Growing up with autism spectrum disorders: outcome in adolescence and adulthood

Barneveld, P.S.

Author: Barneveld, Petra Suzanne
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CHAPTER 3

Barneveld, P.S., Swaab, H., Van Engeland, H., De Sonneville, L.M.J.
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Cross-sectional evidence for a decrease in cognitive function with age in children with autism spectrum disorders?

Abstract

Background: Autism spectrum disorders (ASD) are associated with early disturbances in brain maturation processes and these interferences presumably have their consequences for the progressive emergence of cognitive deficits later in life, as expressed in intelligence profiles. In this study we addressed the impact of age on cognitive functioning of 6-to-15-year-old children and adolescents with ASD.

Method: Intelligence profiles were measured by the Wechsler Intelligence Scale for Children and compared between four consecutive age cohorts (children aged 6.17-8.03 years, children aged 8.04-9.61 years, children aged 9.68-11.50 years, and adolescents aged 11.54-15.85 years) of 237 high functioning boys with ASD.

Results: The results clearly demonstrated that the global intelligence level was lower in children aged eight years and older, when compared to 6-and-7-year-old children with ASD. This is mostly due to the Freedom From Distractibility factor, suggesting that older children were less able to sustain their attention, they were more distractible, or had more graph motor difficulties. Moreover, an effect of age was also found with respect to the relatively poor performance on the subtest Comprehension when compared to other verbal comprehension subtests, indicating that specifically the impairments in verbal comprehension and social reasoning abilities were more profound in older children when compared to 6-and-7-year-old children with ASD.

Conclusion: Findings of this cross-sectional study showed that it is relevant to take age into account when evaluating the impact of cognitive impairments on intelligence in children with ASD, since the impact of these developmental disorders might be different at different ages.

Introduction

Autism Spectrum Disorders (ASD) are developmental disorders affecting social and communicative abilities with assumed profiles of specific characteristic cognitive functions and dysfunctions. Cognitive functioning in ASD patients is mainly evaluated by the assessment of intelligence profiles in terms of Verbal IQ (VIQ) and Performance IQ (PIQ) scale differences. Since patients with ASD are characterized by marked verbal problems (American Psychiatric Association, 2000), a widespread view is that VIQ is commonly lower than PIQ. Some studies indeed found that PIQ was significantly higher than VIQ in patients with ASD (e.g., Lincoln et al., 1988), however, other studies demonstrated that VIQ did not differ from PIQ in ASD (Verter et al., 1992; Siegel et al., 1996; Manjiviona & Prior, 1999; De Bruin et al., 2006), and some studies reported that discrepancies with VIQ significantly higher than PIQ occur nearly as often (Joseph et al., 2002; Charman et al., 2011). These conflicting results might be explained by the level of overall cognitive ability or by differences in age of assessment. Studies of the effect of overall ability on the VIQ-PIQ discrepancy indeed show that this difference tends to be smaller when general intelligence is higher (Rumsey, 1992). Furthermore, Mayes and Calhoun (2003a) concluded in their cross-sectional study that discrepancies between VIQ and PIQ tend to be smaller in a group of 73 school-aged (6 to 15 years) children with autism when compared to a group of 91 preschool (three to five years) children with autism, suggesting an effect of age. This was observed in both lower IQ (total IQ<80) and higher IQ (total IQ≥80) groups, but the VIQ-PIQ difference was not significant yet at age 6 or 7 years in children with higher IQ's, whereas the VIQ-PIQ gap was closed at a later age (9 or 10 year-old) in children with lower IQ's. These results suggest that the impact of age should be considered when investigating intelligence profiles in ASD. This is in line with cognitive-developmental theories that argue that the identification of deficits in cognitive domains related to psychopathology should be done in consideration of the pattern of hierarchical progression of cognitive abilities consistent with brain maturation processes of the central nervous system (Anderson et al., 2001a).

The VIQ versus PIQ discrepancy might not be the most sensitive way to examine cognitive abilities in ASD, since the prototypic VIQ<PIQ pattern appeared to lack consistency, as argued above, and specificity, as VIQ<PIQ differences are also seen in typically developing children and in language-disordered individuals (Lincoln et al., 1995; Siegel et al., 1996). Instead, analysis of factor profiles might be more suitable to assess intellectual strengths and weaknesses, because factor analytic studies demonstrated that the variance in Wechsler subtest scores are best explained by a three-factor solution (review Kaufman, 1990). Lincoln and colleagues (1995) reviewed studies examining the three factors: Verbal Comprehension (VC), Perceptual Organization (PO), and Freedom from Distractibility (FFD) and reported that de VC factor was depressed relative to the PO factor in individuals with autism. This indicates that persons with ASD have verbal comprehension deficits compared to their more effective visual-perception abilities. However, other studies found that the mean of the FFD factor was significantly lower than the means of the VC and PO factor in high functioning children with ASD, indicating concentration problems, distractibility and graphomotor difficulties as central cognitive problems (Mayes & Calhoun, 2003b; Calhoun & Mayes, 2005; De Bruin et al., 2006). Yet another way to investigate profiles of cognitive peaks and troughs in patients with ASD is analyzing scores at subtest level. Studies examining Wechsler subtest profiles suggest that patients with ASD perform better on tasks that require specific visuo-spatial functions and perform more poorly on tasks requiring verbal comprehension and social reasoning. This specific pattern of information processing is reflected in lower mean scores on the subtest Comprehension compared to the other verbal subtest scores, and higher mean scores on the subtest Block Design compared to the other performance subtests (Asarnow et al., 1987; Shah & Frith, 1993; Happé, 1994; Lincoln et al., 1995; Siegel et al., 1996; Mayes & Calhoun, 2003a; 2004).

At present, studies of the effect of age on different abilities as expressed in intelligence profiles are nonexistent, with the exception of the study by Mayes & Calhoun (2003a). This is remarkable since the comparison of cognitive impairments against age-appropriate expectations is particularly relevant in developmental disorders such as ASD (Anderson et al., 2001a). Currently, it is suggested that ASD is associated with early disturbances in brain maturation processes. This abnormal development is even noticeable in prenatal life (Palmen et al., 2004) and some authors found that this aberrant development continues postnatally with an atypical pattern of acceleration in brain growth as indicated by head circumference, probably due to initial extensive generation of synapses or later inadequate synaptic pruning (Palmen & Van Engeland, 2004; Courchesne & Pierce, 2005). As stated by Anderson

(2001a), such an early interference in maturation of the brain presumably has its consequences for the progressive emergence of cognitive deficits later in life, such as expressed in the intelligence profile. Children with ASD may show different cognitive dysfunctions at different ages based on changing windows of development at different ages and it is important to examine the mechanisms of dysfunction in order to determine expectations for children and adolescents with ASD throughout their development.

The current study is about the impact of age on intellectual development reflected by the Wechsler intelligence profiles in a large sample of 6-to-15-year-old high-functioning children and adolescents with ASD. Differences between VIQ and PIQ scales, between the three factors and subtest profiles are compared between four consecutive age cohorts high-functioning children with ASD. No VIQ-PIQ discrepancies were expected because only high functioning children with ASD were included. Because brain maturational disturbances in ASD were assumed to have a developmental impact, it was expected that the characteristic strengths and weaknesses on factor and subtest level were more profound in older children when compared to younger children.

Methods

Procedure and participants

Participants were selected from consecutive referrals to the patient department of Child and Adolescent Psychiatry at the University Medical Centre Utrecht, the Netherlands, from 1985 until 2004. The medical ethics committee approved the study (number 05-319/K) and written informed consent was obtained according to the declaration of Helsinki. To qualify for this study the participants had to meet the following criteria. At first, a diagnosis of ASD was required. In a case conference two board-certified psychiatrists needed to reach a 100% consensus on diagnosis and classification to insure diagnostic reliability. Semi-structured DSM-focused interviews, observations, medical records, and structured questionnaires (Child Behavior Checklist and Teacher's Report Form) (Achenbach, 1986; 1991) were included in the diagnostic process according to the standards of that period. Secondly, the age range had to be between 6 to 15 years. Thirdly, Full Scale IQ's (FSIQ) were required to be 70 or above, as measured with the Dutch adaptations of the Wechsler Intelligence Scales for Children that were customary at the time of referral (WISC-R or WISC-III) (Wechsler, 1974; 1991). Finally, only male subjects were selected in order to rule out the possibility of interfering gender effects. A total of 237 high-functioning boys with ASD participated in the current study. The patient group was equally divided into four age cohorts by number of patients: children aged 6.17-8.03 years (N=59), children aged 8.04-9.61 years (N=60), children aged 9.68-11.50 years (N=59), and adolescents aged 11.54-15.85 years (N=59) (see Table 1).

Materials

Data of intellectual functioning were available from the assessment at referral with the Dutch adaptations of the Wechsler Intelligence Scale for Children (WISC; Wechsler, 1974; 1991). The WISC-R generates a Full Scale Intelligence Quotient (FSIQ), and the VIQ and the PIQ scale scores. The VIQ scale consists of the subtests Information, Similarities, Arithmetic, Vocabulary, Comprehension, and Digit Span. The PIQ scale consists of the subtests Picture Completion, Picture Arrangement, Block Design, Object Assembly, Coding, and Mazes (Wechsler, 1974). The Kaufman factors include the Verbal Comprehension factor (VC; subtests Information, Similarities, Vocabulary, and Comprehension), the Perceptual Organization factor (PO; subtests Picture Completion, Block Design, Object Assembly, and Mazes) and the Freedom from Distractibility factor (FFD; subtests Arithmetic, Digit Span, and Coding) (Kaufman, 1975). Because different versions of the WISC have been used over the years, comparability is obtained by use of standardized scores only. A total of 223 subjects were assessed by the WISC-R and 14 subjects by the WISC-III.

Statistical analyses

Group differences in FSIQ were analyzed by univariate analysis of variance (ANOVA). Simple contrasts were used for the comparison between FSIQ of the four age groups, with the youngest age group being the reference level. VIQ-PIQ scale differences between the age cohorts were analyzed by a repeated measures ANOVA, with VIQ and PIQ differences as levels of the within subjects factor and the age groups as the between subjects factor. Similarly, differences between the four age cohorts were examined with the factors VC, PO, and FFD as levels of the within subjects factor. For the comparison between the factor means, the factors were contrasted with each other. Simple contrasts were used for the comparison between the four age groups, the youngest age group being the reference level. Finally, differences between the age cohorts were examined on the subtests Comprehension and Block Design, the subtests on which ASD patients characteristically show low and high mean scores, respectively. To investigate these subtest profiles within the VC and PO factors in relation to age, repeated measures ANOVAs were conducted. The differences between the mean scores on the subtest Comprehension and the means of the other subtests belonging to the VC factor (Information, Similarities, and Vocabulary) were used as levels of within subjects factors and age groups as between subjects factor. Similarly, the differences between the mean scores of the subtest Block Design and the means of the other subtests belonging to the PO factor (Picture Completion, Object Assembly, and Mazes) were used as levels of within subjects factors and age groups as between subjects factor. Because intelligence levels of the participants were assessed over a long period of time (between 1985 until 2004) a potential Flynn-effect was accounted for by using year of assessment as a covariate in all analyses. Because the effect of this covariate appeared to be not significant, the analyses were rerun without the covariate. Alpha was set to 0.05 and partial eta squared (η_p^2) was computed to estimate effect sizes (weak effect: η_p^2~0.03; moderate: η_p^2~0.06; large: $\eta_p^2 \geq 0.14$) (Stevens, 1986).

Results

Descriptives

The means and standard deviations of FSIQ, VIQ and PIQ of the four age cohorts are shown in Table 1. A total of 16.5% had a FSIQ score between 70 and 84, 69.2% of the children with ASD had an IQ score within the normal range (FSIQ 85 to 115), and 14.3% had an FIQ score above 115.

FSIQ and the PIQ and VIQ scales

The FSIQ means were significantly different between the four age groups [F(3,233)=3.14, p=.026, ηp^2= .039], and simple contrast analyses showed that the mean FSIQ of the youngest age cohort was significantly higher than the FSIQ means of the three older age cohorts (1st vs. 2nd age cohort: p=.026; 1st vs. 3rd: p=.052; and 1st vs. 4th: p=.004). No significant VIQ-PIQ differences were found (p=.293) and the group by scales interactions were not significant (p=.408) (Table 1).

VC, PO, and FFD factors

Means of the factors are displayed in Figure 1. A significant difference was found between the means of the three factors (F(2,446)=15.94, p<.001, ηp^2= .067) and difference contrast analyses showed that the FFD factor differed significantly from the VC and PO factor (F(1,223)=34.16, p<.001, ηp^2= .133). A significant main effect of age was found (F(3,223)=4.03, p=.008, ηp^2=.051). The mean of the three factors of the youngest age cohort was significantly higher than the means of the three older age cohorts (1st vs. 2nd age cohort: p=.013; 1st vs. 3rd: p=.016; and 1st vs. 4th: p=.001). Moreover, an interaction effect (factors x age groups) was found at trend level (F(6,446)=2.02, p=.062, ηp^2=.026). Visual inspection (see Figure 1) suggests that differences between groups were lowest on Verbal Comprehension and highest on freedom from distractibility. Post-hoc analyses showed that the differences between age groups were highest on the FFD factor when compared to the mean of the VC and PO factor (F(3,223)=2.97, p=.033, ηp^2=.038).

Subtests

Table 2 shows the mean scaled subtest scores and standard deviations of children with ASD in the four age groups.

The means of the subtest Comprehension was significantly lower when compared to the means of the other VC subtests (F(1,232)=46.43, p<.001, ηp^2=.167). An interaction effect of VC subtests (mean of Comprehension vs. mean of the other VC subtests) x age groups was found at trend level (F(3,232)=2.13, p=.097, ηp^2=.028), and simple contrast analyses showed that the difference between the means of the subtest Comprehension and the means of the other VC subtests was larger in the two eldest age groups than in the youngest group (1st vs. 3rd age cohort: p=.080; 1st vs. 4th: p=.018) (see Figure 2).

The means of the subtest Block Design was significantly higher when compared to the means of the other PO subtests (F(1,233)=12.11, p=.001, ηp^2=.049), however, no significant interaction effect (PO subtests difference x four age groups) was found (p=.563).

Table 1. The age range, mean age, and mean and standard deviation of Full scale IQ, Verbal IQ, and Performance IQ of the four age cohorts of the children with ASD.

		Age range	Age		Full Scale IQ		Verbal IQ		Performance IQ	
	N	*Min - Max*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Age group 1	59	6.17 - 8.03	7.26	(.56)	102.93	(13.5)	101.81	(14.2)	103.81	(15.1)
Age group 2	60	8.04 - 9.61	8.78	(.45)	97.08	(13.6)	98.12	(12.6)	96.58	(15.7)
Age group 3	59	9.68 - 11.50	10.51	(.53)	97.80	(15.9)	97.29	(16.3)	98.07	(16.9)
Age group 4	59	11.54 - 15.85	13.27	(1.29)	95.25	(13.9)	94.42	(11.9)	97.25	(15.9)

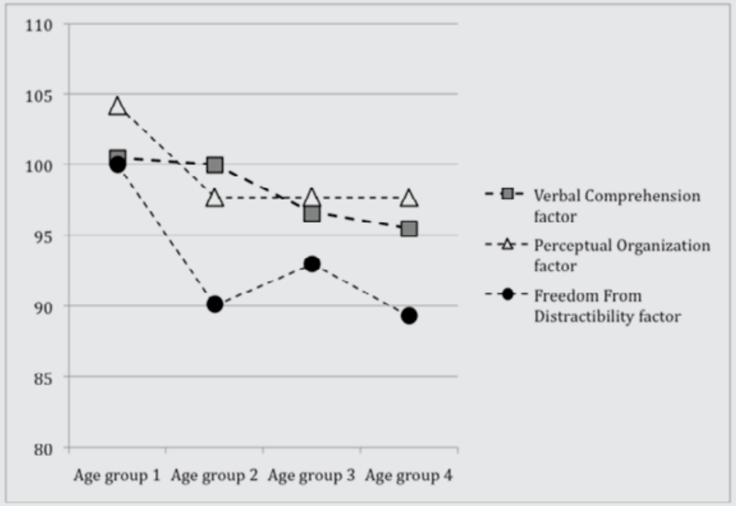

Figure 1. Means of the factors (Verbal Comprehension, Perceptual Organization, and Freedom from Distractibility) of the four age cohorts of the children with ASD.

Table 2. Mean scaled subtest scores and standard deviations of children with ASD in four age groups.

	Age group 1 *N*=59	Age group 2 *N*=60	Age group 3 *N*=59	Age group 4 *N*=59
Subtests VC factor	M (SD)	M (SD)	M (SD)	M (SD)
Comprehension	9.66 (2.5)	9.55 (2.3)	8.54 (2.7)	8.34 (2.1)
Information	10.63 (2.9)	10.35 (3.0)	10.17 (3.3)	9.76 (2.6)
Similarities	10.00 (3.3)	10.40 (2.7)	10.42 (3.3)	10.48 (2.6)
Vocabulary	10.20 (3.3)	9.93 (2.8)	9.41 (3.4)	8.83 (2.5)
Subtests PO Factor				
Block Design	11.33 (3.1)	9.98 (3.4)	10.44 (3.1)	10.77 (3.6)
Picture Completion	10.53 (3.5)	9.53 (3.2)	9.38 (3.2)	9.29 (2.9)
Object Assembly	10.49 (3.3)	9.49 (3.3)	9.60 (3.3)	9.98 (3.9)
Mazes	10.60 (3.1)	10.35 (3.4)	10.56 (3.3)	10.07 (3.1)
Subtests FFD factor				
Arithmetic	10.60 (3.1)	8.98 (3.1)	9.37 (3.6)	9.47 (3.0)
Digit Span	10.34 (3.7)	8.93 (3.3)	9.42 (2.8)	8.12 (2.8)
Coding	9.29 (2.9)	8.03 (3.3)	8.49 (3.2)	7.71 (2.9)

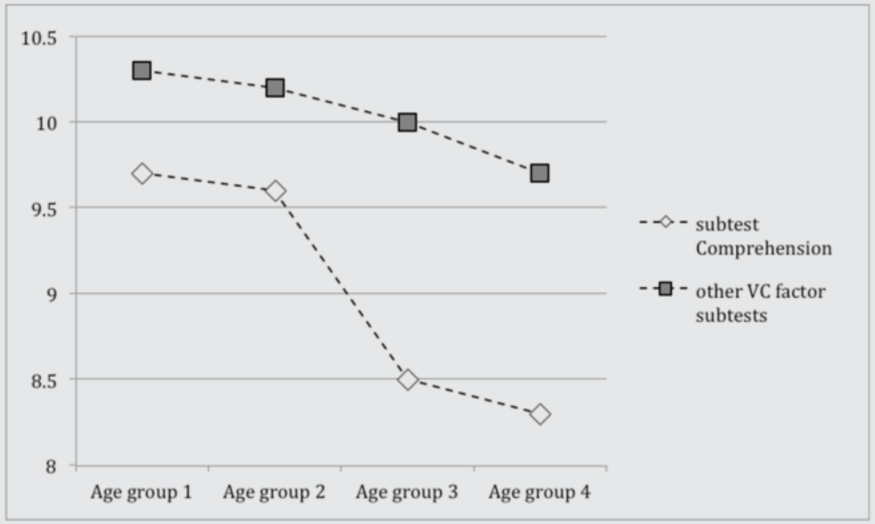

Figure 2. Means of the subtest Comprehension compared to the means of the other Verbal Comprehension (VC) subtests (Information, Similarities, and Vocabulary) of the four age groups.

Discussion

Measurements of cognitive abilities against age-appropriate expectations are highly relevant in studies of developmental disorders such as ASD. In this study we examined the relation between age and intelligence profiles of children and adolescents with ASD in the age range of 6 to 15 years old. The results clearly demonstrate lower general intelligence levels in children aged eight years and older compared to younger children with ASD. Similarly, the analyses of the three factors showed that the FFD factor was relatively lower in children aged eight years and older when compared to 6-and-7-year-old children with ASD. Moreover, an effect of age was also found with respect to the relatively poor performance on the subtest Comprehension, the difference between this subtest and the other VC subtests is larger in the eldest age groups than in the youngest age group.

Although the results have to be interpreted with caution because only cross-sectional data were analyzed and the extent to which IQ scores for individual children with ASD actually decrease with time is not known, the findings suggest a progressive impairment of cognitive functioning in children with ASD. Children from eight years and older have more difficulties to sustain their attention, are more distractible, or have more graph motor difficulties when compared to younger children, as reflected on the differences of the FFD factor. The apparent decline in intelligence around eight years might be associated with a possible absence of the typically expected growth spurt in executive functioning aligned with maturation of the frontal lobe, as seen in typically developing children (Anderson, 2002). Associated with ongoing maturation, children and adolescents may gradually acquire the capacity for more efficient processing, because transmission of nerve impulses is more rapid with increasing myelination of nerve tracks (Anderson et al., 2001b). The development of executive functions might especially be affected in ASD by abnormal growth processes, because of the relatively late and prolonged period of maturation of the putative underlying cortical areas (Courchesne & Pierce, 2005). The impaired development of executive functions might play an important mediating role in the development of intelligence. Furthermore, since executive functions such as attentional control and response inhibition are required when performing tasks of the FFD factor, presumed impairment of executive functions might also contribute to a less harmonious distribution of factor profiles in older children when compared to younger ones.

As expected, no VIQ versus PIQ discrepancies were found in this sample of high functioning ASD children, and there were also no differences between age groups. However, a clear distinction can be made between factor level performances, with relatively better performance on the Verbal Comprehension and Perceptual Organization factors and relatively poorer performance on the Freedom from Distractibility factor. In addition, it was found that children aged eight years and older scored lower on the factors compared to the younger children with ASD. More specifically, the differences between age groups were highest on the Freedom from Distractibility factor. These results suggest that discrimination on the basis of factor profiles is more sensitive when examining the impact of age on intellectual strengths and weaknesses in high-functioning children with ASD than the use of the VIQ and PIQ scales.

When profiles of peaks and troughs in children with ASD were examined at subtest level, this study showed that the patients with ASD performed worse on the subtest Comprehension when compared to the other subtests of the Verbal Comprehension factor. This finding is in correspondence with studies that showed lower mean scores on Comprehension compared to other verbal scale scores (e.g., Siegel et al., 1996; Mayes & Calhoun, 2003b; 2004; De Bruin et al., 2006; Charman et al., 2011). With respect to this subtest, the distinction with the performance on the other VC subtests is larger in the eldest age groups than in the youngest group. This might indicate that specifically the impairments in verbal comprehension and social reasoning abilities are more profound in older children when compared to 6-and-7-year-old children with ASD. Since the ability of social reasoning is believed to be mediated by the frontal regions (Walker & Bollini, 2002), the specific age-effect of performance on Comprehension possibly suggests more profound executive dysfunction in older children with ASD. Typically developing children show increased reasoning and problem-solving abilities and the capacity to think in multiple dimensions at approximately seven years of age (Anderson, 2001b). These executive functions are required for social reasoning as measured by the subtest Comprehension and inefficient acquisition of these skills in children with ASD might result in deviations from expected patterns of development. Besides the characteristic trough in patients with ASD as indicated by the low performance on Comprehension, the typical peak in children with

ASD as indicated by the high performance on the subtest Block Design (e.g., Asarnow et al., 1987; Shah & Frith, 1993; Happé, 1994; Siegel et al., 1996) was also found in this study. The children with ASD scored higher on this subtest when compared to the other subtests of the Perceptual Organization factor, indicating superior abstract visuo-spatial abilities in children with ASD. As described in the weak central coherence theory, the peak of performance on Block Design can be explained as the development of a relatively local, as opposed to global, processing style of children with ASD (Shah & Frith, 1993; Happé, 1994). However, no effect of age was found with respect to abstract visuo-spatial abilities.

In conclusion, findings of this study show that intelligence levels are lower in children aged eight years and older, when compared to 6-and-7-year-old children with ASD, specifically for the FFD factor, indicating difficulties to sustain their attention, higher distractibility, or more graph motor difficulties. Moreover, an effect of age was also found with respect to the relatively poor performance on the subtest Comprehension when compared to other verbal comprehension subtests, indicating that specifically the impairments in verbal comprehension and social reasoning abilities are more profound in older children when compared to 6-and-7-year-old children with ASD. These findings show that it is relevant to take age into account when evaluating cognitive impairments on intelligence in children with ASD, since the impact of these developmental disorders might be different at different ages and become more noticeable later in life. Longitudinal studies are desirable to verify whether or not children with ASD actually have progressive impairments during development, as shown by intelligence profiles.

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