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Intelligence Profile and Executive Function Between Children with Typical Development and Children with High-Functioning Autism Spectrum Disorder

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Abstract. Intelligence plays a significant role in determining the severity of Autism Spectrum Disorder (ASD), thus understanding intelligence among children with ASD is important to guide planning of appropriate interventions. Scores on IQ tests as well as intelligence sub-components between ASD and Typically Developed (TD) children, reflect distinct underlying cognitive processes. Therefore, a comprehensive investigation of the neuropsychological aspects of children ASD may better refine our understanding of the cognitive abilities among children with ASD. The current cross-sectional study investigated differences in intelligence profiles and executive function among children with TD children and children with High-Functioning Autism Spectrum Disorder (HFASD). A total of 34 participants met criteria for inclusion with 24 participants in the TD group, and 10 in the HFASD. Some of the measures which were used included the SB-LM, Executive Function Indonesia (EFI), and Autism Spectrum Quotient: Children's Version (AQ-Child). Data were analysed using Spearman correlation and Mann-Whitney test. Results showed no differences in the intelligence profile in both groups, yet significant differences were found in the composite EF, Inhibitory Control, and Cognitive Flexibility. Additionally, there was a difference in the correlation of intelligence and EF variables between the two groups. Thus, it can be concluded that both groups show qualitatively different cognitive processes. A recommendation derived from these results is that comprehensive EF assessment and treatment should be conducted as part of the global evaluation of ASD patients, primarily to design an intervention to enhance their academic domain.

Keywords: Autism; Executive Function; Intelligence; Inhibitory Control; and Cognitive Flexibility

Since 2012, there has been an increase of Autism Spectrum Disorder (ASD) at a global scale, now reaching a prevalence of 1 case per 100 children (Zeidan et al., 2022). From that group, 67% of them are considered as High-Functioning Autism Spectrum Disorder (HFASD), or ASD with mild symptoms; without intellectual disabilities and without deficiencies in socializing and speaking. Providing the most suitable intervention for children with ASD depends on whether these children experience intellectual disabilities, and it becomes the task of researchers and practitioners to identify whether such deficiencies are evident (American Psychiatric Association, 2013). Therefore, intelligence tests are a key component for diagnosing ASD among children.

Some research has shown that people with ASD have distinct intellectual profiles. This is most

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evident when examining verbal and non-verbal abilities either using the WISC, Stanford-Binet 4th Edition (SB-4) and Stanford-Binet 5th Edition (SB-5) (Baum et al., 2015; Coolican et al., 2008; Joseph et al., 2002). People with ASD perform poorly on the verbal comprehension tests of the WISC subtest, but perform well on the Block Design non-verbal subtest. On the SB-4 test, participants with ASD, had high scores on the pattern analysis subtest but low scores on the Absurdities subtest (Harris et al., 1991). On the SB-5, people with ASD had large discrepancies in performance between the Nonverbal IQ (NVIQ) and Verbal IQ test, with higher scores on the Nonverbal Fluid Reasoning, NV Quantitative Reasoning, and NV Visual Spatial Processing Skills subtest (Coolican et al., 2008). IQ may reflect underlying differences in cognitive processes between typically developing children (TD) or children with ASD. However, it is difficult to directly compare performance on IQ tests between ASD children and typically developing children, since similar scores may reflect different cognitive processes (Rommelse et al., 2015). For example, among TD children, general intelligence ('g') correlates with all cognitive tasks which associates with speed of processing information (Anderson, 2008). However, among children with ASD, low IQ scores do not necessarily correlate with low speed of processing information. This suggests that different factors may be at play in affecting IQ among children with ASD and typically developing children (TD) (Scheuffgen et al., 2000).

In addition, children with HFASD may acquire the intellectual capacities to support their studies in formal education. However, they tend to show poor interpersonal, emotion regulation skills, and higher stress and anxiety compared to TD children (Dijkhuis et al., 2020). Children with HFASD also struggle in maintaining attention to important information and switching attention. They struggle to adapt to new situations, and prefer literal or tangible information as opposed to abstract information (concrete style of thinking). These characteristics often impede their academic performance, even though intelligence tests show that they possess good learning abilities (Qian & Lipkin, 2011). To obtain an accurate understanding of intellectual capacity among children ASD, we need to understand some of the neuropsychological aspects, for example Executive Functioning (EF) (Narzisi et al., 2013). Information about cognitive profiles is essential, since children with HFASD participate in the regular education system where they experience equivalent study workload with typically developing children of their age (Whitby & Mancil, 2009). EF performance can predict a number of social and behavioral problems among ASD (Pellicano, 2013). Therefore, evaluation of EF needs to be included as part of the comprehensive evaluation of ASD. This would allow the design of the most suitable intervention strategies, since data about intellectual capacity may fail to accurately measure the intellectual capacity of children with ASD (Merchán-Naranjo et al., 2016).

EF refers to the mental processes required to concentrate and maintain attention, particularly for contexts where reliance on instinctual drives may lead to undesirable outcomes (Diamond, 2013). EF consists of three components, namely Inhibitory Control (IC), referred to as self-control or drive control, Cognitive Flexibility (CF) or abilities to switch attention, and Working Memory (WM) which is the ability to mentally store and use information. The three components become the basis for forming cognitive complex functions for example reasoning, problem solving, and planning (Ackerman & Friedman-Krauss, 2017). Some research has shown that HFASD adolescents and children have significant deficits in those three components of EF (Kenworthy et al., 2008); (Merchán-Naranjo et al., 2016). Other research has shown that adolescents and children with HFASD have the largest deficit in CF (Granader et al., 2014; Wallace et al., 2016). Meanwhile, other research (Robinson et al., 2009) has shown that children with ASD show low performance only on IC, while performance on WM and CF are similar to typically developing children. WM has been suggested as the EF component which strongly correlates with intelligence (Friedman & Miyake, 2004). Meanwhile, IC and CF have shown low correlations with intelligence. Despite this, research has shown inconsistent results pertaining to the relationship between EF and intelligence, particularly among children with HFASD.

Concerning assessment of intelligence among children with ASD, the WISC and SB are among the most often administered (Coolican et al., 2008; Crocker & Algina, 2008). WISC is often preferred because it measures a number of constructs, and therefore the results are easily interpreted for the goal of designing interventions (Dawson et al., 2015). However, SB, has an advantage over WISC, because younger children with ASD and LFASD generally show better performance in SB compared to WISC. This is because the items of the SB test focus less on verbal abilities as opposed to the Weschler (Baum et al., 2015). With regards to test administration, SB is also preferred among younger children or children with intellectual disabilities since the tasks have more variety and use toys as media, therefore children are better able to focus on completing the tasks (Becker, 2003). Currently, SB is still used in some countries for academic placement and to identify symptoms of intellectual disabilities, because SB was effective in predicting academic performance among children and adolescents in the last 100 years (Beier & Ackerman, 2005). SB-5 has even become the main intelligence test used by the Autism Treatment Network (ATN) to assess cognitive functions and develop a comprehensive intervention toward ASD (Speak, 2010).

Despite this, the SB test which is used in Indonesia is the Stanford-Binet Intelligence Scale form LM (SB-LM). This is the third revised edition which was created in 1960 and adapted and used in Indonesia since 1970 (Wulan, 2016). However, the SB-LM and SB-5 can be considered as completely two different instruments. First, (1) they have different theoretical basis, which determines differences of the measured factors components of intelligence (2) there are differences in the scale items, for example SB-LM was created based on an age scale format while SB-LM was based on a point-scale format; (3) concerning scoring, the SB-LM scores comprise of Mental Age, and Chronological Age, and IQ, while the SB-5 comprises Verbal IQ, Nonverbal IQ, and Full-scale IQ (4) finally, because SB-5 is the latest version which was created in 2003, the items are more relevant for children in the present day context (Becker, 2003). As far as the author is aware, there has not been any research on describing the intelligence profile of HFASD using the SB-LM. As mentioned earlier, intelligence profiling among typically developing or neurotypical children was conducted using the Wechsler, SB-4, or SB-5. Therefore, the current research investigates the intelligence profiles of typically developing children and children with HFASD using SB-LM. In order to arrive at an intelligence profile which is conclusive, researchers need to explore how intelligence profiles can be associated with EF performance.

In the current study, research participants were recruited if their age was 4-8 years. This is because during this age, EF is in rapid development, and previous findings have shown EF to correlate with intelligence components among preschoolers (Ackerman & Friedman-Krauss, 2017). At this age, children are also starting to prepare to enter school (for preschool or elementary school), and therefore still in the process of adapting to the academic environment. Consequently, information about intelligence and EF profiles can guide decisions to provide the most suitable education programs or educational interventions for children with ASD.

Method

Research Design

The current research involves no manipulation of variables and therefore falls within the nonexperimental research category (Kerlinger & Lee, 2000). Based on the frequency of contact with the participants, the current research uses a cross sectional design since the researcher collected the data in a single attempt (Gravetter & Forzano, 2012). Based on the type of the data, this is quantitative research. In quantitative research, the researcher measures a specific variable from a sample of participants. Numeric data is obtained from this process, and through statistical analysis, the researcher interprets the data.

Research Instruments

developmental conditions of the child, diagnosis history, medical history, and therapy history. At this stage, parents from the children with HFASD are also asked to complete an online version of the Autism Spectrum Quotient: Children's Version (AQ-Child) (Auyeung et al., 2008) to ascertain ASD symptoms. The AQ-Child which was used in this research was the adapted version which was translated to Bahasa Indonesia, and readability was evaluated by 15 people. A total of 56 participants completed the questionnaire, consisting of 28 parents from children with typical development, and 28 parents with children with ASD. Based on the statistical computations, the measure had an internal reliability of =.780 and a validity with a rit value between 0.21-0.34 which is categorized as very good. In addition to using the AQ-Child, the researcher also conducted observation on the participants to ensure that the participants met the diagnostical criteria for ASD based on DSM 5. Data collection was conducted in 2 stages. At the first stage, SB-LM was administered to obtain an intelligence profile of the participants. SB-LM also served as a screening instrument; where participants with an IQ lower than 70 were excluded from subsequent stages. The SB-LM used in the current study was the third revised version, created in 1960 and adapted to Indonesian since 1970 (Wulan, 2016). SB-LM measured 7 dimensions of intelligence, namely; verbal abilities, recall, conceptual thinking, reasoning, quantitative reasoning, visual-motoric abilities and social intelligence. This test consists of 142 items which was created based on the age-scale format. SB-LM was administered individually in a closed room, and involved a number of materials for example pictorial cards and toys, like beads, blocks, and toy cars. The test duration for each participant was approximately 30-60 minutes.

In the second stage, EF performance was measured using the Indonesian version of the Executive Function instrument, created by (Hendrawan et al., 2015). The EFI instrument consisted of three tasks which measure EF components among preschoolers; namely the Sun / Grass test to measure IC, Backward Word Span to measure WM, and dimensional change card sort to measure CF. The instrument was pilot tested on typical development preschool children. Therefore, one of the goals of this research was to compare EF performance among preschool children with typical development and preschool children with ASD. Given this data, we would be able to know the extent that the EFI instrument can differentiate the clinical profile of preschoolers.

Participants

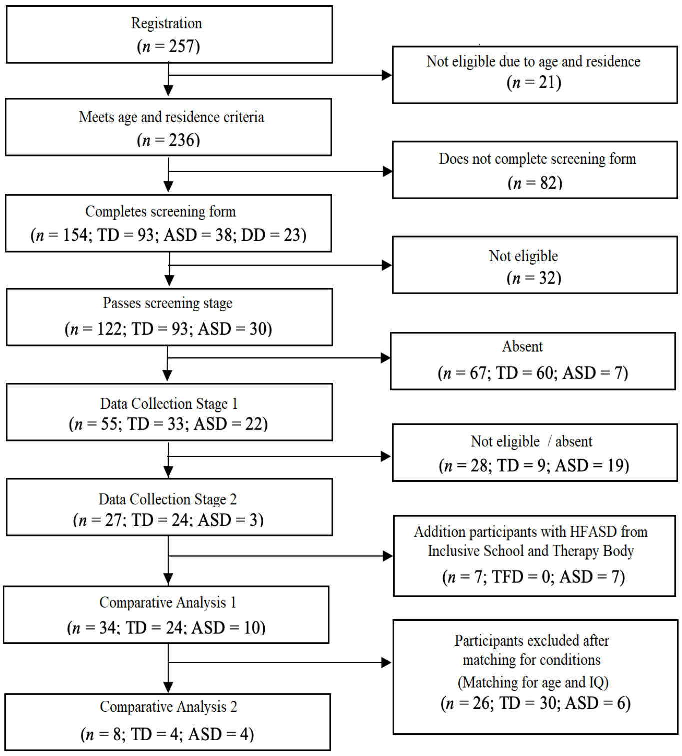
A total of 34 children participated in this study (24 with typical development (TD) and 10 with HFASD) with the following criteria: (a) resided in Jakarta, Bogor, Depok, Tangerang, or Bekasi; (b) aged between 4-8 years; (c) IQ > 70 in the first stage of data collection; (d) able to engage in two-way communication using Bahasa Indonesia as the main language; (e) children with typical development, or; (f) children with HFASD as diagnosed by a psychologist / doctor. Purposive sampling was used, namely a method of collecting a sample which involves intentionally obtaining a representative sample, by involving groups with a specific predetermined criterion (Kerlinger & Lee, 2000). To obtain participants with the criteria mentioned above, the research team posted online recruitment posters through numerous social media platforms. Initially, 257 prospective participants registered for the research. However, 21 participants did not meet the age and residence criteria, and 82 participants were excluded because they did not complete the online screening form. Based on the screening form, 32 people were excluded because they did not meet the criteria for ASD or showed other developmental issues (like ADHD and Intellectual Disability). Therefore, the total number of participants who met the criteria was 122; 93 participants in the typical development group and 23 in the ASD group.

From the 122 participants, only 55 participants were present during the initial data collection stage, which consisted of 33 TD participants and 22 ASD participants. Furthermore, 22 participants were excluded since they did not complete the intelligence test, their IQ was below 70, they did not attend, or they did not agree to continue to the subsequent stages of research. Therefore, the final sample which was used for analysis was 34, with 24 participants from the TD group and 10 participants for the ASD group. The data analysis was conducted in two stages. At the first stage, comparisons were made between the two groups. In the second stage, age and IQ was controlled by matching participants from both groups who had equivalent age and IQ. This led to a sample of 8 participants, with 4 participants in the TD group and 4 participants in the ASD group. A detailed explanation about the total number of participants can be seen in the research stages displayed in Figure 1.

Data Analysis

The research performed correlational analyses using spearman correlation tests. Separate correlational tests were conducted for the HFASD and TD groups to observe correlation coefficients as a function of the two groups. To support the analysis, the researcher also conducted a Mann-Whitney test to observe whether there were differences of test scores between the two groups. Figure 1.

Figure 1
Selection of Participants



Results

Descriptive Statistics

There was a total of 19 (56%) male and 15 (44%) female participants, with an age range of 48-96 months (*M*=64.42 months; *SD*=12.21). The average intelligence of the participants was 105.24 (*SD*=17.2), with the TD group having an average IQ of 110.9 (*SD*=13.6), and HFASD having an average IQ of 91.6 (*SD*=17.9). Based on the family backgrounds, a majority of the participants (47%) had incomes three times higher than the regional minimum wage. Based on the educational background, a majority of the fathers' (25%) and mothers' (94.1%) of participants, have a diploma / bachelor's degree. Information on the characteristics of the participants can be observed in the table below. There was a total of 19 (56%) male and 15 (44%) female participants, with an age range of 48-96 months (*M*=64.42 months; *SD*=12.21). The average intelligence of the participants was 105.24 (*SD*=17.2), with the TD group having an average IQ of 110.9 (*SD*=13.6), and HFASD having an average IQ of 91.6 (*SD*=17.9). Based on the family backgrounds, a majority of the participants (47%) had incomes three times higher than the regional minimum wage. Based on the educational background, a majority of the fathers' (25%) and mothers' (94.1%) of participants, have a diploma / bachelor's degree. Information on the characteristics of the participants can be observed in the table below.

Table 1
Characteristics of Research Participants

Characteristics	Development		Total
	Typical	ASD	
Total participants (%)	(70.5%)	10 (29.4%)	34 (100%) 34 (100%)
Age in months (Mean ± SD)	64.42 (±12.1)	80.5 (±16.4)	69.15 (±15.2)
Gender (%)			
Male	11 (45.8%)	8 (80%)	19 (56%)
Female	13 (54.2%)	2 (20%)	15 (44%)
Intelligence (Mean ± SD)	110.92 (±13.6)	91.6 (±17.9)	105.24 (±17.2)
Father's education (%)			
Senior High School	2 (8.3%)	2 (20%)	4 (11.7%)
Diploma/Bachelor's Degree	17 (70.8%)	8 (80%)	25 (73.5%)
Master's	5 (20.8%)	-	5 (14.7%) 5 (14.7%)
Mother's education (%)			
Senior High School	-	1 (10%)	1 (2.9%)
Diploma/Bachelor's Degree	23 (95.83%)	9 (90%)	32 (94.1%)
Master's	1 (4.16%)	-	1 (2.9%)
Socio-Economic Status] (%)			
Below Regional Minimum Wage*	-	1 (10%)	1 (3%)
Regional Minimum Wage	10 (41.7%)	1 (10%)	1 (3%)
2 times above Regional Minimum Wage	1 (4.2%)	5 (50%%)	6 (17.6%)
> 3 times Regional Minimum Wage	13 (54.2%)	3 (30%)	16 (47.0%)

Correlational Statistics

Based on Spearman correlational analysis, the total IQ score was uncorrelated with the EF composite score or the EF components. The EF composite score for the HFASD correlated with 5 of the 7 components of intelligence, namely; recall (rEF=0.814, p<0.01), conceptual thinking abilities (rEF=0.819, p<0.01), reasoning (rEF=0.858, p<0.01), visual-motoric abilities (rEF=0.719, p<0.05), and social reasoning (rEF=0.755, p<0.01). For the TD group, the EF composite score correlated with all components of intelligence (rEF=0.570, p<0.01; rEF=0.520, p<0.01; rEF=0.542, p<0.01; rEF=0.541, p<0.01; rEF=0.636, p<0.01 rEF=0.438, p<0.05; rEF=0.744, p<0.01).

Among the HFASD group, IC and CF were uncorrelated with any of the intelligence components. Meanwhile, WM correlated with 6 of the 7 components of intelligence, namely recall (rWM=0.809, p<0.01), conceptual thinking abilities (rWM=0.883, p<0.01), reasoning (rWM=0.820, p<0.01), quantitative reasoning (rWM=0.726, p<0.05), visual-motoric abilities (rWM=0.798, p<0.01), and social reasoning (rWM=0.843, p<0.01). Among the TD group, three components of EF correlated with different intelligence components. IC correlated with conceptual thinking abilities (rIC=0.411, p<0.05), quantitative reasoning (rIC=0.466, p<0.05), and social reasoning (rIC=0.577, p<0.01); WM correlated with 5 components of intelligence, namely recall (rWM=0.555, p<0.01), conceptual thinking abilities (*r*WM=0.569,*p*<0.01), quantitative reasoning (*r*WM=0.489, *p*<0.05), visual-motoric abilities (*r*WM=0.435, *p*<0.05), and social reasoning (*r*WM=0.458, *p*<0.05); while CF correlated with verbal abilities (*r*CF=0.500, *p*<0.05), reasoning (*r*CF=0.479, *p*<0.05), and social reasoning (*r*CF=0.539, *p*<0.01).

Among the secondary variables which were measured, only age correlated with the primary variables for both groups. Age for the HFASD group, was uncorrelated with IQ, however it correlated with 6 components of intelligence namely recall (*r*Age=0.773, *p*<0.01), conceptual thinking abilities (*r*Age=0.806, *p*<0.01), reasoning (*r*Age=0.858, *p*<0.01), visual-motoric abilities (*r*Age=0.666, *p*<0.05), social reasoning (*r*Age=0.651, *p*<0.01), the EF composite variable (*r*Age=0.896, *p*<0.01) and WM (*r*Age=0.636, *p*<0.05). Meanwhile, for the TD group, age negatively correlated with IQ (*r*Age=0.444, *p*<0.05), and positively correlated with all components of intelligence (*r*Age=0.454, *p*<0.05; *r*Age=0.575, *p*<0.01; *r*Age=0.601, *p*<0.01; *r*Age=0.476, *p*<0.05; *r*Age=0.673, *p*<0.01; *r*Age=0.694, *p*<0.01; *r*Age=0.440, *p*<0.05), and also the EF composite (*r*Age=0.537, p<0.01) dan WM (*r*Age=0.547, *p*<0.01). The results of the correlational analysis between variables for both groups can be seen in table 2 and table 3.

Table 2
Correlation between Research Variables among the HFASD Group

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Mental Age	.508	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Verbal abilities	.540	.80 b[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Recall	.516	.89 b[b]	.668 a[a]	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Conceptual thinking	.444	.92 b[b]	.626	.939**	-	-	-	-	-	-	-	-	-	-	-	-
6	Reasoning	.429	.86 b[b]	.787 b[b]	.833 b[b]	.857 b[b]	-	-	-	-	-	-	-	-	-	-	-
7	Quantitative Reasoning	.057	.451	.149	.529	.635a[a]	.609	-	-	-	-	-	-	-	-	-	-
8	Visual motoric	.317	.861 b[b]	.557	.855 b[b]	.846 b[b]	.692 a[a]	.590	-	-	-	-	-	-	-	-	-
9	Social reasoning	.728 a[a]	.907 b[b]	.742 a[a]	.921 b[b]	.914 b[b]	.825 b[b]	.383	.739 a[a]	-	-	-	-	-	-	-	-
10	EF Composite	.368	.850 b[b]	.578	.814 b[b]	.819 b[b]	.858 b[b]	.592	.719 a[a]	.755 b[b]	-	-	-	-	-	-	-
11	Inhibitory Control	.285	.309	.220	.270	.355	.433	.422	.126	.272	.446	-	-	-	-	-	-
12	Working Memory	.585	.829 b[b]	.508	.809 b[b]	.883 b[b]	.820 b[b]	.726 a[a]	.798 b[b]	.843 b[b]	.822 b[b]	.420	-	-	-	-	-
13	Cognitive Flexibility	.238	.492	.222	.513	.586	.437	.018	.302	.584	.438	.334	.424	-	-	-	-
14	Age	.086	.81 b[b]	.623	.773 b[b]	.806 b[b]	.858 b[b]	.553	.666 a[a]	.651 a[a]	.896 b[b]	.446	.636 a[a]	.488	-	-	-
15	SSE	-.066	-.381	-.444	-.247	-.138	-.461	-.094	-.348	-.181	-.580	-.067	-.275	.060	-.475	-	-
16	Mother's education	-.117	-.291	-.500	-.118	-.122	-.408	.166	-.188	-.257	-.175	.295	-.183	-.178	-.175	.565	-
17	Father's education	.525	.175	.321	.355	.365	.408	.248	.094	.481	.000	.177	.365	.268	.000	.377	.645

Table 3
Correlation between Variables among TD Group

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	IQ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Mental Age	.135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Verbal Abilities	.184	.660 b[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Recall	.095	.684 b[b]	.527 b[b]	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Conceptual thinking	.200	833 b[b]	.556 b[b]	.787 b[b]	-	-	-	-	-	-	-	-	-	-	-	-
6	Reasoning	.027	.650 b[b]	.275	.421 a[a]	.552 b[b]	-	-	-	-	-	-	-	-	-	-	-
7	Quantitative Reasoning	-.029	.704 a *[a] *	.221	.514 a *.331[a] *.331	.505 a a[a a]	.444 a[a]	-	-	-	-	-	-	-	-	-	-
8	Visual motoric	-.117	.704 b[b]	.269	.331	.492 a [a]	.538 b [b]	.529 b[b]	-	-	-	-	-	-	-	-	-
9	Social reasoning	.346	.827 b[b]	.623 b[b]	.639 b[b]	.743 b[b]	.476 a[a]	.565 b[b]	.365	-	-	-	-	-	-	-	-
10	EF Composite	.182.182	.738 b[b]	.570 b[b]	.520 b[b]	.542 b[b]	.541 b[b]	.636 b[b]	.448 a[a]	.744 b[b]	-	-	-	-	-	-	-
11	Inhibitory Control	.323	.519 b[b]	.307	.351	.411 a[a]	.386	.466 a[a]	.213	.577 b [b]	.736 b [b]	-	-	-	-	-	-
12	Working Memory	-.119	.563 b[b]	.221	.555 b[b]	.569 b[b]	.397	.489 a[a]	.435 a[a]	.458 a[a]	.646 b][b]	.428 a [a]	-	-	-	-	-
13	[Cognitive Flexibility]	.336	.455 b [b]	.500 a [a]	.295	.286	.479 a [a]	.287	.214	.539 b [b]	.748 b [b]	.307	.365	-	-	-	-
14	Age	-.444 a[a]	.766 b[b]	.454 a[a]	.575 b[b]	.601 b[b]	.476 a[a]	.673 b[b]	.694 b[b]	.440 a[a]	.537 b[b]	.262	.543 b[b]	.207	-	-	-
15	SSE	-.079	-.039	-.273	.030	-.085	.066	.081	-.048	.163	.297	.314	.335	.157	-.055	-	-
16	Mother's education	-.060	.060	-.136	-.016	.143	-.222	.019	-.034	.263	.061	.168	.158	-.124	.091	.189	-
17	Father's education	.391	.064	.030	.221	.179	.023	-.133	-.161	.234	.233	.344	186	.201	-.217	.370	.359

Table 4
Mann-Whitney Tests

Variable	Group	Mean Rank	Median	U	Z	p
Age (CA)	HFASD	24.25	86.00	52.5	-2.555	0.011
	TD	14,.69	64.00			
IQ	HFASD	10.15	89.50	46.5	-2.781	0.005
	TD	20.56	110.92			
Mental Age (MA)	HFASD	17.65	68.00	118.5	-0.057	0.955
	TD	17.44	68.00			

Table 5
Mann-Whitney Tests

Variable	Group	Mean Rank	Median	U	Z	p
Age (CA)	HFASD	24.25	86.00	52.5	-2.555	0.011
	TD	14,.69	64.00			
IQ	HFASD	10.15	89.50	46.5	-2.781	0.005
	TD	20.56	110.92			
Mental Age (MA)	HFASD	17.65	68.00	118.5	-0.057	0.955
	TD	17.44	68.00			

Table 6
Additional Mann-Whitney Tests

Variable	Group	Mean Rank	Median	U	Z	p
Age (CA)	HFASD	4.75	76.50	7.00	-.289	.773
	TD	4.25	74.00			
IQ	HFASD	4.75	102.00	7.00	-.296	.767
	TD	4.25	103.50			
Mental Age (MA)	HFASD	4.63	78.50	7.50	-.145	.885
	TD	4.38	76.50			
Verbal abilities	HFASD	4.50	66.00	8.00	.000	1.000
	TD	4.50	66.00			
Recall	HFASD	5.25	96.00	5.00	-.949	.343
	TD	3.75	72.00			
Conceptual thinking	HFASD	5.25	84.00	5.00	-.923	.356
	TD	3.75	78.00			
Reasoning	HFASD	3.75	66.00	5.00	-.949	.343
	TD	5.25	72.00			
Quantitative reasoning	HFASD	4.63	72.00	7.50	-.189	.850
	TD	4.38	72.00			
Visual motoric	HFASD	5.38	84.00	4.50	-1.049	.294
	TD	3.63	72.00			
Social reasoning	HFASD	5.00	96.00	6.00	-.683	.495
	TD	4.00	75.00			
EF Composite	HFASD	2.75	18.50	1.00	-2.033	.042
	TD	6.25	26.00			
Inhibitory control	HFASD	2.75	12.50	1.0	-2.084	.037
	TD	6.25	15.50			

Tabel 6 (Continued)
Additional Mann-Whitney Tests

Working memory	HFASD	5.00	3.00	6.00	-.661	.508
	TD	4.00	3.00			
Cognitive flexibility	HFASD	2.75	5.00	1.00	-2.084	.037
	TD	6.25	7.00			

Comparative Tests

The results of the difference tests showed a significant difference of IQ between the HFASD (*Mdn*=89.5, *n*=10) and TD group (*Mdn*=109.5, *n*=24) with *U*=46.5, *z*=-2.78, *r*=0.005. The results also showed a significant difference of age between the HFASD group (*Mdn*=86.00, *n*=10) and TD group (*Mdn*=64.00, *n*=24) with *U*=52.5, *z*=-2.555, *r*=0.011. Since there was no significant difference between the Mental Age (raw score form SB-LM) between HFASD (*Mdn*=17.65, *n*=10) and TD group (*Mdn*=17.44, *n*=24), it can be concluded that there was a large discrepancy of age between the two groups, therefore further analysis needed to be conducted. The results of the statistical analysis can be seen in table 4.

Additional Comparative Tests

At this stage the researcher controlled the age and IQ variable by matching the conditions of the two variables, therefore obtaining 4 pairs of participants from the two groups. After controlling for age and IQ, participants from both groups did not show different scores for all intelligence components. However, there was a significant difference for the EF composite between the HFASD group (*Mdn*=18.5, *n*=10) and TD group (*Mdn*=26.00, *n*=10) with *U*=1.00, *z*=-2.033, *r*=0.042. Furthermore, based on the EF components, participants from the HFASD group (*Mdn*=12.50, *n*=10) showed a significant difference compared to the TD group (*Mdn*=15.50, *n*=24) on scores of the IC, with *U*=1.00, *z*=-2.033, *r*=0.042. The HFASD group (*Mdn*=2.75, *n*=10) and TD group (*Mdn*=6.25, *n*=24) showed a significant difference on CF scores with *U*=1.00, *z*=-2.084, *r*=0.037. However, there was no difference for the WM scores between the two groups. The results of the tests can be seen in Table 5.

Discussion

The current research was conducted to compare different intelligence profiles and EF between children with HFSAD with children with typical development. Even though some previous research is similar to the present one, however as far as the researcher is aware, none of the existing research use the SB-LM measure and compare it with EF profile. In Indonesia, the SB-LM test is still used and they have not used the latest version of SB. Apart from that, the SB-LM intelligence test was also conducted to test the extent that SB-LM can differentiate clinical profiles between typical children and those with HFASD, since the instrument are often used among young children. The current research was conducted to compare different intelligence profiles and EF between children with HFSAD with children with typical development. Even though some previous research is similar to the present one, however as far as the researcher is aware, none of the existing research use the SB-LM measure and compare it with EF profile. In Indonesia, the SB-LM test is still used and they have not used the latest version of SB. Apart from that, the SB-LM intelligence test was also conducted to test the extent that SB-LM can differentiate clinical profiles between typical children and those with HFASD, since the instrument are often used among young children. The result of the study showed a significant difference of EF composite scores, IC, and CF between the two groups, where the scores of typical children was significantly higher compared to the HFASD. However, there was no significant difference of intelligence from the SB-LM test. The result of the study showed a significant difference of EF composite scores, IC, and CF between the two groups, where the scores of typical children was significantly higher compared to the HFASD. However, there was no significant difference of intelligence from the SB-LM test. The score for the EF composite, IC, and CF was higher for the typical group which was consistent with prior studies showing that impairment in EF was common among children with ASD, whether HFASD or LFASD (Craig et al., 2016).

More specifically, impairments among IC or CF in research was consistent with prior studies (Granader et al., 2014; Ozonoff & Jensen, 1999; Wallace et al., 2016). The low IC among ASD was associated with problems of repetitive behaviors, as well as inabilities to refrain from engaging in inappropriate responses to the social environment (Schmitt et al., 2018). Meanwhile, the low CF among ASD was often associated with repetitive behaviors as well as difficulties in adapting with a new task or new environment (Van Eylen et al., 2011).The score for the EF composite, IC, and CF was higher for the typical group which was consistent with prior studies showing that impairment in EF was common among children with ASD, whether HFASD or LFASD (Craig et al., 2016). More specifically, impairments among IC or CF in research was consistent with prior studies (Granader et al., 2014; Ozonoff & Jensen, 1999; Wallace et al., 2016). The low IC among ASD was associated with problems of repetitive behaviors, as well as inabilities to refrain from engaging in inappropriate responses to the social environment (Schmitt et al., 2018). Meanwhile, the low CF among ASD was often associated with repetitive behaviors as well as difficulties in adapting with a new task or new environment (Van Eylen et al., 2011). In the current study, the HFASD did not show impairments in WM. This was in contrast with research from Merchán-Naranjo et al. (2016) which showed that impairments in WM was one of the features that was often found among ASD. However, Cui et al (2010) suggested that in general children with ASD showed difficulties on visual WM, and showed better performance in verbal WM compared to typical developing children. Given that working memory tasks in this study only measured the verbal working memory domain, therefore the results of the research concerning working memory needs to be interpreted with caution. In the current study, the HFASD did not show impairments in WM.

This was in contrast with research from Merchán-Naranjo et al. (2016) which showed that impairments in WM was one of the features that was often found among ASD. However, Cui et al (2010) suggested that in general children with ASD showed difficulties on visual WM, and showed better performance in verbal WM compared to typical developing children. Given that working memory tasks in this study only measured the verbal working memory domain, therefore the results of the research concerning working memory needs to be interpreted with caution. Furthermore, the results of the analysis after matching the conditions of age and IQ, showed that there were no longer significant differences of intelligence profiles. Although there was no significant difference between the scores of the intelligence component for both groups, however the HFASD showed better performance compared to the TD group in recall, conceptual thinking abilities, visual motoric abilities and social reasoning. The findings align with Crespi (2016) that in relation to intelligence, ASD children are not inferior to TD. Vice versa, individuals with ASD have neuroanatomic conditions which are similar to individuals with higher intelligence. However, among children with ASD, there was an imbalance that caused their performance towards certain tasks to become less optimal Crespi (2016). One of the uniqueness for the cognitive features of ASD is the weakness in central coherence which is characterized by difficulties in integrating information to a broader context. This causes individuals with ASD to be more concerned with detail rather than the general context, therefore in general they have excellent memory because they have intense focus on information detail (Happé & Frith, 2006). Based on this premise, therefore, children in the HFASD have better memory compared to the TD group.

Furthermore, the results of the analysis after matching the conditions of age and IQ, showed that there were no longer significant differences of intelligence profiles. Although there was no significant difference between the scores of the intelligence component for both groups, however the HFASD showed better performance compared to the TD group in recall, conceptual thinking abilities, visual motoric abilities and social reasoning. The findings align with Crespi (2016) that in relation to intelligence, ASD children are not inferior to TD. Vice versa, individuals with ASD have neuroanatomic conditions which are similar to individuals with higher intelligence. However, among children with ASD, there was an imbalance that caused their performance towards certain tasks to become less optimal Crespi (2016). One of the uniqueness for the cognitive features of ASD is the weakness in central coherence which is characterized by difficulties in integrating information to a broader context. This causes individuals with ASD to be more concerned with detail rather than the general context, therefore in general they have excellent memory because they have intense focus on information detail (Happé & Frith, 2006). Based on this premise, therefore, children in the HFASD have better memory compared to the TD group.

Meanwhile, the group score of the HFASD was higher in motoric visual and social reasoning was contrary with previous research. According to Miller et al. (2014), children with ASD generally have weaker motoric abilities compared to TD children. However, this was not found in the current research. This was also the case for social reasoning. These are contradictive findings, given that weaknesses in social interaction is one of the main features of ASD. The current findings need to be further explored to know whether the HFAS scores that are higher are caused by the characteristics of the sample from the unique population of HFASD in general, or this was caused by characteristics of the items of the SB-LM which gave an "advantage" to HFASD. Meanwhile, the group score of the HFASD was higher in motoric visual and social reasoning was contrary with previous research. According to Miller et al. (2014) children with ASD generally have weaker motoric abilities compared to TD children. However, this was not found in the current research. This was also the case for social reasoning. These are contradictive findings, given that weaknesses in social interaction is one of the main features of ASD. The current findings need to be further explored to know whether the HFAS scores that are higher are caused by the characteristics of the sample from the unique population of HFASD in general, or this was caused by characteristics of the items of the SB-LM which gave an "advantage" to HFASD.

The current research also showed a difference in the correlation between the intelligence components and EF components for both groups, which suggest that there are differences in cognitive processes. As an example, in this study, social reasoning and CF were correlated among the TD group, however this was not the case for the HFASD group. Based on the definition, social reasoning is an ability to make judgements in social situations (Sattler, 1965). In implementing the tasks which require social reasoning, CF is needed, because judgement and responses in social situations is not independent from an understanding of the context. Based on this premise, social reasoning should have positively correlated with CF. However, this correlation was not found for the HFASD group. This means that in general, children with HFASD are able to follow social expectations, although they may struggle. Meanwhile, social reasoning among HFASD correlated with recall. However, this was not found among the TD group. This is an interesting finding that can be further explored in future research. This finding shows that EF is one of the important components that underlies academic performance. Therefore, EF intervention needs to be considered in improving academic performance, particularly among the ASD population. EF intervention does not only benefit to improve cognitive abilities, but also to improve self-regulation which is needed for socializing (Traverso et al., 2015). The current research also showed a difference in the correlation between the intelligence components and EF components for both groups, which suggest that there are differences in cognitive processes. As an example, in this study, social reasoning and CF were correlated among the TD group, however this was not the case for the HFASD group. Based on the definition, social reasoning is an ability to make judgements in social situations (Sattler, 1965). In implementing the tasks which require social reasoning, CF is needed, because judgement and responses in social situations is not independent from an understanding of the context. Based on this premise, social reasoning should have positively correlated with CF. However, this correlation was not found for the HFASD group. This means that in general, children with HFASD are able to follow social expectations, although they may struggle. Meanwhile, social reasoning among HFASD correlated with recall. However, this was not found among the TD group. This is an interesting finding that can be further explored in future research. This finding shows that EF is one of the important components that underlies academic performance. Therefore, EF intervention needs to be considered in improving academic performance, particularly among the ASD population. EF intervention does not only benefit to improve cognitive abilities, but also to improve self-regulation which is needed for socializing (Traverso et al., 2015).

As mentioned earlier, in addition to obtaining a comprehensive cognitive profile among children with HFASD, this study investigated whether the SB-LM was able to differentiate the profile of ASD and TD. However, this goal was not achieved in this study. There are two reasons why this is so. First, the characteristics of the participants from both groups are homogenous. Second, SB-LM was not designed to specifically differentiate between children with ASD and TD. As mentioned earlier, in addition to obtaining a comprehensive cognitive profile among children with HFASD, this study investigated whether the SB-LM was able to differentiate the profile of ASD and TD. However, this goal was not achieved in this study. There are two reasons why this is so. First, the characteristics of the participants from both groups are homogenous. Second, SB-LM was not designed to specifically differentiate between children with ASD and TD.

There are some things which need to be considered in using the SB-LM. Most importantly is the extent that the SB-LM is a reliable and valid measure of intelligence. The instrument may be outdated and many of the items may be irrelevant for the present-day context. Furthermore, the distribution of the items for each component are not equal for each age sub-scale. This makes it difficult to compare intra-test performance. In addition, there are items which are too easy or too difficult, making it less appropriate for the age specific demands for the age sub-scale that is given. In line with (Sattler, 1965), some items overlap or were more appropriate to measure other intelligence components. This condition is particularly the case for items measuring verbal abilities, reasoning and conceptual thinking. Therefore, future research needs to consider retesting the validity and reliability of SB-LM in measuring intelligence of children. There are some things which need to be considered in using the SB-LM. Most importantly is the extent that the SB-LM is a reliable and valid measure of intelligence. The instrument may be outdated and many of the items may be irrelevant for the present-day context. Furthermore, the distribution of the items for each component are not equal for each age sub-scale. This makes it difficult to compare intra-test performance. In addition, there are items which are too easy or too difficult, making it less appropriate for the age specific demands for the age sub-scale that is given. In line with (Sattler, 1965), some items overlap or were more appropriate to measure other intelligence components. This condition is particularly the case for items measuring verbal abilities, reasoning and conceptual thinking. Therefore, future research needs to consider retesting the validity and reliability of SB-LM in measuring intelligence of children.

Despite this, SB-LM stands out from other tests in Indonesia due to its advantages. The first advantage is the low basal age, therefore allowing the test materials to be administered for younger children. This is not the case for the WPPSI instrument. From the aspect of test administration, SB-LM is also more interesting for younger children or for children with intellectual disabilities because the tasks are diverse, and use games, allowing children to lend more focus on completing the task (Becker, 2003). Furthermore, the verbal tests are less demanding, which makes it more appropriate for children who struggle with verbal abilities. Despite this, SB-LM stands out from other tests in Indonesia due to its advantages. The first advantage is the low basal age, therefore allowing the test materials to be administered for younger children. This is not the case for the WPPSI instrument. From the aspect of test administration, SB-LM is also more interesting for younger children or for children with intellectual disabilities because the tasks are diverse, and use games, allowing children to lend more focus on completing the task (Becker, 2003). Furthermore, the verbal tests are less demanding, which makes it more appropriate for children who struggle with verbal abilities.

The results of the analysis for the secondary variable showed that only the factor age correlated with the main variable, and this correlation was only observed for the TD group. This means that among the TD group, the higher the age the higher the IQ score. However, the same correlation was not found among the ASD group. Meanwhile, the SSE or the educational level of the parents did not correlate with IQ, intelligence components, the EF composite score, or EF components. This is not in line with previous findings. This condition can be caused by family background characteristics of the participants which were not diverse. Most of the participants were from high SSE families, and most parents obtained a diploma or bachelor's degree.

Theoretically highly educated parents tend to pay more attention to the development of their children particularly to the academic aspect (Ardila et al., 2005). Therefore, parents with higher education will be more interested in participating in this research. Furthermore, in relation to SSE, children from parents with higher SSE have higher chances to receive stimulation or experience that can support development of intelligence or EF (Ardila et al., 2005; Brooks-gunn et al., 2008). If we study this more carefully, SSE does not directly affect the child's intelligence or EF. The factor that plays a larger contribution directly toward the development of intelligence or EF of the child is the stimulation or child's participation in educational institutions which meet their developmental needs. The results of the analysis for the secondary variable showed that only the factor age correlated with the main variable, and this correlation was only observed for the TD group. This means that among the TD group, the higher the age the higher the IQ score. However, the same correlation was not found among the ASD group. Meanwhile, the SSE or the educational level of the parents did not correlate with IQ, intelligence components, the EF composite score, or EF components.

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Conclusion

Based on this study, there was no difference of IQ and intelligence components between HFASD and TD. However, there was a significant difference on EF composite, IC, and CF. This means, that compared to intelligence tests, measurement of EF was better able to differentiate the ASD population from the typical population. There was also a difference in the correlation among components of intelligence and EF components between the two groups, which suggests that there is a difference of cognitive processes between the HFASD and TD groups. The findings call for different approaches of treatment to improve academic abilities among children with HFASD. One such approach may be to consider interventions which improve EF performance. Based on this study, there was no difference of IQ and intelligence components between HFASD and TD. However, there was a significant difference on EF composite, IC, and CF. This means, that compared to intelligence tests, measurement of EF was better able to differentiate the ASD population from the typical population. There was also a difference in the correlation among components of intelligence and EF components between the two groups, which suggests that there is a difference of cognitive processes between the HFASD and TD groups. The findings call for different approaches of treatment to improve academic abilities among children with HFASD. One such approach may be to consider interventions which improve EF performance.

Recommendation

This study suggests that EF is one of the important components that underlies academic performance. Therefore, assessment or interventions directed at EF need to involve enhancement of academic abilities, particularly among the ASD population. EF intervention not only benefits improvement of cognitive abilities, but also improves self-regulations which is needed by children to improve their social abilities (Traverso et al., 2015).This study suggests that EF is one of the important components that underlies academic performance. Therefore, assessment or interventions directed at EF need to involve enhancement of academic abilities, particularly among the ASD population. EF intervention not only benefits improvement of cognitive abilities, but also improves self-regulations which is needed by children to improve their social abilities (Traverso et al., 2015).

The limitations in the current study calls for a number of suggestions for future work, namely (1) increase the number of participants, particularly for the HFASD group; (2) ensure that the total participants for each group is equal, and match conditions for age and IQ; (3) involve other intelligence measures for comparison. The limitations in the current study calls for a number of suggestions for future work, namely (1) increase the number of participants, particularly for the HFASD group; (2) ensure that the total participants for each group is equal, and match conditions for age and IQ; (3) involve other intelligence measures for comparison.

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Author Contribution

The main author was responsible for the research design, data collection, data analysis, and writing the manuscript. The second author was responsible as a supervisor in and guiding through all stages of the research process.

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Competing Interest

The researcher declares no conflict of interest.

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