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MATRICS cognitive consensus battery (MCCB) performance in children, adolescents, and young adults

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Abstract

Background—Neurodevelopmental models of schizophrenia suggest that cognitive deficits may be observed during childhood and adolescence, long before the onset of psychotic symptoms. Elucidating the trajectory of normal cognitive development during childhood and adolescence may therefore provide a basis for identifying specific abnormalities related to the development of schizophrenia. The MATRICS Consensus Cognitive Battery (MCCB), which was designed for use in clinical trials targeting cognitive deficits most common in schizophrenia, may provide a mechanism to understand this trajectory. To date, however, there is no performance data for the MCCB in healthy children and adolescents. The present study sought to establish performance data for the MCCB in healthy children, adolescents, and young adults.

Methods—The MCCB was administered to a community sample of 190 healthy subjects between the ages of 8 and 23 years. All MCCB domain scores were converted to T-scores using sample means and standard deviations and were compared for significant performance differences between sex and age strata.

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Contributions

Dr. DeRosse, Dr. Peters, Dr. Burdick, Dr. Gopin, and Dr. Malhotra were responsible for protocol and study design and management of data collection. Dr. Nitzburg and Dr. DeRosse undertook the literature search and statistical analyses of the present study. All authors have contributed to and have approved the final manuscript.

Conflict of Interest

The authors have declared that there are no conflicts of interest in relation to the subject of this study.

Results—Analyses revealed age effects following quadratic trends in all MCCB domains, which is consistent with research showing a leveling off of childhood cognitive improvement upon approaching late adolescence. Sex effects after controlling for age only presented for one MCCB domain, with males exhibiting well-known spatial reasoning advantages.

Conclusions—Utilizing this performance data may aid future research seeking to elucidate specific deficits that may be predictive of later development of SZ.

Keywords

Cognition; Schizophrenia; Pediatric; Neurodevelopment; Neuropsychology

Introduction

The National Institute of Mental Health (NIMH), with the Food and Drug Administration (FDA) and pharmaceutical industry representatives, developed The Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) Consensus Cognitive Battery (MCCB) with a series of sponsored consensus conferences (Nuechterlein et al., 2008). The goal of these efforts was to aid in the development of cognitive-enhancing medications that might target the schizophrenia-related cognitive deficits linked to poor functional outcomes (Green et al., 2004). The MCCB is composed of 10 independently-developed and separately-published tests assessing several cognitive domains. Although each MCCB subtest has been normed on its own, a neurocognitive battery comprised of independently-developed tests can operate differently than the individual tests comprising the battery (Russell et al., 2005). Test-order, practice, and fatigue effects can all change when individual tests become systematically administered within a larger battery. Furthermore, probability for a false-positive score in the abnormal range increases with number of tests administered. Consequently, performance data based on a single test administered alone can be invalid for a test battery (Ingraham and Aiken, 1996). Scores in conceptually-related cognitive domains are also bound to be directly compared in search of deficits, but to accurately make such comparisons, scores must be standardized to the same measurement scale and remain stable across demographic strata (Russell et al., 2005). For these reasons, the MCCB was co-normed to ensure the battery's reliability and validity as a whole.

Although MCCB co-norms are established in healthy adults (Kern et al., 2008) and schizophrenia patients (Green et al., 2008), comparative youth performance data has not yet been established. Assessing youths' MCCB performance is critical given neurodevelopmental models of cognitive change in schizophrenia. Cognitive impairment is a core feature of schizophrenia (Reichenberg, 2010) and deficits may present long before symptom onset (Bilder et al., 2006; Brewer et al., 2005; Cornblatt et al., 2003; Cullen et al., 2010; Lewis and Levitt, 2002; MacCabe, 2008; Reichenberg et al., 2002; Tiihonen et al., 2005). The MCCB has also evidenced sensitivity to cognitive differences between adolescent healthy controls and adolescents with early-onset schizophrenia (Holmén et al., 2010) demonstrating the applicability of administering the MCCB with young populations. Understanding MCCB performance data in youth could provide a much needed mechanism for assessing cognitive trajectories across neurodevelopment, which may be critical to understanding schizophrenia etiology (e.g. at-risk and early onset cohorts) and evaluating childhood schizophrenia treatments.

Our study sought to evaluate MCCB performance in healthy children, adolescents, and young adults, and examine whether performance differs between sexes and age groups. Findings could supply the performance data necessary to correct MCCB scores based on age and sex strata in at-risk and psychiatrically-ill youths. Such data might allow for more precise assessment of the cognitive deficits predating schizophrenia onset.

Methods

Participants

Our sample consisted of 190 healthy volunteers aged 8–23 (mean = 16.55 ± 4.0) recruited by newspaper and Internet advertisements, posted flyers, or personal referrals from the general population in a region bridging urban New York City with suburban Long Island. Age ranges were selected based on a meta-analysis evaluating cognitive age effects in healthy youths (Romine and Reynolds, 2005). Age ranges included 1) 8–11, n=24 (12.6%), 2) 11–14, n=21 (11.1%), 3) 14–17, n=54 (28.4%), 4) 17–20, n=46 (24.2%), and 5) 20–23, n=45 (23.7%) year-olds. Regarding socioeconomic status, n=35 (19.8%) were upper-class, n=64 (36.2%) were upper-middle-class, n=49 (27.7%) were middle-class, and n=29 (16.4%) were lower-middle-class or below; n=13 (6.8%) did not disclose socioeconomic status. For full demographic data, see Table 1. All participants over 18 provided written informed consent; all minors provided assent alongside parental written informed consent to a protocol approved by the Institutional Review Board of North Shore-Long Island Jewish Health System. Participants were excluded if they had a past or present Axis-I diagnosis, active or recent (within the past month) substance abuse, intellectually disability, incidence of head injury with loss of consciousness (for any amount of time), medical illnesses that could affect brain functioning, or were taking medications with known cognitive effects (e.g. psychostimulants, antipsychotics, cholinesterase inhibitors). Adults were excluded if they had first-degree relatives with known or suspected Axis-I disorders. Children were excluded if they had first-degree relatives with known or suspected major depressive disorder, bipolar disorder, or psychotic disorder.

Clinical assessments

To rule out Axis-I disorders, participants over age 16 were administered the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders, Non-Patient Version (SCID-NP; First et al., 1995). Participants under age 16 were administered the Kiddie-Schedule for Affective Disorders and Schizophrenia - Present and Lifetime Version (K-SADS-PL; Kaufman et al., 1997). SCID-NP and K-SADS-PL screeners and diagnostic modules were conducted by licensed psychologists or by trained undergraduate-level or graduate-level research assistants supervised by a licensed psychologist. SCID-NP information was compiled into narrative case summaries and absence of pathology was determined in consensus conferences by two expert diagnosticians. The K-SADS-PL and SCID-NP have demonstrated strong test-retest reliability, with kappa coefficients ranging from 0.67-to-1.00 for K-SADS-PL (Kaufman et al., 1997) and 0.92 for SCID-NP (Stukenberg et al., 1990).

Neurocognitive assessment

MCCB—All MCCB tests were administered except the Mayer-Salovey Emotional Intelligence Test (MSCEIT; Mayer, 2002) because a MSCEIT youth-version had not been adequately validated at the time of data collection. Thus, MCCB subtests fell into six instead of seven domains. Our battery consisted of 9 subtests assessing six cognitive domains, including 1) Processing Speed, measured by the symbol coding subtest of the *Brief Assessment of Cognition in Schizophrenia* (BACS Symbol Coding; Keefe et al., 2004), the *Trail Making Test: Part A* (Trails-A; Army Individual Test Battery, 1944), and *Category Fluency: Animal Naming* (Animal Naming; Spreen and Strauss, 1998), 2) Attention/ Vigilance, measured by the *Continuous Performance Test – Identical Pairs* (CPT-IP; Cornblatt et al., 1988), 3) Working Memory, measured by the spatial span subtest of the

Wechsler Memory Scale, Third Edition (WMS-III Spatial Span; Wechsler, 1997) and *Letter Number Span* (LNS; Gold et al., 1997), 4) Verbal Learning, measured by the *Hopkins Verbal Learning Test – Revised* (HVLT-R; Brandt and Benedict, 2001), 5) Visual Learning, measured by the *Brief Visuospatial Memory Test – Revised* (BVMT-R; Benedict, 1997), and 6) Reasoning and Problem Solving, measured by the *Neuropsychological Assessment Battery* mazes subtest (NAB Mazes; Stern and White, 2003).

Pubertal development—To control influence from sexual development on cognitive performance, the widely-used Tanner stages scale of pubertal development (Tanner, 1962) was administered. This scale asks subjects to look at drawings depicting bodies in various stages of pubertal development and identify their stage, resulting in subscales measuring 1) body structure and 2) pubic hair development.

Data Analysis

MCCB scoring and standardization—Analyses were conducted using the same methodology as Kern et al. (2008) except for the MSCEIT being excluded (see above). The remaining nine MCCB subtests were assessed for normality of their distributions, and notably skewed variables were corrected using logarithmic transformation; only one subscale, Trails-A, was skewed and required this logarithmic transformation. Raw scores were then standardized to T-scores using the full sample of 190 healthy subjects. Scores on Trails-A were also reversed so longer completion times properly denoted weaker performance. Adhering to the Kern et al. (2008) methodology, summary scores were computed for MCCB cognitive domains with greater than one subscale by summing the T-scores of those subscales and standardizing those sums to T-scores. Similarly, the overall composite score for global cognition was computed by summing the T-scores for all nine subtests and standardizing this sum to a T-score. Thus, all MCCB domains were standardized to the same measurement scale (mean=50; standard deviation=10).

Statistical analyses—The sample was analyzed using independent samples t-tests to examine sex differences in MCCB performance and one-way analyses of variance (ANOVAs) to examine MCCB performance differences between age groups. All tests were two-tailed. Cognitive capacity was hypothesized to show a quadratic curve as it increases throughout childhood and levels off into late adolescence (Romine and Reynolds, 2005). Thus for all statistically significant age effects, follow-up polynomial contrasts were analyzed for quadratic trends.

Results

Age effects

One-way ANOVAs showed significant age effects on subjects' performance in all MCCB domains and overall performance on the MCCB (processing speed: $F=34.08$, $df=4, 183$, $p<0.001$; attention/vigilance: $F=37.05$, $df=4, 176$, $p<0.001$; working memory: $F=12.61$, $df=4, 184$, $p<0.001$; verbal learning, $F=3.76$, $df=4, 184$, $p<0.01$; visual learning, $F=4.63$, $df=4, 179$, $p<0.01$; reasoning and problem solving, $F=11.76$, $df=4, 182$, $p<0.001$; overall composite score, $F=27.70$, $df=4, 173$, $p<0.001$). All assumptions for ANOVAs were met except in the verbal learning and visual learning domains, which were both significant on Levene's test (verbal learning: $F=3.06$, $p=0.018$; visual learning: $F=3.00$, $p=0.02$). Thus, two Welch's tests were performed which also found significant age effects (verbal learning: Welch's $F=2.75$, $p<0.05$; visual learning: Welch's $F=3.42$, $p<0.05$), confirming that these ANOVA findings were not merely due to heterogeneity of variances between groups. Post-hoc polynomial contrasts on age groups confirmed significant quadratic trends for all MCCB domains, as cognitive capacities increased throughout childhood and leveled off approaching late adolescence and young adulthood (processing speed: F=19.22, df=1, 183, p<0.001; attention/vigilance: F=8.37, df=1, 176, p<0.01; working memory: F=6.62, df=1, 184, p<0.01; verbal learning, F=3.97, df=1, 184, p<0.05; visual learning, F=9.95, df=1, 179, p<0.01; reasoning and problem solving, F=18.28, df=1, 182, p<0.001; overall composite score, F=26.48, df=1, 173, p<0.001).

The potential impact of adolescent sexual development on cognitive performance was next ruled out using Tanner pubertal stage data (Tanner, 1962). Results found Tanner stages' body structure and pubic hair were not significantly associated with the MCCB overall composite score in the presence of age (Tanner body structure: β=0.76, p=0.435; Tanner pubic hair: β= −0.65, p=0.552; age: β=6.32, p=7.83 × e^{-006}).

Furthermore, to be consistent with Kern et al. (2008), observed age effects were confirmed using regression-based T-scores, which were calculated in line with the regression-based approach of the MCCB computer scoring program. Specifically, regression-based T-scores were generated by regressing age and sex on subtest raw scores to produce predicted values that were subtracted from each subtest raw score before converting to T-scores. Regression-based T-scores are not dependent on sample size as they are generated based upon expected change over time. Since our data included some age groups with small sample sizes, ANOVAs were re-run using regression-based T-scores, which confirmed observed age effects showing quadratic trends. For a full age effects summary, see Table 2 and Figure 1. Table 2 includes two different metrics, with the top half displaying community-sample-based T-scores derived using calculations that are common across all ages and the bottom half displaying regression-based calculations that adjust for age.

Sex effects

Independent samples t-tests evidenced ;only one significant sex difference in test performance: males evidenced significantly higher performance on the reasoning and problem solving task (i.e. NAB Mazes) compared to females (t=3.24, df=2, 181, p≤.001). Given significant age effects across all MCCB domains, a follow-up ANCOVA was conducted to ensure sex effects would remain significant after controlling for age. Indeed, even after controlling for age, males showed significantly higher performance on the reasoning and problem solving domain (F=12.34, df=1, 183, p<0.001). No other significant sex differences were found. For a full sex effects summary, see Table 3.

Discussion

The present study extends data on adults' MCCB performance to include a child, adolescent, and young adult sample. This youth performance data may provide common reference and comparison group when assessing cognitive changes in the development of schizophrenia. Moreover, these data may provide a better understanding of schizophrenia as a neurodevelopmental disorder via future studies of youths using the MCCB's targeted assessment of cognitive domains impacted by schizophrenia.

A primary finding was that significant MCCB performance differences were found between age groupings. Specifically, performance in all MCCB domains followed quadratic trends, where scores tended to show marked cognitive improvement in childhood, followed by mild cognitive improvement in early adolescence, and a leveling-off for subjects in late adolescence and early adulthood. These age effects are consistent with past meta-analytic research showing strong cognitive improvement during childhood, moderate improvement in adolescence, and only slight improvement in late adolescence and young adulthood (Romine and Reynolds, 2005).

In addition, even after controlling for age, males performed significantly better than females on the reasoning and problem solving domain of the MCCB, which consists of a timed task requiring subjects to complete increasingly difficult mazes. This finding is consistent with past research showing cognitive advantages for males on spatial reasoning tasks (Geary et al., 2000), which perhaps conferred an advantage for our male subjects when tasked with completing mazes.

Our study was limited by a relatively small sample size of 190 subjects. In addition, unlike the original Kern et al. (2008) study, our study did not use a scientific sampling method but rather recruited subjects using posted flyers and advertisements. Collecting a community sample may have contributed to some ways our sample differed from the population-at-large, including somewhat smaller N's in our younger age groups and that our sex distribution varied somewhat across age groups (ranging from 46.3% to 62.2% female). Our study also had smaller samples of 8–11 and 11–14 year-olds and a disproportionate number of African-Americans in the 8–11 year-old age group. Due to these limitations, our study may have been subject to sampling bias and small sample size, making results less generalizable than studies with scientific sampling methods and larger, more geographically-diverse samples that are more representative of the population-at-large. Follow-up studies are therefore needed to examine MCCB performance in larger and more geographically diverse samples, with particular focus on 8–11 and 11–14 year-olds. However, age effects were confirmed with regression-based T-scores, which helped attenuate the limitation of small sample size. Moreover, evaluating MCCB performance in youth remains critically important, and our study's sampling method, sampling distribution, and sample size are comparable to (and regarding sample size, in some cases larger than) past studies aimed at establishing child performance data on neuropsychology tests or extending neuropsychological tasks to include younger age ranges (Courtney et al., 2003; Epsy and Cwik, 2004; Luciana and Nelson, 2002; Piper et al., 2010).

While the MSCEIT was excluded from our study, the BACS Symbol Coding, NAB Mazes, WMS-III Spatial Span, and LNS tasks, also lacked norms for subjects under age 16 but were still included. This decision was based on our assessment of each task's complexity or the extent of the task's similarity to other validated measures. Specifically, the BACS Symbol Coding and LNS tasks are nearly identical to the validated Digit-Symbol Coding and Letter-Number Sequencing tasks of the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler, 2003). In addition, instructions for NAB Mazes and WMS-III Spatial Span were judged to be easily comprehended by children, as NAB Mazes asks subjects to complete timed mazes while WMS-III Spatial Span asks subjects to touch blocks in the same order as the examiner and then in reverse order. This is quite different from the MSCEIT requiring subjects have the ability to envision adult life scenarios such as engaging in office politics and being cut off in traffic. Thus, although younger children would likely display poorer performance on these cognitive tasks, it was also likely they would be able to understand and adhere to task instructions, whereas the MSCEIT was substantially less likely to be comprehensible for young subjects. Furthermore, past child and adolescent norms were within one standard deviation of our data except for Trails-A, where adolescents were within one standard deviation but 8–13 year-olds showed poorer Trails-A performance compared with 1969, 1994, and 1995 norms (Baron, 2004). However, all our data was within one standard deviation of more recent MCCB performance in a 12–18 year-old control group (Holmén et al., 2010). Regardless, our study is limited by the lack of a social cognition measure, such as the MSCEIT, which negatively impacts the usefulness of the present data in identifying the relative contribution of social cognition to schizophrenia etiology.

Our study may also be limited by statistical issues regarding heterogeneity of variances between groups. Both Verbal Learning and Visual Learning showed significance on Levene's test while examining age effects, and thus effects could have been impacted by differences in N between age groups. Indeed, both these domains had more subjects over versus under age 14 (verbal learning: 8–11 years (n=24), 11–14 years (n=21), 14–17 years (n=54), 17–20 years (n=45), 20–23 years (n=41); visual learning: 8–11 years (n=23), 11–14 years (n=21), 14–17 years (n=51), 17–20 years (n=45), 20–23 years (n=40)). However, two Welch's tests, which do not assume equality of variances, confirmed our age effects. Present data are also congruent with past research suggesting adolescents over age 14 show less cognitive change than younger age groups (Romine and Reynolds, 2005) and thus observed variances between age groups may merely reflect this shift.

We should note our study uses T-scores differently from how they are typically used in other contexts, such as in school settings or during learning disability evaluations. Typically, T-scores are applied in contexts where each individual's performance is being compared against demographically-matched peers; in these contexts, using age as an example, T-scores would typically compare individuals against same-age peers, and thus would be standardized within each age group rather than across all age groups. However, the purpose of our study was assess child and adolescent performance the MCCB by standardizing T-scores across (and not within) all age and sex strata. Thus, participants aged 8–11 displayed "low" T-scores not because they have performance deficits compared to other 8–11 year-olds, but rather because their T-scores are lower compared to older children, teens, and young adults. The same is true for sex strata used in the present study. Thus, to aid future studies and replication efforts, unadjusted means and standard deviations are provided for the raw scores on all MCCB subtests in Table 4.

In summary, these data may provide researchers with the performance data needed for demographic correction of the MCCB with children and teens, which in turn may provide the greater accuracy and specificity needed to pinpoint neurocognitive precursors to schizophrenia across child and adolescent development. Such precursors can assist in early prevention efforts as well as in the assessment of childhood schizophrenia treatments and the development of cognition enhancing psychotropic medications to combat cognitive deterioration in schizophrenia.

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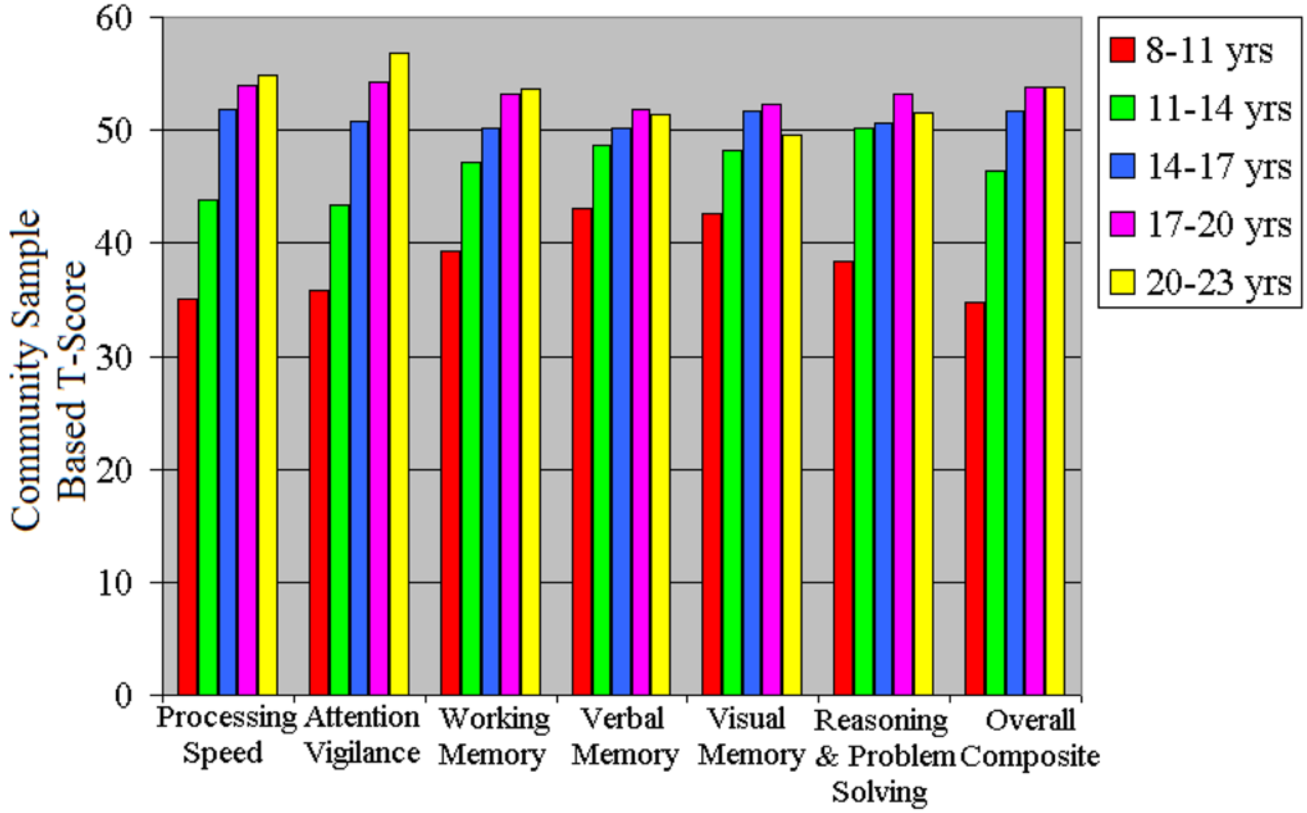

Figure 1.
Age effects on MCCB performance
Note: Community-sample-based T-scores are derived from community sample means and standard deviations.

Table 1

Demographic data by age group

	Age Groups					
	8–11 y (n=24)	11–14 y (n=21)	14–17 y (n=54)	17–20 y (n=46)	20–23 y (n=45)	Total (n=190)
% Female	58.3%	57.1%	46.3%	47.8%	62.2%	53.2%
Ethnicity						
Asian	1 (4.1%)	3 (14.3%)	6 (11.1%)	4 (8.7%)	4 (8.9%)	18 (9.5%)
African-American	8 (33.3%)	5 (23.8%)	11 (20.4%)	11 (23.9%)	7 (15.6%)	42 (22.1%)
Hispanic/Latino	2 (8.3%)	0 (0%)	5 (9.3%)	2 (4.3%)	7 (15.6%)	16 (8.4%)
Caucasian	10 (41.6%)	12 (57.1%)	28 (51.9%)	27 (58.7%)	25 (55.6%)	102 (53.7%)
Other	3 (12.5%)	1 (4.7%)	4 (7.4%)	2 (4.3%)	2 (4.4%)	12 (6.3%)
Socioeconomic Status						
Upper Class	5 (20.8%)	5 (23.8%)	6 (11.1%)	9 (19.6%)	10 (22.2%)	35 (19.8%)
Upper-Middle Class	5 (20.8%)	6 (28.6%)	19 (16.7%)	17 (37.0%)	17 (37.8%)	64 (36.2%)
Middle Class	7 (29.1%)	5 (23.8%)	17 (31.5%)	10 (21.7%)	10 (22.2%)	49 (27.7%)
≤ Lower-Middle Class	7 (29.1%)	4 (19.1%)	8 (14.8%)	4 (8.7%)	6 (13.3%)	29 (16.4%)
Did Not Disclose	0 (0%)	6 (28.6%)	7 (13.0%)	0 (0%)	0 (0%)	13 (6.8%)

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Table 2

Age effects showing quadratic trends on MCCB domains using community-sample-based T scores and regression-based T-scores

	Age Groups: Unadjusted Means (±SD)						
MCCB Community-Sample-Based T-Score	**8–11 (n=24)**	**11–14 (n=21)**	**14–17 (n=54)**	**17–20 (n=46)**	**20–23 (n=45)**	**Statistic**	**p**
Processing Speed	35.11(±8.24)	43.86(±6.51)	51.88(±7.65)	53.92(±7.85)	54.92(±7.62)	F(1,183)=19.22	p<.001
Attention/Vigilance	35.82(±6.91)	43.43(±8.67)	50.79(±6.73)	54.27(±6.69)	56.80(±8.55)	F(1,176)=8.37	p<.01
Working Memory	39.28(±10.95)	47.12(±7.47)	50.23(±8.54)	53.27(±9.61)	53.66(±7.66)	F(1,184)=6.62	p<.01
Verbal Learning	43.08(±12.27)	48.72(±11.05)	50.25(±10.05)	51.90(±7.36)	51.31(±9.03)	F(1,184)=3.97	p<.05
Visual Learning	42.64(±11.84)	48.26(±12.03)	51.66(±8.26)	52.26(±9.07)	49.52(±8.60)	F(1,179)=9.95	P<.01
Reasoning/Problem Solving	38.39(±9.67)	50.12(±10.93)	50.69(±8.82)	53.19(±8.65)	51.59(±8.10)	F(1,182)=18.28	p<.001
Overall Composite	34.72(±9.17)	46.33(±8.27)	51.69(±7.38)	53.86(±7.03)	53.73(±8.12)	F(1,173)=26.48	p<.001
MCCB Regression-Based T-Score							
Processing Speed	44.97(±10.82)	50.28(±7.45)	53.90(±9.39)	51.62(±9.91)	45.88(±9.17)	F(1,182)=21.18	p<.001
Attention/Vigilance	46.51(±8.34)	49.91(±11.68)	53.03(±9.09)	50.78(±8.77)	47.32(±11.47)	F(1,176)=8.84	p<.01
Working Memory	46.92(±12.21)	51.96(±8.78)	51.43(±9.45)	51.01(±10.71)	47.81(±8.65)	F(1,184)=6.66	p≤.01
Verbal Learning	47.37(±12.53)	51.31(±11.48)	51.11(±10.39)	50.94(±7.78)	48.37(±9.15)	F(1,184)=4.14	p<.05
Visual Learning	46.04(±11.83)	50.31(±12.23)	52.50(±8.69)	51.67(±9.39)	47.04(±8.80)	F(1,179)=10.75	p≤.001
Reasoning/Problem Solving	45.06(±10.24)	54.82(±11.75)	51.74(±9.98)	51.22(±8.55)	46.76(±8.64)	F(1,182)=17.55	p<.001
Overall Composite	44.20(±10.24)	52.86(±11.00)	53.52(±8.51)	51.57(±8.46)	45.65(±10.29)	F(1,173)=25.97	p<.001

Note: Community-sample-based T-scores use a calculation that is common across all ages, where scores are derived from community sample means and standard deviations. Regression-based T-scores use a calculation that adjusts for age, where scores are computed by regressing age and sex on subtest raw scores to produce predicted values that are subtracted from each subtest raw score before converting to T-scores.

Table 3

Sex effects on MCCB domains

MCCB T-Scores	Sex: Unadjusted Means (±SD)			
	Male (n=89)	**Female (n=101)**	**Statistic**	**p**
Processing Speed	50.30(±9.51)	49.65(±10.53)	t(2,182)= 0.44	ns
Attention/Vigilance	51.28(±9.78)	49.29(±10.14)	t(2,175)= 1.32	ns
Working Memory	51.23(±10.99)	48.82(±8.78)	t(2,183)= 1.66	ns
Verbal Learning	49.73(±10.38)	49.83(±9.66)	t(2,183)= −0.06	ns
Visual Learning	49.00(±11.04)	50.47(±8.80)	t(2,178)= −0.99	ns
Reasoning/Problem Solving	52.31 (±9.69)	47.62(±9.83)	t(2,181)= 3.24	p≤.001
Overall Composite	51.19(±10.38)	48.86(±9.44)	t(2,172)= 1.55	ns

Note: T-scores were derived from community sample means and standard deviations.

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Table 4

MCCB subtest raw score means by age group and sex

MCCB Raw Scores	Age Groups: Unadjusted Means (±SD)				
	8–11 (n=24)	11–14 (n=21)	14–17 (n=54)	17–20 (n=46)	20–23 (n=45)
BACS Symbol Coding	40.00(±7.64)	51.52(±8.32)	60.58(±8.06)	63.09(±8.48)	64.34(±9.36)
Animal Naming	17.42(±6.09)	20.29(±3.59)	22.07(±4.53)	23.50(±4.81)	23.07(±5.11)
Trail Making Test A*	42.94(±17.74)	34.26(±8.55)	28.08(±9.27)	26.92(±10.79)	25.51(±8.38)
CPT-IP: DPrime Average	1.12(±0.56)	1.74(±0.70)	2.33(±0.54)	2.61(±0.54)	2.82(±0.69)
WMS Spatial Span	13.58(±3.59)	15.10(±2.59)	16.19(±3.05)	16.64(±3.57)	16.83(±2.21)
Letter-Number Span	10.25(±3.35)	13.19(±2.84)	13.87(±2.80)	15.13(±3.01)	15.17(±2.65)
HVLT-R	22.54(±4.93)	24.81(±4.45)	25.43(±4.04)	26.09(±2.96)	25.85(±3.63)
BVMT-R	21.74(±6.77)	24.95(±6.88)	26.90(±4.73)	27.24(±5.19)	25.68(±4.92)
NAB Mazes	12.50(±5.44)	19.10(±6.15)	19.42(±4.96)	20.82(±4.86)	19.93(±4.55)

MCCB Raw Scores	Sex: Unadjusted Means (±SD)	
	Male (n=89)	Female (n=101)
BACS Symbol Coding	57.85(±12.02)	58.72(±11.25)
Animal Naming	22.27(±5.36)	21.50(±5.05)
Trail Making Test A*	28.39(±10.91)	30.95(±12.95)
CPT-IP: DPrime Average	2.37(±0.79)	2.21(±0.82)
WMS Spatial Span	16.21(±3.80)	15.78(±2.55)
Letter-Number Span	14.41(±3.43)	13.48(±3.10)
HVLT-R	25.22(±4.17)	25.26(±3.88)
BVMT-R	25.38(±6.32)	26.22(±5.03)
NAB Mazes	20.33(±5.45)	17.69(±5.53)

* Scores indicate completion times; higher scores denote slower processing speed.