DOCUMENT SUMMARY This 2011 research paper by Soulières et al. investigates the nature of intelligence in individuals with **Asperger syndrome**. It compares their performance on **Wechsler scales** (like FSIQ, VIQ, PIQ) with their performance on **Raven's Progressive Matrices (RPM)**, a key measure of **fluid intelligence**. The study finds that, similar to other autistic individuals, those with Asperger's show a significant advantage on RPM, suggesting that standard intelligence tests may underestimate their true intellectual capabilities.

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FORMATTED CONTENT

The Level and Nature of Autistic Intelligence II: What about Asperger Syndrome?

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Abstract

A distinctively uneven profile of intelligence is a feature of the **autistic spectrum**. Within the spectrum, **Asperger** individuals differ from autistics in their early speech development and in being less likely to be characterized by visuospatial peaks. While different specific strengths characterize different **autistic spectrum** subgroups, all such peaks of ability have been interpreted as deficits: isolated, aberrant, and irreconcilable with real human intelligence.

> This view has recently been challenged by findings of autistic strengths in performance on **Raven's Progressive Matrices (RPM)**, an important marker of general and **fluid intelligence**.

We investigated whether these findings extend to **Asperger syndrome**, an **autistic spectrum** subgroup characterized by verbal peaks of ability, and whether the cognitive mechanisms underlying autistic and **Asperger RPM** performance differ. Thirty-two **Asperger** adults displayed a significant advantage on **RPM** over **Wechsler Full-Scale** and Performance scores relative to their typical controls, while in 25 **Asperger** children an **RPM** advantage was found over **Wechsler** Performance scores only. As previously found with autistics, **Asperger** children and adults achieved **RPM** scores at a level reflecting their **Wechsler** peaks of ability. Therefore, strengths in **RPM** performance span the **autistic spectrum** and imply a common mechanism advantageously applied to different facets of cognition.

> **Autistic spectrum intelligence** is atypical, but also genuine, general, and underestimated.

Introduction

Individuals on the **autistic spectrum** are currently identified according to overt atypicalities in socio-communicative interactions, focused interests and repetitive behaviors. More fundamentally, individuals on the **autistic spectrum** are characterized by atypical information processing across domains (social, non-social, language) and modalities (auditory, visual), raising the question of how best to assess and understand these individuals' intellectual abilities. Early descriptions and quantifications of their intelligence emphasized the distinctive unevenness of their abilities. While their unusual profile of performance on popular intelligence test batteries remains a durable empirical finding, it is eclipsed by a wide range of speculative deficit-based interpretations. Findings of strong performance on specific tests have been regarded as aberrant islets of ability arising from an array of speculated deficits (e.g., "weak central coherence") and as incompatible with genuine human intelligence.

> For example, Hobson concluded that regardless of strong measured abilities in some areas, autistics lack "both the grounding and the mental flexibility for intelligent thought."
>
> Thus, there is a long-standing assumption that a vast majority of autistic individuals are intellectually impaired.

In recent years, this assumption has been challenged by investigations that exploit two divergent approaches represented by **Wechsler scales** of intelligence and **Raven's Progressive Matrices** to measuring human intelligence. **Wechsler scales** estimate IQ through batteries of ten or more different subtests, each of which involves different specific oral instructions and tests different specific skills. The subtests are chosen to produce scores that, for the typical population, are correlated and combine to reflect a general underlying ability. Advantages of this approach include the availability of subtest profiles of specific skill strengths and weaknesses, index scores combining related subtests, and dichotomized Performance versus Verbal IQ scores (**PIQ** vs. **VIQ**), as well as a **Full-Scale IQ (FSIQ)** score. However, the range of specific skills assayed by **Wechsler scales** is limited (e.g., reading abilities are not included), and atypical individuals who lack specific skills (e.g., typical speech processing or speech production) or experiences (e.g., typical range of interests) may produce scores that do not reflect those individuals' general intelligence.

In contrast, **Raven's Progressive Matrices (RPM)** is a single self-paced test that minimizes spoken instruction and obviates speech production or typicality of experiences. The format is a matrix of geometric designs in which the final missing piece must be selected from among an array of displayed choices. Sixty items are divided into five sets that increase progressively in difficulty and complexity, from simple figural to complex analytic items. **RPM** is regarded both as the most complex and general single test of intelligence and as the best marker for **fluid intelligence**, which in turn encompasses reasoning and novel problem-solving abilities. **RPM** tests flexible co-ordination of attentional control, working memory, rule inference and integration, high-level abstraction, and goal-hierarchy management. These abilities, as well as **fluid intelligence** itself, have been proposed as areas of deficit in autistic persons, particularly when demands increase in complexity.

Against these assumptions, we reported that autistic children and adults, with **Wechsler FSIQ** ranging from 40 to 125, score an average 30 percentile points higher on **RPM** than on **Wechsler** scales, while typical individuals do not display this discrepancy, as shown in Figure 1. **RPM** item difficulty, as reflected in per-item error rate, was highly correlated between the autistic and non-autistic children (r=.96). An **RPM** advantage for autistic individuals has been reported in diverse samples. Bolte et al. tested autistic, other atypical (non-autism diagnoses), and typical participants who varied widely in their age and the version of **Wechsler** and **RPM** they were administered; autistics with **Wechsler FSIQ** under 85 were unique in having a relative advantage on **RPM**. Charman et al. reported significantly higher **RPM** than **Wechsler** scores (**FSIQ** and **PIQ**) for a large population-based sample of school-aged **autistic spectrum** children. In Morsanyi and Holyoak, autistic children, who were matched with non-autistic controls on two **Wechsler** subtests (**Block Design** and Vocabulary), displayed a numeric, though not significant, advantage within the first set of Raven's Advanced Progressive Matrices items.

The nature of autistic intelligence was also investigated in an fMRI study. Autistics and non-autistics matched on **Wechsler FSIQ** were equally accurate in solving the 60 **RPM** items presented in random order, but autistics performed dramatically faster than their controls. This advantage, which was not found in a simple perceptual control task, ranged from 23% for easier **RPM** items to 42% for complex analytic **RPM** items. Autistics' **RPM** task performance was associated with greater recruitment of extrastriate areas and lesser recruitment of lateral prefrontal and medial posterior parietal cortex, illustrating their hallmark **enhanced perception**. One replicated manifestation of autistics' **enhanced perception** is superior performance on the **Wechsler Block Design** subtest, suggesting a visuospatial peak of ability. Even when autistics' scores on all other **Wechsler** subtests fall below their **RPM** scores, their **Block Design** and **RPM** scores lie at an equivalent level. Thus, enhanced occipital activity, superior behavioral performance on **RPM**, and visuospatial peaks co-occur in individuals whose specific diagnosis is autism, suggesting an increased and more autonomous role of perception in autistic reasoning and intelligence.

But what about individuals whose specific diagnosis is **Asperger syndrome**? In Dawson et al.'s previous investigations of autistics' **RPM** performance, **Asperger** individuals were excluded. **Asperger syndrome** is a relatively low-prevalence **autistic spectrum** diagnosis characterized by intelligence scores within the normal range (non-**Asperger** autistics may have IQs in any range). Two main distinctions between the specific diagnosis of autism and **Asperger syndrome** are relevant to the question of intelligence in the **autistic spectrum**. First, while their verbal and nonverbal communication is not necessarily typical across development, **Asperger** individuals do not, by diagnostic definition, exhibit characteristic autistic delays and anomalies in spoken language. While both autistic and **Asperger** individuals produce an uneven profile on **Wechsler** subtests, **Asperger** individuals' main strengths, in contrast with those of autistics, are usually seen in verbal subtests (as illustrated in Figure 2). Although **RPM** is often deemed a "nonverbal" test of intelligence, in practice typical individuals often rely on verbal abilities to perform most **RPM** items. Second, at a group level, **Asperger** individuals do not display the autistic visuospatial peak in **Wechsler** scales; rather, their **Block Design** subtest performance tends to be unremarkably equivalent to their **FSIQ** (see Figure 2). The question of whether **Asperger** individuals display the autistic advantage on **RPM** over **Wechsler** is thus accompanied by the possibility that the **Asperger** subgroup represents an avenue for further investigating the nature of this discrepancy.

Our goal was to investigate whether the autistic advantage on **RPM** is also characteristic of **Asperger syndrome** and, further, whether **RPM** performance reveals a fundamental property of

intelligence across the **autistic spectrum**. If the mechanism underlying autistics' advantage on **RPM** is limited to visuospatial peaks or to language difficulties disproportionately hampering **Wechsler** performance, then the advantage should not be found in **Asperger** individuals. Indeed, as predicted by Bolte et al., **Asperger** individuals should perform even better on **Wechsler** scales than on **RPM**. If instead the underlying mechanism is more general and versatile, then **Asperger** individuals should demonstrate at least some advantage on **RPM**. Preliminary findings have suggested this to be the case. In one recent study, **Asperger** children (age 6-12) obtained significantly higher raw scores on **RPM** than did typical children matched on age and **Wechsler** performance.

Figure 1. Performance on the Wechsler Intelligence Scales and Raven's Progressive Matrices by autistic and non-autistic adults (A) and children (B). Adapted from Dawson et al., 2007.

Figure 2. Wechsler subtest profile in Asperger adults and children. Asperger adults are shown in blue and Asperger children in red. INF: Information. SIM: Similarities. ARI: Arithmetic. VOC: Vocabulary. COM: Comprehension. PC: Picture completion. COD: Digit symbol-Coding. PA: Picture arrangement. BD: Block Design. MA: Matrix Reasoning.

Methods

Participants

Asperger participants. The sample included 32 **Asperger** adults (age 16 to 49 years, M=20.8) and 25 **Asperger** children (age 7 to 15 years, M=11.9), whose characteristics are summarized in Table 1. The data for the **Asperger** adults and children were retrieved from the database of the Centre d'excellence en troubles envahissants du développement de l'Université de Montréal. All consecutive individuals who met the diagnostic criteria and had completed both **RPM** and **Wechsler scales** (WAIS-III or WISC-III) were entered in the study. Diagnosis was achieved with the ADI-R, administered to all participants, complemented by the ADOS (module 3 or 4) administered to 51 of the 57 participants, as well as clinical expertise. A diagnosis of **Asperger syndrome** was given if ADI-R scores were above autism thresholds (or a maximum of 2 points under the communication domain threshold) and there was no delayed speech (first single words before 24 months and first phrases before 33 months), echolalia (score of 0, i.e., rarely or never echoes), pronoun reversal (score of 0, i.e., no confusion between first person and second or third person), or stereotyped speech (score of 0 or 1, i.e., speech could be relatively repetitive but not stereotyped in an odd or unusual way), all as measured by the ADI-R. Exclusion criteria were any known genetic or additional neurological conditions.

Non-Asperger control participants. A sample of 39 adults (age 16 to 37 years, M=23.1) and 27 children (age 6 to 16 years, M=11.3) with typical development was recruited through ads in local newspapers. Exclusion criteria were the presence of personal or familial history of psychiatric, neurological or genetic conditions, as assessed in a semi-structured interview. Some of the control participants were included in a previous study.

Informed assent (child participants) and written informed consent (adult participants and parents of child participants) was provided for any data included in the database, which was formally approved by the ethics committee of Rivière-des-Prairies Hospital (Montréal, Canada).

Tasks and procedure

In an individual setting, all participants completed the standard version of **RPM**, and child participants completed the **Wechsler Intelligence Scale for Children (WISC-III, Canadian norms)**, whereas adult participants completed the **Wechsler Adult Intelligence Scale (WAIS-III, Canadian norms)**. All instruments were administered by clinicians unaware of the hypotheses of this study. The order of the tests was counterbalanced across participants.

Data analysis

Non-parametric tests were used for all data analyses. Mann-Whitney U tests were conducted for between-group comparisons of the **Wechsler** versus **RPM** difference. Within-group comparisons of **Wechsler** versus **RPM** level of performance were carried with Wilcoxon signed-rank tests. Spearman rank correlations were computed separately in each group to assess the presence of associations between **RPM** performance and **Wechsler** performance (IQs and subtests). Note that similar results were obtained with parametric tests. All statistical analyses were carried using SPSS 17.

Table 1. Participants' characteristics.

Numbers are given as Mean (standard deviation). FSIQ: Full-Scale IQ. VIQ: Verbal IQ. PIQ: Performance IQ.

	Children		**Adults**	
	Asperger	**Non-Asperger**	**Asperger**	**Non-Asperger**
Sample size (gender)	25 (6 F, 19 M)	27 (7 F, 20 M)	32 (4 F, 28 M)	39 (2 F, 37 M)
Age (years)	11.88 (2.62)	11.26 (3.28)	26.84 (9.03)	23.10 (5.03)
Wechsler scales IQ (percentiles)				
FSIQ	52.12 (28.63)	69.26 (20.79)	46.63 (26.88)	68.74 (17.29)
VIQ	63.74 (25.13)	69.78 (20.14)	54.74 (25.83)	67.13 (20.01)
PIQ	41.08 (31.34)	64.78 (23.41)	39.38 (26.44)	64.21 (22.23)
Raven's Progressive Matrices (percentiles)	59.05 (30.64)	71.83 (22.41)	67.67 (49.14)	80.66 (18.08)

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Results

Adult samples

As illustrated in Figure 3, the average **RPM** score for **Asperger** adults was at the 74th percentile, whereas their average **Wechsler FSIQ** was at 47th percentile (a difference of 27 percentiles). For the non-**Asperger** adult controls, their average **RPM** score was at the 81st percentile, whereas their average **FSIQ** was at the 69th percentile. The **Asperger** adults demonstrated an advantage of **RPM** over **Wechsler FSIQ** that was significantly greater than that of the non-**Asperger** adult controls, Mann-Whitney U=366.5, p<.01.

As often reported in samples of **Asperger** individuals, the **Asperger** adults' **Wechsler VIQ** was significantly higher than their **PIQ** (55th vs. 39th percentile), 3.43, p<.01, but the **Asperger** adults had **RPM** scores that were significantly higher than both their **VIQ** and **PIQ** scores, both ps<.01. In contrast, non-**Asperger** adults had **VIQ** and **PIQ** scores that were statistically equivalent (67th vs. 64th percentile), z=0.61, p=.54, and despite their **RPM** scores exceeding their **VIQ** and **PIQ** scores, both ps<.01, the magnitude with which their **RPM** exceeded their **PIQ** was significantly smaller than it was for the **Asperger** adults, U=332.0, p<.01.

Correlations and subtests. Asperger adults' **RPM** scores were highly correlated with their **FSIQ**, **VIQ**, and **PIQ** scores, r=.70, 56, and 80, respectively, all ps<.01. Among their **Wechsler** subtests, the **Asperger** adults' Matrix Reasoning subtest scores had the highest correlation with their **RPM** scores, r=.71, p<.01 and this subtest approached the level of their **RPM** performance (65th and 74th percentile, respectively). Their performance on three verbal subtests, Information, Similarities, and Vocabulary (66th, 62nd, and 63rd percentile, respectively; see Figure 2) approached their **RPM** performance. Their performance on these three subtests was also correlated with their performance on **RPM**, r=.40, 50, and 47, respectively, all ps<.05.

For non-**Asperger** adults, their **RPM** scores were also correlated with their **FSIQ** and **PIQ** scores, x=53 and 47, respectively, ps<.01 but no significant correlation was found between **RPM** and **VIQ**, r=.26, p=.11. Among their **Wechsler** subtests, Matrix Reasoning had the highest correlation with **RPM** performance, r=.63, p<.01, as with the **Asperger** adults. The difficulty level of each **RPM** item was computed as the percentage of participants, within each group, who achieved the correct answer. The difficulty level of the 60 items was highly correlated across the **Asperger** and non-**Asperger** adults, r=90.

Child samples

Compared with the **RPM**-**Wechsler** discrepancies found for the **Asperger** adults, the discrepancies found for the **Asperger** children were less marked. Their average performance was at the 59th percentile on **RPM** and the 52nd percentile on **Wechsler FSIQ**. Non-**Asperger** children obtained almost identical average **RPM** and **FSIQ** scores, at the 72nd and 69th percentile. The discrepancy between the two tests was not significantly different in **Asperger** children and non-**Asperger** children, U=307.0, p=.58.

As with the **Asperger** adults, there was a significant discrepancy between **Asperger** children average **VIQ** (64th percentile) and **PIQ** score (41st percentile), z=3.16, p<.01, and **Asperger** children **RPM** scores were significantly higher than their **PIQ**, z=2.64, p<.01, but not significantly different from their **VIQ** scores, z=1.27, p=.21. In contrast, non-**Asperger** children obtained similar **VIQ** and **PIQ** scores (69th and 65th percentile), p=.32, and there was no significant difference between the non-**Asperger** children **RPM** scores and their **VIQ** (p=.51) or **PIQ** scores (p=.17).

Correlations and subtests. For **Asperger** children, performance on **RPM** correlated significantly with **FSIQ** (r=.54) and **VIQ** (r=.75) but only marginally with **PIQ** (r=.38, p=.06). Three **Wechsler** verbal subtests Similarities, Arithmetic and Vocabulary were the most highly correlated with **RPM** performance, r=.58, .65, and 50, all ps≤.01. **Asperger** children also achieved some of their highest scores on two of these subtests, Similarities and Vocabulary, respectively at the 68th and 61st percentile, above or similar to their **RPM** performance 59th percentile).

In non-**Asperger** children, correlation between **RPM** scores and **FSIQ** (r=.33, p=.09) or **VIQ** (r=.36, p=.06) approached significance, but there was no significant correlation between **RPM** and **PIQ** scores (r=.19, p=.35). None of their **Wechsler** subtest scores correlated significantly with their **RPM** scores. As with **Asperger** adults, the difficulty level of the 60 **RPM** items was highly correlated across **Asperger** children and non-**Asperger** children, r=.94.

Comparisons with autistic children

Data from **Asperger** children in this study were compared to those of autistic children of a previous study, presented in Figure 1. Discrepancy between **RPM** and **FSIQ**, as well as between **RPM** and **VIQ**, was significantly higher in autistic children than in **Asperger** children, both ps<.01. However, the discrepancy between **RPM** and **PIQ** did not differ between groups, p=.56. Furthermore, although the discrepancy between **RPM** and **Block Design** subtest did not differ between the two groups, p=.29 the discrepancy between **RPM** and four other subtests, Information, Vocabulary, Arithmetic, and Similarities, was consistently higher for the autistic than the **Asperger** children, all ps<.05.

For the autistic children, **RPM** was similarly correlated with **FSIQ**, **VIQ** and **PIQ**, respectively 49, 44 and 51, p≤.01, whereas for the **Asperger** children, **RPM** was more strongly associated with **VIQ** than with **PIQ**. Also, for the autistic children, **Block Design** was most strongly associated with **RPM** performance, r=.57, p<.01, whereas for the **Asperger** children, the correlation was lower, r=.41 p=.04. Lastly, for the autistic children, the verbal subtests (Information, Similarities, Arithmetic and Vocabulary) were less strongly associated with **RPM**, r respectively 34, 40, 45 and 35, p≤.05 than they were for **Asperger** children.

Figure 3. Performance on the Wechsler Intelligence Scales and Raven's Progressive Matrices. Performance on the Wechsler Intelligence Scales (blue) and Raven's Progressive Matrices (red) is shown for A) Asperger adults and non-Asperger adults, and B) Asperger children and non-Asperger children. FSIQ: Full-Scale IQ. VIQ: Verbal IQ. PIQ: Performance IQ.

Discussion

Asperger individuals differ from autistics in their early speech development, in having **Wechsler** scores in the normal range, and in being less likely to be characterized by visuospatial peaks. In this study, **Asperger** individuals presented with some significant advantages, and no disadvantages, on **RPM** compared to **Wechsler FSIQ**, **PIQ**, and **VIQ**. **Asperger** adults demonstrated a significant advantage, relative to their controls, in their **RPM** scores over their **Wechsler FSIQ** and **PIQ** scores, while for **Asperger** children this advantage was found for their **PIQ** scores. For both **Asperger** adults and children and strikingly similar to autistics in a previous study, their best **Wechsler** performances were similar in level to, and therefore plausibly representative of, their general intelligence as measured by **RPM**.

We have proposed that autistics' cognitive processes function in an atypically independent way, leading to "parallel, non-strategic integration of patterns across multiple levels and scales" and to versatility in cognitive processing. Such "**independent thinking**" suggests ways in which apparently specific or isolated abilities can co-exist with atypical but flexible, creative, and complex achievements. Across a wide range of tasks, including or perhaps especially in complex tasks, autistics do not experience to the same extent the typical loss or distortion of information that characterizes non-autistics' mandatory hierarchies of processing. Therefore, autistics can maintain more veridical representations (e.g. representations closer to the actual information present in the environment) when performing high level, complex tasks.

> The current results suggest that such a mechanism is also present in **Asperger syndrome** and therefore represents a commonality across the **autistic spectrum**. Given the opportunity, different subgroups of autistics may advantageously apply more independent thinking to different available aspects of information: verbal information, by persons whose specific diagnosis is **Asperger's**, and perceptual information, by persons whose specific diagnosis is autism.

One could alternatively suggest that the construct measured by **RPM** is relative and thus would reflect processes other than intelligence in **autistic spectrum** individuals. However, a very high item difficulty correlation is observed between autistic individuals and typical controls, as well as between **Asperger** individuals and typical controls. As previously noted, these high correlations indicate that **RPM** is measuring the same construct in autistics and non-autistics, a finding now extended to **Asperger syndrome**. Therefore, dismissing these **RPM** findings as not reflecting genuine human intelligence in autistic and **Asperger** individuals would have the same effect for non-autistic individuals. The discrepancies here revealed between alternative measures of intelligence in a subgroup of individuals underline the ambiguous non-monolithic definition of intelligence.

Undoubtedly, autistics' intelligence is atypical and may not be as easily assessed and revealed with standard instruments. But given the essential and unique role that **RPM** has long held in defining general and **fluid intelligence**, we again suggest that both the level and nature of autistic intelligence have been underestimated.

> Thus, while there has been a long tradition of pursuing speculated autistic deficits, it is important to consider the possibility of strength-based mechanisms as underlying autistics' atypical but genuine intelligence.

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