61]

those who were evaluated and diagnosed with non-ASD difficulties, and those evaluated and diagnosed with ASD) were further compared using analysis of variance and Tukey's post hoc tests. Results indicated significant differences between groups on all summary variables (all 23 items of the M-CHAT, 9 items of the CHAT, and 6 critical items as determined by DFA). Internal reliability for the entire checklist and for the 6 critical items was found to be adequate (Cronbach's alpha = 0.85 and 0.83, respectively). All of the M-CHAT items significantly differentiated between children with ASD and other developmental or language disorders, except items (1) ''Does your child enjoy being swung, bounced on your knee, etc.?'' and (16) ''Does your child walk?'' These items represent motor skills that are usually intact in children with ASD and were not expected to differentiate ASD from non-ASD. The DFA correctly classified 99% children as non-ASD or ASD based on M-CHAT data alone.

The PDDST-II[62] consists of 3 stages designed for use in different clinical settings. The PDDST-II Stage 1 (22 items, 2-choice response) was developed for Level I screening in primary care settings with children aged 12 to 48 months. The manual[62] reports sensitivity of 0.92 and specificity of 0.91 based on a sample of 937 children (681 suspected of having an ASD and 256 suspected of non-ASD delays). The other 2 stages of the PDDST-II are considered to be Level II screening instruments. Stage 2 consists of 14 items, developed for use in developmental clinics; sensitivity and specificity are reported in the manual as 0.73 and 0.49, respectively. Stage 3 consists of 12 items for use in autism-specific clinics; sensitivity and specificity are reported in the manual as 0.58 and 0.60, respectively. Psychometric properties from large-scale studies with Level I or II samples have not yet been published in peer-reviewed journals.

The STAT[16,63] consists of a 20-minute play-based interactive session, designed to differentiate autism from other developmental delays in 24- to 35-month-old children already identified as being at risk (Level II); it is not designed to detect broader ASD. There are 12 scored items assessing 4 domains which do not require language comprehension (play, requesting, directing attention, and motor imitation). Results based on a sample of 52 children (26 with autism and 26 with non-ASD delays)[63] indicated sensitivity of 0.92 and specificity of 0.85. In a sample of 82 children (50 with autism and 39 with non-ASD delays),[63] concurrent validity with the Autism Diagnostic Observation Schedule was high (kappa = 0.95); concurrent validity with a smaller sample of children matched on mental age (n = 24) was also high (kappa = 0.92).

FURTHER RESEARCH INVOLVING THE CHAT AND M-CHAT

The Checklist for Autism in Toddlers (CHAT) and Modified Checklist for Autism in Toddlers (M-CHAT) have been used by independent research groups. Scambler et al[65] used the CHAT as a Level II screen in a chronologically older sample (two to three years old, mean age 33 months) of 44 children referred for developmental delay (DD). Sensitivity and specificity for autism were calculated using 3 scores: the original CHAT high-risk score[1] (failure of parent report of pretend play and protodeclarative pointing and observation of impaired gaze monitoring, pretend play, and protodeclarative pointing), original CHAT medium-risk score (failure of protodeclarative pointing both by parent report and observation and 1 or more of the items pertaining to pretend play or gaze monitoring), and the Denver Criteria, developed post hoc during this study (failure of pretend play *or* protodeclarative pointing by parent report and observation of impaired protodeclarative pointing). Sensitivity was reported at 46% using high-risk criteria, 65% using the medium-risk criteria, and 85% using the Denver Criteria. All 3 scoring systems resulted in 100% specificity (i.e., no false positives were identified). The children with autism who were not identified by the Denver Criteria had mental ages above 24 months, suggesting that the CHAT may be less sensitive in children who are developmentally 2 years or older. Furthermore, because the criteria were developed on the sample under study, cross-validation is needed.

Wong et al[66] translated the M-CHAT and CHAT into what they refer to as traditional Chinese to form the CHAT-23. The instrument contains the 23 parent-report items from the M-CHAT, with a unique 4-choice response subsequently collapsed into yes/no, and the 5 observation items from the CHAT. In a sample of 212 children (87 with ASD and 125 non-ASD [67 of whom had non-ASD delays and 58 were typically developing], mental age 18–24 months, chronological age 16–86 months), they identified cutoff scores and critical items similar to those found by Robins et al.[61] In fact, 5 of their 7 critical items (*imitation*, pretend play, *protodeclarative pointing*, social referencing, *showing to parent*, *following a point*, and *interest in peers*) overlap with those identified as critical items by Robins et al. Based on their results, the authors recommend using the CHAT-23 in 2 stages: initial administration consisting of the 23 parent-report items, and follow-up with the 5 CHAT observations for children found to be at risk for autism based on parent report (failure of any 6 parent-report items or 2 of the 7 critical items). Failure of any 2 observations (excluding observation item 5, block building) indicates risk for autism.

Additional research has also been published based on a subsample of children involved in the ongoing M-CHAT study at the University of Connecticut. Given that the diagnosis of ASD in children younger than 3 years has only become common in recent years, Dixon et al[67] reported on the agreement between the diagnostic tools and *DSM-IV* criteria used in the evaluation of 45 toddlers aged 16 to 31 months. Clinically, many practitioners are reluctant to diagnose a toddler using *DSM-IV* criteria developed with older children in mind. In addition, current diagnostic instruments were developed for use with older children and must be used with caution in children with mental ages below 24 months. A majority of the children in the M-CHAT sample have mental ages below 24 months, and this sample provides a valuable opportunity

to examine the performance of multiple diagnostic instruments when used with such a sample.

It is critical to evaluate current diagnostic instruments in very young children; as screening methods identify children at younger ages, the need for accurate diagnostic tools in toddlers increases. The instruments used include the Autism Diagnostic Interview–Revised (ADI-R)[68] or ADI–Toddler form,[69] the Autism Diagnostic Observation Schedule (ADOS),[70] and the Childhood Autism Rating Scale (CARS).[71] The ADI is considered to be the ''gold standard'' diagnostic interview for autism; however, it was interpreted with caution given that valid administration of the ADI requires the child's developmental age to be 24 months or older. The ADOS requires a nonverbal mental age of 12 months, and the CARS requires a chronological age of 24 months. All 3 measures were compared with clinical judgment, which was based on *DSM-IV*[5] criteria.

High levels of agreement were found among the ADOS and CARS, compared with each other and with clinical judgment; however, agreement between the ADI and other measures, including clinical judgment, was poor. The young children in the study tended to fail to meet ADI criteria for autism in the restricted, repetitive, and stereotyped behavior domain. It is important to note that this domain of functioning is not included in the ADOS algorithm and is not required for a diagnosis of PDD–NOS, if deficits in social relatedness and communication are present. The signs and symptoms in this domain may be the most difficult to apply to very young children because restricted, repetitive, and stereotyped interests and behaviors may emerge later than social and communication deficits, and precursors to these behaviors may not meet the specific criteria outlined in *DSM-IV*.

Another important consideration for many pediatric clinicians is the ability to distinguish the child with a non-ASD DD from those with an ASD. Toward that end, Dixon et al[72] reported on analysis of data collected from all participants (including those evaluated in the original M-CHAT article[61]) who received evaluations based on at-risk scores on the M-CHAT (children with non-ASD delays and children diagnosed with ASD). Although the authors are clear that this is not a representative sample of all children with non-ASD delays, these are children who scored at risk on the M-CHAT between 16 and 30 months, suggesting that they comprise a subset of children with non-ASD delays who show some of the same features seen in children with ASD.

Differentiating between children with ASD and non-ASD diagnoses is challenging, and this study attempted to identify behavioral markers that differentiate non-ASD delays from ASD. All children who received an evaluation as part of the larger M-CHAT study were eligible for this analysis. Of 195 children included in this analysis, 150 received a diagnosis of ASD (in this study, autism and PDD–NOS were not considered separately), 15 received a diagnosis of global DD, and 30 were diagnosed with developmental language disorder (DLD). The DD and DLD groups were combined for most analyses to increase power. Children with non-ASD delays and ASD were compared on measures of cognitive ability, adaptive functioning, and autism-specific symptoms. In addition to significantly greater delay on cognitive and adaptive functioning measures, the children with ASD were found to show greater impairment in social-relatedness skills, particularly in the area of joint attention, as compared with children with non-ASD delays. Participants with ASD also showed greater impairment on selected aspects of communication and play and showed atypical sensory processing relative to the participants with non-ASD diagnoses. The only difference between the DD and DLD samples on the M-CHAT was that parents of children with DD reported that their child did not point to indicate interest significantly more often than parents of children with DLD. Small sample size prohibited more complex comparison between DD and DLD.

CURRENT USE OF THE M-CHAT IN BOTH RESEARCH AND CLINICAL SETTINGS

Given the driving goal of facilitating early intervention by improving the early detection of ASD, the Modified Checklist for Autism in Toddlers (M-CHAT) has been available for research and clinical use since the late 1990s. The caveats are that validation of the instrument is ongoing, and because of the emphasis on sensitivity, a high false-positive rate is expected with the current scoring criteria, particularly when used without the telephone interview. Large-scale cross-validation studies (preferably from multiple sites) are critical to ensure that the M-CHAT can be recommended for clinical use without the need for caveats.

It is notable that several groups are advocating screening in general, and some specifically recommend Level I screening for ASD using the M-CHAT. First Signs (www.firstsigns.org) is a parent-run group dedicated to the improvement of early screening, both broadly and specifically for ASD. Using a state-by-state approach beginning with New Jersey, First Signs has engaged in a campaign to raise awareness about the need for screening and to provide tools to health care providers for doing so since 2001. They have published a kit, available for purchase on their website, which provides information and screening instruments, including the M-CHAT, and a book[73] highlighting the importance of early detection and intervention for ASD. In addition, the Centers for Disease Control has begun a campaign entitled ''Learn the Signs. Act Early,'' which includes distribution of a brochure advocating screening (www.cdc.gov/actearly; 800-CDC-INFO), information cards, fact sheets, and a poster appropriate for a pediatric waiting room.

The authors of the M-CHAT are presently conducting a cross-validation study of the instrument. They are addressing 2 major limitations identified in the first article:[61] (1) analyses combined participants from the unselected population and from the early intervention group, which may have led to inflated results, and (2) most accurate calculation of sensitivity and specificity requires longitudinal data, which was not available at the time of the original study. The current cross-validation study involves

3 separate samples: (1) Level I screening of children at well-child pediatric visits, (2) Level II screening of children referred for evaluation by the statewide early intervention program, and (3) Level II screening of the younger siblings of children already diagnosed with an ASD (a collaborative effort between the University of Connecticut and the University of Washington). Younger siblings offer a unique opportunity to study a high-risk sample; children born into a family with an older child diagnosed with ASD have a dramatically increased likelihood of developing an ASD.[33]

In addition to the ongoing study at the University of Connecticut, a new site has been established at Georgia State University in Atlanta, GA, for Level I screening of children. Emphasis is being placed on ensuring that the sample is diverse, both socioeconomically and ethnoculturally. This is a critical area of study because both represent understudied populations. Although research has found similar prevalence rates of ASD in white, African-American, and other races, children of ''black, younger, or less educated mothers'' were less likely to be diagnosed before school-age, meaning that these children missed the earliest intervention opportunities.[9] Special efforts are being made to increase the diversity at all participating sites through the inclusion of private practices with diverse patient populations and primary care centers serving economically disadvantaged families. To date, more than 5000 children have been screened across these sites (beginning with children screened after the initial validation sample, published in 2001); findings will be reported as soon as power is sufficient. Data from Level I and Level II samples will be analyzed independently; within each level of screening, the psychometric properties of the M-CHAT and its scoring system will be re–evaluated. Of particular interest is whether, in the final analysis, the M-CHAT will continue to show high sensitivity, as pilot data presented at national and international conferences suggest. Further analysis will examine the utility of the *DSM-IV* criteria when applied to a very young sample.

To address the issue of accurate calculation of psychometric properties, a longitudinal design has been adopted. Incorporated in this design are several procedures aimed at identifying missed cases: (1) children are rescreened using the M-CHAT at age 3.5 to 4 years, (2) during rescreening, parents report whether their child has received any diagnoses in the interim, (3) primary care providers are given the opportunity to flag an M-CHAT for children they suspect are at risk for ASD, and (4) all children evaluated at Time 1 are re–evaluated 2 years later to examine diagnostic stability and calculate psychometric properties.

Sensitivity and specificity, using longitudinal data to confirm ASD (i.e., incorporating possible misses from the initial M-CHAT screening), will be calculated separately for Levels I and II samples. There is always a balance between sensitivity and specificity; to maximize one value, the other value is likely decreased. The authors of the M-CHAT maintain that maximizing sensitivity is critical for 2 reasons. First, to optimize long-term prognosis, early identification and early intervention are essential. Second, although false-positive screening cases do not have an ASD, most children, to date, show significant delays warranting intervention (e.g., language delay); therefore, overidentification with the M-CHAT is preferable to underidentification.

Three aspects of scoring for Levels I and II screening will be evaluated using the longitudinal data: (1) determination of the optimal cutoff score(s) to maximize sensitivity without unduly compromising specificity and positive predictive power, (2) determination of whether there is a subset of items that adds to the sensitivity of the instrument (i.e., critical items), and (3) if so, empirical derivation of the critical items that best discriminate participants with ASD from those with a non-ASD diagnosis. It is possible that these analyses will indicate that different cutoff scores should be used with Level I (i.e., well-child care visits) and Level II samples (i.e., siblings of children diagnosed with ASD or children referred for evaluation). Ideally, these revisions will decrease the need for the structured follow-up interview allowing the M-CHAT to be used with ease within a primary care physician's busy practice. In addition, the items most frequently requiring clarification may be revised or removed from the M-CHAT.

Such widespread use in different patient populations will be informative and may lead to further revisions not only of the instrument itself, but also its administration and scoring. It is hoped that the M-CHAT will be incorporated into the screening conducted during the 18- or 24-month well-child care visit. However, given that the majority of children are not at risk for ASD, it may be most effective when used in combination with other screening techniques. For example, an upcoming study intends to examine the ASD-specific sensitivity of the Parent's Evaluation of Developmental Status (PEDS)[55] to determine whether use of the M-CHAT should be administered concurrently to maximize sensitivity, or only following an at-risk score on the PEDS to differentiate ASD risk from general risk of developmental difficulties, to provide appropriate ASD-specific referrals.

Other future directions include screening children younger than 16 months to determine whether screening is effective in an even younger sample. Retrospective[25,74] and prospective research[32] suggests that some children with ASD show symptoms much younger than the current M-CHAT screening age; it will be important to evaluate whether a brief screening instrument is able to accurately identify those children, particularly given that, as the age of screening is lowered, the false-positive rate may increase. Although 1 group suggested that 18 months is too young for screening,[75] most research is focused on identifying ASD as early as possible. It is likely that the M-CHAT's scoring would require adaptation for use in a sample younger than 16 months. However, given the strong call for improved screening techniques in the United States from multiple disciplines involved in the care of very young children, it is anticipated that research investigating earlier screening would be well received.

To date, the M-CHAT appears to be a promising tool for the early detection of ASD. Because cross-validation

is currently underway, practitioners are cautioned when using the M-CHAT to screen clinical samples, particularly without the structured follow-up interview. Research through the University of Connecticut and Georgia State University has used the structured follow-up interview as a telephone interview; however, practicing pediatric clinicians may choose to administer the structured interview clarifying the parent's responses on the M-CHAT during the office visit. It is anticipated that paraprofessionals and medical office staff could learn to use the structured interview with minimal training; the interview provides additional assessment of ASD risk and may assist practitioners in determining appropriate referrals. Pediatric practitioners who see toddlers for well-child care visits are often the only professionals who interact with the children before preschool. Therefore, they are in the best position to engage in screening for ASD and other developmental difficulties, which has become more formalized during the past decade. Screening through primary care providers will facilitate the earliest identification and referral for intervention services for children with ASD.

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Appendix A

M-CHAT

Please fill out the following about how your child usually is. Please try to answer every question. If the behavior is rare (e.g., you've seen it once or twice), please answer as if the child does not do it.

1.	Does your child enjoy being swung, bounced on your knee, etc.?	Yes No
2.	Does your child take an interest in other children?	Yes No
3.	Does your child like climbing on things, such as up stairs?	Yes No
4.	Does your child enjoy playing peek-a-boo/hide-and-seek?	Yes No
5.	Does your child ever pretend, for example, to talk on the phone or take care of a doll or pretend other things?	Yes No
6.	Does your child ever use his/her index finger to point, to ask for something?	Yes No
7.	Does your child ever use his/her index finger to point, to indicate interest in something?	Yes No
8.	Can your child play properly with small toys (e.g. cars or blocks) without just mouthing, fiddling, or dropping them?	Yes No
9.	Does your child ever bring objects over to you (parent) to show you something?	Yes No
10.	Does your child look you in the eye for more than a second or two?	Yes No
11.	Does your child ever seem oversensitive to noise? (e.g., plugging ears)	Yes No
12.	Does your child smile in response to your face or your smile?	Yes No
13.	Does your child imitate you? (e.g., you make a face-will your child imitate it?)	Yes No
14.	Does your child respond to his/her name when you call?	Yes No
15.	If you point at a toy across the room, does your child look at it?	Yes No
16.	Does your child walk?	Yes No
17.	Does your child look at things you are looking at?	Yes No
18.	Does your child make unusual finger movements near his/her face?	Yes No
19.	Does your child try to attract your attention to his/her own activity?	Yes No
20.	Have you ever wondered if your child is deaf?	Yes No
21.	Does your child understand what people say?	Yes No
22.	Does your child sometimes stare at nothing or wander with no purpose?	Yes No
23.	Does your child look at your face to check your reaction when faced with something unfamiliar?	Yes No

Appendix B. Selected items from the structured telephone interview.

4. **You reported that _____ does not enjoy playing peek-a-boo / hide – and –seek. Is this still true?**

If No Longer True > Then your child does enjoy playing peek-a-boo or hide-and-seek?

*If **YES** > **PASS***

*If **NO** or **Sometimes** > **Continue***

If Still True or Sometimes True > Does your child like any games that involve a back – and – forth exchange with another person?

*If **YES** > Please* give me an example

*If **NO** >* What does s/he do if you try to play a game like peek-a-boo or pat-a-cake with him/her?

PASS	**FAIL**
Smiles/laughs_____	Refuses to play _____
Vocalizes pleasure _____	Leaves situation if parent initiates_____
Requests repetition verbally ("more")_____	Not interested in those games_____
Requests repetition non-verbally _____	Cries_____
Initiates game again _____	

*If **YES to any PASS example** > **PASS***
*If **NO** >**FAIL***

6. You reported that _____ does not use his/her pointer finger to point, to ask for something.
Is this still true?

If No Longer True > Then your child does use his/her pointer finger in order to ask for something?

*If **YES** > **PASS***

*If **NO** or **sometimes** > **continue***

If Still True, or Sometimes True > If there is something your child wants that is out of reach, such as a cookie up on a counter, how does he/she get it?

PASS	**FAIL**
Points with index finger____	Reaches for object with whole hand____
Asks for it ____	Leads the parent to the object___
	Just tries to get it himself___

If parent does not give a PASS response, continue.

What if you said "Show me?" Would he/she point at it?

*If **YES** > **PASS***

*If **NO** > **FAIL***