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Adaptive and Maladaptive Behavior in Children with Smith-Magenis Syndrome

Staci C. Martin,[1,2,5] Pamela L. Wolters,[1,2] and Ann C. M. Smith[3,4]

Children with Smith-Magenis Syndrome (SMS) exhibit deficits in adaptive behavior but systematic studies using objective measures are lacking. This descriptive study assessed adaptive functioning in 19 children with SMS using the Vineland Adaptive Behavior Scales (VABS). Maladaptive behavior was examined through parent questionnaires and the Childhood Autism Rating Scale. Cognitive functioning was evaluated with an age-appropriate test. Children scored below average on VABS Communication, Daily Living Skills, and Socialization scales. Learning problems and hyperactivity scales on the Conner's Parent Rating Scale were elevated, and girls were more impulsive than boys. Stereotypic and self-injurious behaviors were present in all children. Cognitive functioning was delayed and consistent with communication and daily living skills, while socialization scores were higher than IQ.

KEY WORDS: Smith-Magenis syndrome; adaptive functioning; social skills; IQ.

Smith-Magenis Syndrome (SMS) is a congenital disorder associated with an interstitial deletion on chromosome 17 (17p11.2), which is related to a specific pattern of physical, behavioral, and developmental characteristics. This syndrome is estimated to be present in 1 in 25,000 children (Greenberg *et al.*, 1991), and is likely under-diagnosed due to an overlap of symptoms with other developmental disorders and a lack of awareness of the disorder in much of the medical community (Smith & Gropman, 2001).

Initially described by Smith *et al.* (Smith *et al.*, 1986; Smith, McGovran, Waldstein, & Robinson, 1982), the syndrome was delineated more fully in later publications that define the complex phenotype (Greenberg *et al.*, 1991, 1996; Potocki, Shaw, Stankiewicz, & Lupski, 2003; Smith & Gropman, 2001). Unique physical characteristics seen in children with SMS include craniofacial anomalies, such as brachycephaly with a flat mid-face, a broad nasal bridge, deep-set eyes, a down-turned mouth, a prominent jaw, short fingers, and short stature (Greenberg *et al.*, 1991; Potocki *et al.*, 2003). An increased risk of certain health conditions, including opthalmological and otolaryngologic problems, cardiac and/or renal/urinary tract abnormalities, and hypercholesterolemia, has been reported as well. Recent data suggest that deletion size does not correlate with the major clinical features of SMS and that the clinical spectrum remains variable even among individuals with the same size (common) deletion (Potocki *et al.*, 2003).

[1] HIV and AIDS Malignancy Branch, National Cancer Institute, Bethesda, MD, USA.
[2] Medical Illness Counseling Center, Chevy Chase, MD, USA.
[3] Medical Genetics Branch, National Human Genetics Research Institute, Bethesda, MD, USA.
[4] Georgetown University Medical Center, Washington, DC, USA.
[5] Correspondence should be addressed to: Staci C. Martin, National Cancer Institute, 9030 Old Georgetown Road, 107, Bethesda, MD 20892-8200, USA; E-mail: martins@mail.nih.gov

A distinct and complex neurobehavioral phenotype has been described in SMS that includes cognitive impairments, stereotypies, maladaptive behaviors, and a chronic sleep disturbance that is associated with an unusual inverted circadian rhythm of melatonin (De Leersnyder *et al*., 2001; Smith, Dykens, & Greenberg, 1998a, 1998b). Deficits in adaptive behavior typically become apparent in late infancy or early childhood and seem to last throughout the lifespan, with a vast majority of adults with SMS being unable to fully care for themselves. One study of adaptive functioning among adults with SMS reported that all participants required some level of supervision; more than half lived with their parents, and the rest lived in residential facilities (Udwin, Webber, & Horn, 2001). Among children, poor adaptive functioning has been described qualitatively, but published objective measurements describing clearly defined patient groups are lacking. A study combining data from teenagers and adults ages 14 to 51 found significant delays in each of the three primary domains of adaptive functioning (Communication, Daily Living Skills, Socialization) as measured by the Vineland Adaptive Behavior Scales (VABS; Dykens, Finucane, & Gayley, 1997).

In addition to delays in the acquisition of adaptive skills, studies suggest that significant behavior problems are common, including temper tantrums, self-injurious behaviors (SIBs), and physical aggression towards others (Greenberg *et al*., 1991). These behavioral difficulties often are significant enough to interfere at least moderately with daily functioning (Finucane, Dirrigl, & Simon, 2001) and sometimes warrant professional intervention. In a small study that examined maladaptive behavior in 10 individuals with SMS (mean age = 27 years, age range 14–51), 80% of the sample was described as "impulsive" and "overactive" on the Reiss Screen for Maladaptive Behavior (Dykens *et al*., 1997). Finucane *et al*. (2001) described patterns of self-injurious behavior among 15 children with SMS (mean age = 6.5 years). Responses to questionnaires administered to parents over the telephone indicated that 87% of the children engaged in hand or wrist biting, and one-fourth to one-half engaged in head banging, hair pulling, and skin picking. Interestingly, some children with SMS engage in head banging or rocking behaviors while falling asleep (Smith *et al*., 1998a).

Some evidence suggests that behavior problems in children with SMS are more severe than those seen in several other genetically disordered populations. For example, Dykens and Smith (1998) compared groups of children with SMS, Prader-Willi Syndrome, and nonspecific intellectual disabilities. Their results showed that the children with Smith-Magenis Syndrome scored significantly higher than the other two groups on a measure of externalizing behavior problems (Child Behavior Checklist; Achenbach & Edelbrock, 1983). In another paper comparing maladaptive behavior among individuals with Prader-Willi, Cri du chat, and Smith-Magenis Syndromes, it was found that individuals with SMS scored higher on scales assessing irritability/agitation and hyperactivity/noncompliance (Clarke & Boer, 1998). These results should be interpreted with caution, however, as no statistical analyses regarding the significance of the findings were reported.

From the available research, some degree of cognitive deficits is invariably present among individuals with SMS. Reports estimate that as many as three-fourths of children with SMS exhibit moderate to severe mental retardation (Udwin *et al*., 2001). Also, it is important to note that significant expressive language delays in early childhood in the presence of maladaptive behaviors can impact reliable cognitive and functional assessment in this syndrome (Gropman, Wolters, Solomon, & Smith, 1999; Smith & Gropman, 2001).

Because of the limited research on cognitive and adaptive functioning in children with SMS, it is helpful to examine what is known about these variables in other developmentally delayed populations. In autistic children, for example, both cognitive and adaptive deficits have been well-documented (Freeman, Ritvo, Yokota, Childs, & Pollard, 1988). Studies have put forth a systematic relationship between cognitive and adaptive functioning in autistic children, with adaptive skills often more impaired than intellectual abilities (Freeman *et al*., 1991). It also has been noted that cognitive functioning is unrelated to the number of maladaptive behaviors reported by parents of children with autism (Freeman *et al*., 1991).

Among children with Asperger's Syndrome (AS), results of several studies have documented cognitive functioning in the normal range, while socialization and daily living skills are described as significantly below average (Szatmari, Archer, Fisman, Streiner, & Wilson, 1995). By contrast, children with Williams Syndrome present with significant impairments in both cognitive and adaptive skills (Greer, Brown, Pai, Choudry, & Klein, 1997). Relative to other developmentally delayed populations, the proportion of moderate to severe mental

retardation among individuals with SMS was higher than for individuals with Prader-Willi Syndrome, and was similar to individuals with Cri du chat Syndrome (Clarke & Boer, 1998). Estimates of impairment were obtained via caregiver report in this study.

Findings from some other developmentally delayed populations have suggested the presence of age and gender differences in behavioral and/or cognitive functioning. For example, autistic boys have been described as higher functioning on measures of receptive vocabulary and visual-motor integration, and have been rated as less socially competent with more stereotypic play behavior than girls (Lord, Schopler, & Revicki, 1982; McLennan, Lord, & Schopler, 1993). Differences in cognitive and adaptive functioning between boys and girls and children of various ages are areas that have not been extensively studied in the SMS population. Among the few studies that have addressed this topic, Dykens and Smith (1998) found no significant age- or gender-related associations with the number of stereotypic and self-injurious behaviors or level of cognitive delay. Another study found a higher rate of self-injurious behavior in older children with SMS compared with younger children (Finucane *et al*., 2001).

Clearly, findings from studies of various developmentally delayed populations indicate that patterns of cognitive and adaptive functioning differ with respect to profiles of strengths and weaknesses and the relationship between these variables. While little is known about the specific pattern of deficits among children with SMS, available descriptions of cognitive and adaptive functioning clearly suggest that these are areas of concern in the families' lives. However, several studies in this topic area combine data from children, adolescents, and adults with SMS, thus obscuring the picture of adaptive functioning in each age group. Other studies describe adaptive functioning in this population without the use of a standardized, validated assessment instrument.

The first goal of this study is to describe the adaptive and maladaptive behavior patterns among children with SMS using reliable, objective assessment tools. The second goal is to examine the relationship between cognitive functioning and adaptive and maladaptive behavior. Since little is known about possible gender or age differences in the SMS population, exploratory analyses were conducted in order to assess for systematic differences based on gender and/or age with respect to the variables of interest.

METHOD

Participants

Children throughout the United States with a confirmed diagnosis of Smith-Magenis Syndrome were eligible to participate in this research study conducted at the National Institutes of Health (NIH) in Bethesda, Maryland. Diagnoses of SMS were confirmed through molecular cytogenetic testing that included fluorescent in situ hybridization (FISH). Participants were consecutively enrolled on an IRB-approved natural history protocol of SMS at the NIH (01-HG-0109) between 1998 and 2003. Parental informed consent was obtained prior to enrollment.

The total sample consisted of 19 children, 10 girls and 9 boys, between the ages of 2 and 12 years (mean age 5.7 years). All were Caucasian, and all were the biological offspring of their current caregivers. The mean level of parental education was 15.7 years, and there was no difference between parents of boys and girls with respect to years of education (*ns*). Also, girls and boys did not differ with respect to mean age (*ns*).

Measures

Cognitive Functioning

Child participants were administered a test of cognitive functioning, either the Bayley Scales of Infant Development – Second Edition (BSID-II; Bayley, 1993), or the Stanford Binet Intelligence Scale – Fourth Edition (SB-IV; Thorndike, Hagen, & Sattler, 1986), depending on their age and ability level. The BSID-II is a developmental measure of cognitive functioning administered to infants and young children up to the age of 42 months. It provides a Mental Developmental Index that is comparable to an IQ score, and has a mean of 100 and standard deviation of 15. Reliability and validity of the BSID-II have been established through numerous studies (Atkinson, 1990). The SB-IV is a widely used measure of cognitive abilities given to individuals between the ages of 2 years, 6 months to 23 years, 11 months. The child's performance on individual subtests yields standard scores on several subscales and a Composite Standard Age Score (SAS) with a mean of 100 and standard deviation of 16. Psychometric properties of the SB-IV are well established (Dacey, Nelson, & Stoeckel, 1999). Three children who were older than the upper age limit for the BSID-II were unable to obtain basal scores on the

SB-IV. For these children, the BSID-II was administered and a ratio IQ was computed. Ratio IQ computations from the BSID-II have been shown to be a reliable indicator of performance on the SB-IV (Atkinson, 1990; Lindsey & Brouwers, 1999). Thus, use of this method in our study was not expected to impact our findings.

Adaptive Behavior

Parents were interviewed with the Vineland Adaptive Behavior Scales (VABS), a structured interview designed to assess domains of adaptive functioning (Sparrow, Balla, & Cicchetti, 1984). Studies confirming the reliability and validity of the VABS have solidified this measure as one of the most widely used assessments of adaptive behavior (Sparrow & Cicchetti, 1985). Data from the Communication, Daily Living Skills, and Socialization scales were included in the analyses for the current study. The Communication Domain is comprised of three sub-domains: Receptive, Expressive, and Written Language. The Daily Living Skills scale includes the Personal, Domestic, and Community sub-domains. The Socialization scale is comprised of the Interpersonal, Play & Leisure, and Coping Skills subdomains.

Maladaptive Behavior

Three self-report questionnaires were administered to the primary caregivers of the children in our study. First, parents completed the Conners Parent Rating Scale (CPRS; Conners, 1989), a 48-item measure designed to assess patterns of behavior problems in children. The caregiver's responses yield T-scores with a mean of 50 and standard deviation of 10 on six subscales: Conduct Problems, Learning Problems, Psychosomatic, Anxiety, Impulsive, and a Hyperactivity Index. The CPRS is a widely used measure of behavioral and emotional functioning in children, and reliability and validity have been well-documented (Conners, Sitarenios, Parker, & Epstein, 1998).

Parents also were administered modified versions of the Stereotypy Checklist (Bodfish *et al.*, 1995) and the Self-Injurious Behavior Checklist (Powell, Bodfish, Parker, Crawford, & Lewis, 1996), two measures assessing the presence of maladaptive behaviors. The Stereotypy Checklist (SCL) is an instrument that asks the caregiver to indicate from a list of stereotypical behaviors those in which their child engages. On the Self-Injurious Behavior Checklist (SBCL), the parent is asked to review a list of self-injurious behaviors (SIBs) and indicate those that their child exhibits. The modified versions of these scales, used in a prior study of individuals with SMS (Dykens & Smith, 1998), include several additional behaviors specific to SMS (e.g., self-hugging, object insertion). An additional subscale was added to each of these measures to assess the severity of the behaviors. This subscale was structured as a 5-point Likert scale, and the parent was asked to indicate how much each behavior interfered with the child's daily functioning (0 = no interference to 4 = extreme interference). The versions of these measures used in our study included 36 behaviors on the SCL, and 11 behaviors on the SBCL. Data from fifteen families were included in analyses, since these measures were finalized following the assessments conducted with the first four families enrolled on the study. For all parent measures, if more than one caregiver was present during the assessment, the parent who typically spent the most time with the child was asked to complete the questionnaires and participate in the VABS interview.

To assess autistic-like behaviors, the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1999) was completed by the examiner after each evaluation. For this scale, the examiner rates the child on 15 maladaptive behavioral items relevant to autism, such as relating to people, imitation, activity level, and nonverbal communication. Items are scored on a scale ranging from 1 (age-appropriate; no abnormality) to 4 (severely abnormal), and a total score is calculated by summing item responses. Possible total scores, which range from 15 to 60, correspond to three categories: Non-autistic (15.0–29.5), Mildly to Moderately Autistic (30.0–36.5), and Severely Autistic (37.0–60.0).

Statistical Analyses

Non-parametric statistics were used since the scores obtained by our patient sample on measures of interest were not normally distributed. The Wilcoxon rank-sum test was used to compare differences between VABS subscales and between CPRS subscales. Spearman correlation coefficients were examined to assess the relationship between scores on measures of adaptive and maladaptive behavior, and cognitive functioning, and to examine whether age-related differences were present on any of the variables of interest. To assess for gender differences, the Wilcoxon rank-sum test or Chi-square tests of

independence were employed depending on whether the dependent variable was continuous or categorical. For analyses involving sub-domains on the VABS, age-equivalent scores were transformed to standard scores to allow for comparisons with other standardized scores (e.g., IQ). In addition, scores on the SB-IV were transformed to have a standard deviation of 15 in order to be consistent with other measures (BSID-II, VABS). Due to the number of analyses performed, alpha was set at .01.

RESULTS

Cognitive Functioning

Of the 19 children in our study, one child demonstrated significant behavioral difficulties during the testing session and a valid assessment of cognitive functioning was not obtained. Thus, IQ scores are reported for the 18 remaining children. A vast majority of children were functioning considerably below average (mean IQ score = 62.5 ± 14.4), with IQ scores ranging from 39 to 84. Based on classifications outlined in the Diagnostic and Statistical Manual of Mental Disorders—Fourth Edition (DSM-IV; American Psychiatric Association, 1994), 67% ($n = 12$) of children in our sample met criteria for either mild ($n = 6$) or moderate ($n = 6$) mental retardation. An additional 28% ($n = 5$) fell in the Borderline range of intellectual functioning, and 6% ($n = 1$) scored in the Low Average range of cognitive ability. There were no significant gender differences or age-related effects with respect to IQ ($ps > .01$).

Adaptive Behavior

Based on parent interviews with the VABS, children in our sample were functioning significantly below average in all areas of adaptive functioning. Mean scores on the Socialization subscale (mean = 70.0 ± 13.3) were significantly higher than scores on the Communication (mean = 62.5 ± 15.8) and Daily Living Skills (mean = 54.9 ± 13.5) subscales ($ps < .01$). Communication scores were higher than Daily Living Skills scores, but this difference did not reach statistical significance ($p > .01$). No significant gender differences were revealed on any of the VABS domains ($ps > .01$). However, the child's age was inversely related to Daily Living Skills ($r = -.68$, $p < .001$). Thus, proficiency with activities of daily living seemed to get worse in comparison to age-related peers as chronological age increased.

An examination of standard scores based on VABS sub-domain age equivalents provides a similar picture as that revealed from the primary domains. Children's mean scores were well below average on all sub-domains, and no gender or age-related differences were present (all $ps > .01$).

Maladaptive Behavior

Conner's Parent Rating Scale

As shown in Table I, parent responses on the CPRS indicated the presence of significant elevations, defined as having a T-score greater than or equal to 70, on the Learning Problems (mean = 81.4 ± 13.1) and Hyperactivity (mean = 70.5 ± 14.0) scales. These subscale scores were significantly higher than the remaining four subscales ($ps < .01$), and the mean Learning Problems score was significantly higher than the mean score on the Hyperactivity Index ($p < .001$). Mean scores on the Impulsivity Scale were not significantly higher than the Psychosomatic scores ($p > .01$), but were significantly higher than scores on the Anxiety and Conduct Problems scales ($ps < .01$), although each of these four scales were within normal limits.

The mean scores obtained by girls and boys on each of the subscales of the CPRS are displayed in Table I. Analyses revealed a significant gender difference on the Impulsivity subscale. Parent ratings of impulsive behavior for girls (mean = 65.0 ± 13.0) were significantly higher than ratings for boys (mean = 50.5 ± 10.1; $p < .01$). The unexpectedness of this finding led us to wonder if the result was an artifact of the standardization process. That is, perhaps girls with SMS are not actually exhibiting more impulsiveness than boys, but transforming the

Table I. Mean T-scores on the Conners Parent Rating Scale (CPRS)

CPRS subscale[a]	Mean (SD) Total sample	Mean (SD) Boys	Mean (SD) Girls
Conduct	47.9 (10.4)	42.9 (5.2)	52.5 (12.0)
Learning[b]	81.4 (13.1)	81.2 (14.5)	81.6 (12.5)
Psychosomatic	54.9 (14.3)	51.7 (9.5)	56.4 (18.1)
Impulsive[c]	58.2 (13.6)	50.5 (10.1)	65.0 (13.0)
Anxiety	48.1 (7.1)	47.2 (7.6)	48.8 (6.8)
Hyperactivity[b]	70.5 (14.0)	63.0 (9.3)	77.3 (14.4)

[a]CPRS *t*-scores have a mean of 50 and standard deviation of 10.
[b]Subscale mean fell in the clinically elevated range.
[c]Difference between boys and girls significant at .01 level.

raw scores to standard scores may have given the impression of a more impaired level of impulsivity in girls, given the base rates of these behaviors in non-disordered children. To explore this further, we examined the raw scores of the girls and boys in our sample. These raw scores were consistent with the previous finding based on the standard scores. Raw scores on impulsivity also were higher for girls (mean = 7.9 ± 3.4) than boys (mean = 4.0 ± 2.3).

Although the tendency for girls to score higher on the Hyperactivity scale emerged as a nonsignificant trend ($p = .015$), no other gender differences were demonstrated on the remaining CPRS subscales at the .01 level. None of the subscales were related to the chronological age of the child ($ps > .01$).

Stereotypy Checklist

Of the 36 items on the SCL, the number of reported stereotypic behaviors ranged from 6 to 22 (mean = 13.2). The percentages of children who exhibited each stereotypic behavior are reported in Table II. For purposes of simplicity and space in the table, items assessing similar aspects of a particular behavior pattern were combined to create composite items. For example, ''stares closely at objects'' was combined with ''stares closely at hands'' to form one category: ''stares closely at objects or hands.'' Among the most frequently reported stereotypic behaviors were teeth grinding (87%), inserting hands in mouth (87%), and inserting objects in mouth (80%). On the 5-point Likert scale described earlier, parents rated the extent to which present stereotypical behaviors interfered with their child's life. Of these most frequent behaviors, inserting hands and inserting objects in mouth both were rated as interfering at least moderately in the child's life. The remaining stereotypic behaviors reported were described as interfering with the child's functioning only minimally, if at all.

Table II. Number of Children Exhibiting Stereotypic Behaviors ($n = 15$)

Behavior	*N*	%
Grinds teeth	13	87
Inserts hands in mouth	13	87
Inserts objects into mouth	12	80
Covers ears or eyes	10	67
Hugs/squeezes upper body	9	60
Turns book pages repetitively	9	60
Walks on tip-toes	9	60
Flaps, waves, or claps hands	9	60
Purposely drops or throws objects	9	60
Taps or rubs objects or body	8	53
Rocks or sways back and forth	8	53
Stares closely at objects or hands	8	53
Whirls, turns in circles	7	47
Jumps repetitively	6	40
Shouts repetitively (when not upset)	5	33
Smells, sniffs objects	5	33
Rolls, tilts, or turns head	5	33
Immediate or delayed echolalia	4	27
Breathes forcefully	4	27
Wiggles or flicks fingers	3	20
Maintains set body posture	3	20

Self-Injurious Behavior Checklist

Results of the SBCL are summarized in Table III. Of the 11 behaviors listed, the number of SIBs reported ranged from 2 to 9 (mean = 5.4). The most frequently reported SIBs included hitting oneself (93%) and biting oneself (80%). Mean parent ratings for both of these behaviors indicated that they interfered mildly in the child's life. One behavior's mean rating suggested at least a moderate level of interference: ''pulls out finger or toe nails,'' and this behavior was demonstrated by 13% ($n = 2$) of the children in our sample. All other behaviors on the SBCL were described as interfering to a mild extent in the child's life.

Chi-square tests of independence were utilized for determining if any gender differences were present with respect to individual stereotypic and self-injurious behaviors. Results of these analyses indicated that boys engaged in repetitive shouting significantly

Table III. Number of Children Exhibiting Self-injurious Behaviors ($n = 15$)

Behavior	N	%
Hits self	14	93
Bites self	12	80
Hits self against surface or object	8	53
Inserts fingers or objects into other body openings (besides mouth)	7	47
Pulls hair or skin	6	40
Rubs or scratches self	5	33
Pulls hair out	4	27
Hits self with object	4	27
Pokes self in eye	3	20
Pulls out finger or toe nails	2	13
Pulls out teeth	1	7

more than girls ($\chi^2 = 7.27$, $p = .007$). Other nonsignificant patterns revealed the tendencies for girls to engage in staring closely at objects ($\chi^2 = 6.35$, $p = .012$) and pulling out their hair ($\chi^2 = 6.23$, $p = .013$) more than boys.

Childhood Autism Rating Scale

With respect to the evaluator's ratings on the CARS, children obtained a mean total score of 31.3 ± 4.3, indicating that these children's behavioral profiles fall at the low end of the Mild classification of autism. As stated previously, the Mild to Moderately Autistic category ranges from 30 to 36.5. Total scores obtained by our sample of children ranged from 24 to 37, and no gender differences or age-related differences were present ($ps > .01$).

Relationship Between Adaptive Behavior, Maladaptive Behavior, and Cognitive Functioning

Adaptive Behavior and Cognitive Function

As shown in Fig. 1, children's scores on the Socialization scale were significantly higher than their IQ score ($p < .01$), while Communication and Daily Living Skills scores were not significantly different from IQ scores ($ps > .01$). Results of Spearman correlation analyses assessing the relationship between cognitive and adaptive functioning are shown in Table IV. As can be seen in the table, Socialization scores were significantly correlated with IQ ($p < .01$). An analysis of Socialization sub-domains revealed that scores on the Interpersonal Skills and the Play and Leisure subscales were positively correlated with IQ ($ps < .01$), and the relationship between IQ and the Coping Skills sub-domain approached significance ($p < .01$). Scores on the global Communication domain were significantly related to IQ ($p < .01$), and the sub-domains assessing receptive and expressive communication were also positively related to IQ ($ps < .01$). The Written Language sub-domain was not associated with IQ ($p > .01$). IQ scores were not related to the Daily Living Skills domain scores, or to any of the three sub-domains (Personal, Domestic, and Community; $ps > .01$).

Adaptive and Maladaptive Behavior

No relationships between adaptive and maladaptive behavior were evident. Global adaptive behavior domain scores on the VABS were not related to behavior subscales on the CPRS, or to the

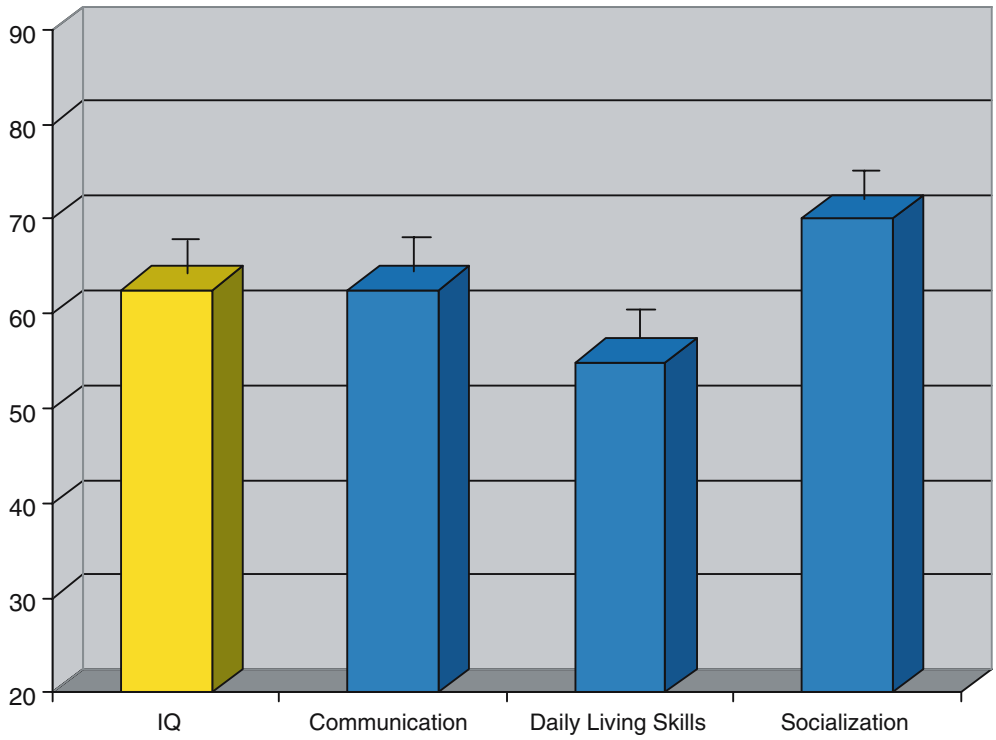

Fig. 1. Mean standard scores on the Communication, Daily Living Skills, and Socialization domains of the Vineland Adaptive Behavior Scales and IQ scores.

Table IV. Spearman Correlations Between VABS Domains Sub-domains and IQ

Domain/Sub-domain	IQ
Communication	.62*
Receptive	.87**
Expressive	.60*
Written	.21
Daily Living Skills	.44
Personal	.35
Domestic	.57
Community	.57
Socialization	.63*
Interpersonal	.63*
Play & Leisure	.64*
Coping Skills	.62

Note. VABS = Vineland Adaptive Behavior Scales.
*$p < .01$, **$p < .001$.

number or severity of stereotypic or self-injurious behaviors reported ($ps > .01$). Analyses of VABS subdomains also showed no significant relationships with CPRS subscales, or the number and severity of behaviors reported on the SCL or SBCL ($ps > .01$). Total scores on the CARS were unrelated to scores on the three VABS subscales ($ps > .01$).

Cognitive Function and Maladaptive Behavior

There were no significant relationships between cognitive functioning and maladaptive behavior. Problem behaviors as indicated on the CPRS were not associated with cognitive abilities ($ps > .01$). Similarly, the number and severity of maladaptive behaviors reported by parents on the SCL and SBCL were unrelated to the child's level of cognitive functioning ($ps > .01$). Finally, total scores on the CARS were unrelated to IQ scores ($p > .01$).

DISCUSSION

This study is the first to provide a thorough description of adaptive and maladaptive behavior based on objective, validated assessment techniques, and their relationship to cognitive functioning specifically among children with SMS. With respect to cognitive functioning, the majority of children in our sample (67%) met criteria for mild or moderate levels of mental retardation (MR), and the range of scores was wide, from severely delayed to the low end of the average range in one child. Compared to another report in the literature (Udwin *et al.*, 2001) in which all child participants were described as mentally retarded, six of the children in our study scored above the cut-off for MR on an objective measure of intellectual abilities. There are several differences between the groups of children assessed in these two studies. The children in Udwin's study were somewhat older than ours, ranging in age from 6 to 16 years with a mean age of 9.3. Also, while Udwin's study reports results from the Wechsler Intelligence Scale for Children—Third Edition (WISC-III; Wechsler, 1991), our children were tested with the BSID-II and SB-IV due to their younger age.

Adaptive functioning among our sample of children with SMS was delayed in all areas. Socialization skills proved to be an area of relative strength, emerging as significantly more developed than daily living skills and communication skills. This is in contrast to results reported by Dykens *et al.* (1997), who found no differences between the three aforementioned areas of adaptive functioning. However, Dykens' study included individuals ranging in age from 14 to 51, so the extent to which age-related changes may have existed in her sample remains unclear. Age was significantly related to daily living skills in our study. Specifically, as the age of the child increased, scores on the daily living skills domain decreased. Thus, acquisition of daily living skills may plateau in children with SMS while peers without SMS continue to gain new skills.

With respect to the relationship between adaptive behavior and cognitive functioning, daily living skills and adaptive communication abilities were consistent with cognitive test results, while socialization skills were significantly higher than IQ scores. This finding points to interesting comparisons between children with SMS and other developmentally delayed populations. Specifically, socialization in autistic children tends to be the area of most notable delay compared to other adaptive behavior areas, and is often significantly lower than IQ (Freeman *et al.*, 1988). In contrast, children with SMS often are described as friendly, affectionate, and outgoing, much like the characteristics of children with Down Syndrome (Loveland & Kelley, 1991). In children with Williams Syndrome, socialization skills have been found to be significantly higher than daily living skills, and yet consistent with IQ (Greer *et al.*, 1997).

Scores from the Communication and Socialization scales of the VABS were significantly related to IQ, while Daily Living Skills scores were not. To date, no other published studies have reported correlations

between objective measures of cognitive and adaptive functioning among the SMS population. Investigations of children with autism have reported inconsistent findings with respect to the nature of the relationship between these variables. While some studies of autistic children have found that all three domains of the Vineland (Communication, Socialization, and Daily Living Skills) were significantly correlated with IQ (Carpentieri & Morgan, 1996; Freeman *et al*., 1988), others have suggested that the relationship depends upon the ability level of the child (Freeman *et al*., 1991; Liss *et al*., 2001). For example, significant correlations between scores on the WISC-R and the three Vineland domains were obtained in a study of 53 children and adolescents with autism (Freeman *et al*., 1991). However, for a subgroup of 13 participants with higher IQ scores (mean IQ = 97.8), only the Communication domain was significantly associated with cognitive level. It is likely that the relationship between cognitive and adaptive functioning differs across populations, so further studies with children with SMS are needed in order to more fully explore these variables and the implications of how they interact.

Of the few studies of children with SMS that include data on adaptive functioning as assessed by the VABS, none have examined the various sub-domains of the scales. Our study found that IQ was correlated with several sub-domains of adaptive functioning within the Communication and Socialization scales, but was not related to any of the Daily Living Skills sub-domains. Regarding the Communication scale, receptive and expressive communication were related to cognitive functioning in our study, but written communication was not. Items on the Written Communication sub-domain are geared toward children beginning at age 5, while the suggested basal age for the Receptive and Expressive sub-domains is less than 1 year. Given the typical ability level of our patient sample, many children reached their ceiling on the Written Communication sub-domain prior to or close to items at the 5-year age level. Thus, this sub-domain may not be developmentally appropriate for our sample and interpretations based on this subscale are limited.

Within the Socialization scale, scores on the Interpersonal Relations and the Play and Leisure sub-domains were correlated with IQ, while scores on the Coping Skills sub-domain were unrelated to IQ. Many items on the Coping subscale are related to the child's ability to inhibit inappropriate behavioral impulses and follow rules. Obviously, the maladaptive behaviors present among children with SMS would interfere with a child's ability to score high on the Coping Skills subscale.

Maladaptive behaviors proved to be a notable problem among the children in our study. Results from the CPRS revealed significant learning problems, which is consistent with test results from the standardized IQ assessments. Hyperactivity was another area of concern indicated by the CPRS, and this validates other published reports characterizing the behavioral phenotype of children with SMS (Dykens & Smith, 1998). Additional maladaptive behaviors commonly reported by parents of children in our study included teeth grinding, insertion of hands or objects into their mouths or other body openings, and self-injurious behaviors in the form of hitting, scratching, and biting.

In another assessment of self-injurious behaviors among children with SMS, Finucane and colleagues (2001) found that 86% engaged in self-biting and 33% in hair-pulling, rates that are similar to our sample. However, 27% of the children in Finucane's study engaged in pulling out fingernails or toenails, compared with only 13% of the children in our sample. In general, the frequencies of SIBs reported in both studies suggest that these behaviors are not an uncommon occurrence among children with SMS.

Examination of stereotypic and self-injurious behaviors indicated that several of these behaviors, particularly those involving the child inserting their hands or other foreign objects into their mouth, interfered at least moderately with the child's daily functioning. However, the majority of behaviors, such as hitting and biting oneself, were described by parents as causing only minimal interference. Thus, these data suggest that most children with SMS do not significantly hurt themselves or cause considerable disruption when engaging in these behaviors. The fact that parents did not indicate more of a disruption also may suggest that they have found moderately successful methods for dealing with their child's stereotypic and self-injurious behaviors, thereby decreasing the level of interference that would otherwise be induced by such behaviors.

Despite the fact that children with SMS share a number of behaviors with autistic children (self-injurious behavior, delayed verbal language), results of the CARS emphasized the apparent differences between the two disorders, such as the contrast in socialization skills discussed previously. Children in our study typically fell at the low end of the Mildly Autistic classification category, suggesting that the

general behavioral presentations are not as similar as some might think. Thus, it is essential to consider a diagnosis of SMS and a genetic assessment in children who present with SIBs and lack of verbal language, especially if they have adequate social skills. Nonetheless, it is important to note that our study lacks an actual comparison group of autistic children. Any conclusions made regarding similarities and differences between the SMS and autistic populations should be interpreted with caution. Further studies are needed that directly compare children with SMS and Autistic Disorder.

The presence of maladaptive behaviors, as assessed by the CPRS, SCL, SBCL, and CARS, was independent of both adaptive functioning and cognitive functioning in this group of children with SMS. The lack of relationship between cognitive functioning and maladaptive behavior is in accordance with results in the autism literature (Freeman *et al*., 1991), although a prior report on children with SMS suggested that the prevalence of SIBs was positively related to intellectual functioning (Finucane *et al.,* 2001). The fact that Finucane's study assessed cognitive impairment via parent report through a telephone interview while our study used objective test scores may be a contributing factor to this difference. A lack of a significant relationship between adaptive and maladaptive behavior is not a unique finding among children with developmental disabilities. A review of other populations reveals that adaptive and maladaptive behavior have been found to be unrelated to each other in children with Fragile X and Down Syndrome (Fisch *et al.,* 1999), both of which are populations with cognitive and developmental delays.

Results of our exploratory analyses examining gender differences in our sample revealed that girls were described as more impulsive than boys. This is an interesting finding given the historical tendency for boys to display more impulsivity than girls, both in normal (Cote, Tremblay, Nagin, Zoccolillo, & Vitaro, 2002) and Attention Deficit Hyperactivity Disorder (Newcorn *et al*., 2001) populations. The only other significant gender difference to emerge in terms of individual maladaptive behaviors in our study suggested that boys with SMS engage in more repetitive shouting than girls. While little is known about variations in patterns of behavior among girls vs. boys in the SMS population, there is preliminary evidence based on animal models from a recent study examining behavior in mice that were genetically engineered to have the p11.2 deletion on chromosome 17 (Walz *et al*., 2004). Results indicated that male SMS mice exhibited hypoactivity compared with wild-type mice, but this difference in activity level was not seen in female mice with the SMS deletion. It is premature to draw conclusions about implications for humans with SMS, but these results would be consistent with our findings of girls being more impulsive (and hyperactive at a non-significant level) than boys. Studies comparing gender differences in children with SMS are sorely needed. In fact, in a review article by Thompson, Caruso, and Ellerbeck (2003), the authors perceptively make the point that an astoundingly small proportion of studies of individuals with developmental disabilities consider possible gender differences in their samples. Thus, despite the findings presented here, there is a clear need for more research in this area before definitive conclusions can be drawn regarding any systematic gender differences in the SMS population.

An inherent limitation of descriptive research lies in the lack of a control group. As previously noted, the purpose of this study was to describe patterns of adaptive and maladaptive behavior among children participating in a natural history study of SMS. Our findings should be viewed in this context. Future research goals need to incorporate comparison groups comprised of other developmentally delayed populations as well as non-disordered individuals in order to expand our understanding of the specific nature of SMS. Another limitation of this study was the somewhat small sample size, although it was larger than many that have been published on this population.

Systematic objective longitudinal research to examine the way that cognitive functioning and adaptive/maladaptive behavior changes over time is critically needed. Data from the current study is part of a longitudinal research project that aims to accomplish this goal. Smith-Magenis Syndrome remains a relatively under-diagnosed disorder, and there is much about this syndrome we have yet to fully understand. By gaining a more complete picture of the pattern of strengths and weaknesses in these children, we can begin to design therapeutic interventions in an effort to help them reach their full potential.

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REFERENCES

Achenbach, T., & Edelbrock, C. (1983). *Manual for the child behavior checklist and revised child behavior profile*. Burlington, VT: University of Vermont.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, D.C: American Psychiatric Association.

Atkinson, L. (1990). Reliability and validity of ratio developmental quotients from the Cattell Infant Intelligence Scale. *American Journal on Mental Retardation*, *95*(2), 215–219.

Bayley, N. (1993). *Bayley scales of infant development* (2nd ed.). San Antonio, TX: Psychological Corporation.

Bodfish, J. W., Crawford, T. W., Powell, S. B., Parker, D. E., Golden, R. N., & Lewis, M. H. (1995). Compulsions in people with mental retardation: Prevalence, phenomenology, and comorbidity with stereotypy and self-injury. *American Journal on Mental Retardation*, *100*(2), 183–192.

Carpentieri, S., & Morgan, S. B. (1996). Adaptive and intellectual functioning in autistic and nonautistic retarded children. *Journal of Autism and Developmental Disorders*, *26*(6), 611–620.

Clarke, D. J., & Boer, H. (1998). Problem behaviors associated with Deletion Prader-Willi, Smith-Magenis, and Cri Du Chat syndromes. *American Journal on Mental Retardation*, *103*(3), 264–271.

Conners, C. K. (1989). *Conners' rating scales: Conners' teacher rating scales and Conners' parent rating scales*. Los Angeles, CA: Western Psychological Services.

Conners, C. K., Sitarenios, G., Parker, J. D. A., & Epstein, J. N. (1998). The revised Conners' parent rating scale (CPRS-R): Factor structure, reliability, and criterion validity. *Journal of Abnormal Child Psychology*, *26*(4), 257–268.

Cote, S., Tremblay, R. E., Nagin, D., Zoccolillo, M., & Vitaro, F. (2002). The development of impulsivity, fearfulness, and helpfulness during childhood: Patterns of consistency and change in the trajectories of boys and girls. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *43*(5), 609–618.

Dacey, C. M., Nelson, W. M., & Stoeckel, J. (1999). Reliability, criterion-related validity and qualitative comments of the Fourth Edition of the Stanford-Binet Intelligence Scale with a young adult population with intellectual disability. *Journal of Intellectual Disability Research*, *43*(3), 179–184.

De Leersnyder, H., de Blois, M., Vekemans, M., Sidi, D., Villain, E., Kindermans, C. *et al.* (2001). Beta(1)-adrenergic antagonists improve sleep and behavioural disturbances in a circadian disorder, Smith-Magenis syndrome. *Journal of Medical Genetics*, *38*(9), 586–590.

Dykens, E. M., Finucane, B. M., & Gayley, C. (1997). Brief report: Cognitive and behavioral profiles in persons with Smith-Magenis syndrome. *Journal of Autism and Developmental Disorders*, *27*(2), 203–211.

Dykens, E. M., & Smith, A. C. M. (1998). Distinctiveness and correlates of maladaptive behaviour in children and adolescents with Smith-Magenis syndrome. *Journal of Intellectual Disability Research*, *42*(6), 481–489.

Finucane, B., Dirrigl, K. H., & Simon, E. W. (2001). Characterization of self-injurious behaviors in children and adults with Smith-Magenis syndrome. *American Journal of Mental Retardation*, *106*(1), 52–58.

Fisch, G. S., Carpenter, N. J., Holden, J. J., Simensen, R., Howard-Peebles, P. N., Maddalena, A. *et al.* (1999). Longitudinal assessment of adaptive and maladaptive behaviors in fragile X males: Growth, development, and profiles. *American Journal of Medical Genetics*, *83*(4), 257–263.

Freeman, B. J., Rahbar, B., Ritvo, E. R., Bice, T. L., Yokota, A., & Ritvo, R. (1991). The stability of cognitive and behavioral parameters in autism: A twelve-year prospective study. *Journal of the American Academy of Child & Adolescent Psychiatry*, *30*(3), 479–482.

Freeman, B. J., Ritvo, E. R., Yokota, A., Childs, J., & Pollard, J. (1988). WISC-R and vineland adaptive behavior scale scores in autistic children. *American Academy of Child and Adolescent Psychiatry*, *27*(4), 428–429.

Greenberg, F., Guzzetta, V., Montes de Oca-Luna, R., Magenis, E., Smith, A. C. M., Richter, S. F. *et al.* (1991). Molecular analysis of the Smith-Magenis syndrome: A possible contiguous-gene syndrome associated with del(17)(p11.2). *American Journal of Human Genetics*, *49*(6), 1207–1218.

Greenberg, F., Lewis, R. A., Potocki, L., Glaze, D., Parke, J., Killian, J. *et al.* (1996). Multi-disciplinary clinical study of Smith-Magenis syndrome (deletion 17p11.2). *American Journal of Medical Genetics*, *62*(3), 247–254.

Greer, M. K., Brown, F. R., Pai, G. S., Choudry, S. H., & Klein, A. J. (1997). Cognitive, adaptive, and behavioral characteristics of Williams Syndrome. *American Journal of Medical Genetics*, *74*(5), 521–525.

Gropman, A., Wolters, P., Solomon, B., & Smith, A. C. M. (1999). Neurodevelopmental assessment and functioning in five young children with Smith-Magenis Syndrome (SMS) [Abstract]. *The American Journal of Human Genetics*, *65*(4), A151.

Lindsey, J. C., & Brouwers, P. (1999). Intrapolation and extrapolation of age-equivalent scores for the Bayley II: A comparison of two methods of estimation. *Clinical Neuropharmacology*, *22*(1), 41–53.

Liss, M., Harel, B., Fein, D., Allen, D., Dunn, M., Feinstein, C. *et al.* (2001). Predictors and correlates of adaptive functioning in children with developmental disorders. *Journal of Autism and Developmental Disorders*, *31*(2), 219–230.

Lord, C., Schopler, E., & Revicki, D. (1982). Sex differences in autism. *Journal of Autism and Developmental Disorder*, *12*(4), 317–330.

Loveland, K. A., & Kelley, M. L. (1991). Development of adaptive behavior in preschoolers with autism or Down syndrome. *American Journal of Mental Retardation*, *96*(1), 13–20.

McLennan, J. D., Lord, C., & Schopler, E. (1993). Sex differences in autism. *Journal of Autism and Developmental Disorder*, *23*(2), 217–227.

Newcorn, J. H., Halperin, J. M., Jensen, P. S., Abikoff, H. B., Arnold, E., Cantwell, D. P. *et al.* (2001). Symptom profiles in children with ADHD: Effects of comorbidity and gender. *Journal of the American Academy of Child & Adolescent Psychiatry*, *40*(2), 137.

Potocki, L., Shaw, C. J., Stankiewicz, P., & Lupski, J. R. (2003). Variability in clinical phenotype despite common chromosomal deletion in Smith-Magenis syndrome [del(17)(p11.2p11.2)]. *Genetics In Medicine*, *5*(6), 430–434.

Powell, S. B., Bodfish, J. W., Parker, D. E., Crawford, T. W., & Lewis, M. H. (1996). Self-restraint and self-injury: Occurrence and motivational significance. *American Journal on Mental Retardation*, *101*(1), 41–48.

Schopler, E., Reichler, R. J., & Renner, B. R. (1999). *The childhood autism rating scale (CARS)*. Los Angeles: Western Psychological Services.

Smith, A. C. M., Dykens, E., & Greenberg, F. (1998a). Behavioral phenotype of Smith-Magenis syndrome (del 17p11.2). *American Journal of Medical Genetics*, *81*(2), 179–185.

Smith, A. C. M., Dykens, E., & Greenberg, F. (1998b). Sleep disturbance in Smith-Magenis syndrome (del 17 p 11.2). *American Journal of Medical Genetics*, *81*(2), 186–191.

Smith, A. C. M., & Gropman, A. (2001). Smith-Magenis syndrome. In S. B. Cassidy, & J.E. Allanson (Ed.), *Management of genetic syndromes*. Wiley-Liss, Inc.

Smith, A. C. M., McGavran, L., Robinson, J., Waldstein, G., Macfarlane, J., Zonona, J. *et al*. (1986). Interstitial deletion of (17)(p11.2p11.2) in nine patients. *American Journal of Medical Genetics*, *24*(3), 393–414.

Smith, A. C. M., McGovran, L., Waldstein, G., & Robinson, (1982). Deletion of the 17 short arm in two patients with facial clefts and congenital heart disease [Abstract]. *American Journal of Human Genetics*, *34*(6), 179–191.

Sparrow, S., Balla, D., & Cicchetti, D. (1984). *Vineland adaptive behavior scales*. Circle Pines, MN: American Guidance Service.

Sparrow, S. S., & Cicchetti, D. V. (1985). Diagnostic uses of the vineland adaptive behavior scales. *Journal of Pediatric Psychology*, *10*(2), 215–225.

Szatmari, P., Archer, L., Fisman, S., Streiner, D., & Wilson, F. (1995). Asperger's syndrome and autism: Differences in behavior, cognition, and adaptive functioning. *Journal of the American Academy of Child & Adolescent Psychiatry*, *34*(12), 1662–1671.

Thompson, T., Caruso, M., & Ellerbeck, K. (2003). Sex matters in autism and other developmental disabilities. *Journal of Learning Disabilities*, *7*(4), 345–362.

Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). Stanford-Binet intelligence scale (4th ed.) Chicago, Riverside.

Udwin, O., Webber, C., & Horn, I. (2001). Abilities and attainment in Smith-Magenis syndrome. *Developmental Medicine & Child Neurology*, *43*(12), 823–828.

Walz, K., Spencer, C., Kaasik, K., Lee, C. C., Lupski, J. R., & Paylor, R. (2004). Behavioral characterization of mouse models for Smith-Magenis syndrome and dup(17)(p11.2p11.2). *Human Molecular Genetics*, *13*(4), 367–378.

Wechsler, D. (1991). *Wechsler intelligence scale for children* (3rd ed.). San Antonio, TX: Psychological Corporation.