

# School Age Outcomes of Children Diagnosed Early and Later with Autism Spectrum Disorder

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**Abstract** Early diagnosis of Autism Spectrum Disorder is considered best practice, increasing access to early intervention. Yet, many children are diagnosed after 3-years. The current study investigated the school age outcomes of children who received an early and later diagnosis of ASD. The cognitive and behavioural outcomes of children diagnosed early ( $n=48$ ), were compared to children diagnosed after 3-years ( $n=37$ ). Children diagnosed early accessed more intervention, demonstrated better verbal and overall cognition at school age, were more likely to attend mainstream school and required less ongoing support than children diagnosed later. Behavioural differences were not found between groups. Earlier diagnosis is important and is likely to promote more positive outcomes at school age due to increased opportunity for EI.

**Keywords** Early and later diagnosis · School age · Outcomes · Cognition · Behaviour

## Introduction

Comprehensive monitoring of children's early social communication development can advance the earlier detection and subsequent diagnosis of Autism Spectrum Disorder (ASD). However, in practice, ASD is rarely diagnosed

before 3-years of age, despite parental concerns surrounding a child's development arising as early as the first birthday (Barbaro and Dissanayake 2009; Werner et al. 2000; Young et al. 2003). In Australia, the average age of diagnosis remains high at 4-years as indicated by Bent, Dissanayake and Barbaro, (2015); however, they found that the most frequently reported age of diagnosis was 6-years in a large sample of children aged under 7-years.

Until recently, a lack of knowledge of the early signs of ASD, coupled with a reluctance by health care professionals to diagnose children early, has meant that many children are not diagnosed until after 3-years (Bent et al. 2015), with concerns surrounding the long-term stability of early diagnoses. However, it has been confirmed that diagnoses made at 24-months, are both reliable and stable into the pre-school (Barbaro and Dissanayake 2016; Stone et al. 1999) and school years (Clark et al. 2017; Lord et al. 2006; Turner et al. 2006).

## Early Diagnosis and Intervention

Children diagnosed early have increased access to Early Intervention (EI) which enables them to benefit from rich learning opportunities delivered when their brains are maximally malleable (Dawson 2008). The recommended intensity of EI for children with autism is controversial. While some encourage a high intensity delivery of between 30 and 40-hours per week (Reichow and Wolery 2009; Dawson et al. 2010; Darrou et al. 2010), others have concluded that *more* intervention is not necessarily better (Hebbler et al. 2007; Moran et al. 2004; Weitlauf et al. 2014). In a recent report by the National Disability Insurance Agency (NDIS 2017), it was suggested that intervention is best matched to the child's needs, rather than adopting a 'more is better' philosophy. Perhaps the age a child begins intervention has

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more bearing than the amount of intervention received. Early is considered best when it comes to intervention (Anderson et al. 2014; Dawson et al. 2012; Granpeesheh et al. 2009; Harris and Handleman 2000; Vivanti and Dissanayake 2016) where the largest improvements are made by children who commenced EI at a younger age, when compared to children who began EI later.

Timely access to intervention promotes positive developmental gains, particularly improvements in cognition and language. MacDonald, Parry–Cruwys, Dupere, and Ahearn (2014) investigated the social communication behaviours, cognition and stereotypies of toddlers with autism pre intervention and 12-months later, following 1 year of Early Intensive Behavioral Intervention (EIBI). Children who commenced EIBI prior to age 2, demonstrated greater gains in their cognition and language, and demonstrated improved play, joint attention and imitation skills and fewer stereotyped behaviors at follow-up (between 30 and 36-months).

Anderson et al. (2014) found that early abilities and intervention were predictive of later adult outcomes. Adults who demonstrated the best cognitive outcomes at 19-years of age, had commenced EI soon after diagnosis (at 2-years) and experienced a reduction in their RRB's between the ages of 2 and 3-years. However, there is still disagreement regarding the effect EI has on later ASD symptomatology. Some studies show reduced ASD symptoms following EI while others fail to demonstrate changes in ASD symptom severity (Clark et al. 2017; Dawson et al. 2010; Green et al. 2012; Vivanti et al. 2014; Vivanti and Dissanayake 2016).

To date, there is no evidence available to establish whether children diagnosed with ASD after 3-years have similar or different developmental outcomes at school age, when compared to children diagnosed early at 2-years.

### The Importance of Early Intervention for Later Outcomes

Early brain malleability means that young children are more sensitive and responsive to experiences that contribute to greater acquisition of skills (Edwards and Silva 2017). Indeed, early learning experiences modify the developing brain (Dawson 2008), such that children diagnosed earlier have an increased opportunity to benefit from EI, thus, laying foundations for later learning. A diagnosis made at 24-months may be advantageous, by maximizing the opportunity for intervention from a younger age. In contrast, diagnoses made at or after 3-years, limits the amount of EI that can be accessed prior to school entry, which may differentiate children in their later school age outcomes.

Higher intensity of EI such as speech therapy between the ages of 2-and 3-years, has been associated with improved cognitive and language outcomes at 9-years (Turner et al. 2006). Similarly, children who commence intervention at

an earlier age (2-years) often demonstrate more positive outcomes as measured by placement in mainstream schools (Harris and Handleman 2000) and IQ gains at follow-up (Harris et al. 1991; Ben Itzchak et al. 2008; McEachin et al. 1993). Thus, the advantage of early diagnoses may be two-fold: (1) more opportunities to acquire skills from a young age, and (2) the opportunity to build on this 'head start' throughout childhood and into the school years.

Cognitive and adaptive scores measure standardized and real life competencies, respectively, following receipt of EI. Enhanced cognitive development is often documented, while adaptive outcomes are more variable with more cognitive gains relative to adaptive gains reported (Flanagan et al. 2015). Nonetheless, cognitive and adaptive functioning have been strongly interrelated in the literature, with more cognitively able individuals often demonstrating better adaptive skills (Baghdadli et al. 2012; Bolte and Poustka 2002). Adaptive behaviour refers to age appropriate skills necessary to live an independent life, to communicate effectively, establish interpersonal relationships and adapt to domestic and broader community environments. Adaptive behaviour, in conjunction with a measure of IQ, provides a comprehensive picture of functioning across contexts.

Verbal abilities have been identified as meaningful markers of later social and adaptive outcomes, with higher verbal abilities predictive of improved long-term prognosis in ASD (McGovern and Sigman 2005; Perry et al. 2009). Baghdadli et al. (2012) used the Vineland Adaptive Behaviour Scales (Sparrow et al. 2005) with a sample of 152 children with ASD to chart their adaptive functioning from childhood to adulthood. A larger improvement in communication, socialisation and daily living skills was observed between the ages of 5 and 8-years, slowing into adolescence, between the ages of 8 and 18-years. Despite improvements over time, deficits in adaptive skills were found to persist into adulthood across all areas tested. Other long-term studies validate IQ and language as some of the strongest predictors of adaptive outcomes (Howlin 2000; Magiati et al. 2011; Szatmari et al. 2003); however, those with higher cognitive profiles do not consistently demonstrate gains in their adaptive skills suggesting that, like autism symptoms, adaptive outcomes are heterogeneous.

The largest rise in ASD prevalence has been found in school age children between the ages of 7 and 17-years (Blumberg et al. 2013), yet there is a surprisingly small body of research on the cognitive and behavioural outcomes of children at school age. Though gains are reported in many EI studies, many children with ASD continue to experience considerable difficulties, particularly in the areas of socialisation, communication and adaptive behaviour into their adolescent years (Baghdadli et al. 2012).

A recent review of long-term follow-up studies conducted between 1993 and 2014, by Starr et al. (2016) sought to

determine if the positive impacts of EI could be maintained by children with ASD, following the transition into primary school. Several studies reported that children with ASD continued to experience difficulties into their school years, suggesting that EI alone was not sufficient to support their development long-term. Ongoing intervention into the school years was recommended to foster the transfer of skills into other contexts and to minimize ongoing difficulties, especially in socialisation and language.

A parent reported outcome study of 80 children aged between 6 and 8-years, diagnosed with ASD before 3-years, was conducted to investigate behavioural, language and social outcomes, medication use and school placement (Towle et al. 2014). Though a small proportion of their sample (20%) were considered to experience ‘optimal outcome’ at school age, as measured by participation in team sports, sleep overs and birthday parties, the remainder of children continued to experience difficulties at school age. Sixty-two percent of parents reported a language problem, while up to 59% reported medication use to manage behavioural problems; 95% of parents also reported social problems at school age. Fifty-five percent of children were attending mainstream settings, with 45% of these children requiring additional support from a classroom aide; 17% of children also had a behaviour plan in place.

### The Current Study

Significant improvements in cognition and language, and a reduction in ID from 24-months to school age, were the positive outcomes of an early diagnosis in the Social Attention and Communication Study (SACS) cohort (Clark et al. 2017), which is the focus of the current study. However, the extent that an early diagnosis and subsequent access to EI has contributed to the positive outcomes of this cohort can only be determined by comparison with children diagnosed later. Therefore, the aim in the current study was to compare the outcomes at school age of the SACS cohort in relation to a sample of children, diagnosed later, after 3-years and prior to school entry at age 5. This will establish whether the SACS cohort, identified prospectively in a low-risk community-based sample and diagnosed at 24-months (Barbaro and Dissanayake 2010), were advantaged by their earlier diagnosis in terms of their cognitive and behavioural outcomes compared to a group of children diagnosed later.

It was hypothesised that despite individual variability in outcomes, an earlier age of diagnosis (at 24-months) will, at a group level, promote more positive cognitive and behavioural outcomes at school age in children with ASD, compared to those receiving a later diagnosis (between 3-to 5-years). As adaptive behaviour outcomes are often correlated with cognition, children diagnosed early were expected to also demonstrate better adaptive functioning at school

age. We also examined autism severity but no directional hypothesis was proposed given the mixed results to date.

## Method

### Participants

Forty-eight children (36 males, 12 females) comprised the *early diagnosis* group. They were ascertained from a large, low-risk community cohort of children from the SACS (see Barbaro and Dissanayake 2010) who had been diagnosed with ASD at 24-months. The SACS involved monitoring of key early signs of autism during routine developmental surveillance of infants and toddlers by Maternal and Child Health Care Nurses (MCHN) trained to identify anomalies in early social attention and communication skills. All children in 17 local government areas (LGA's) who attended their routine 12, 18 and 24-months health check-ups were monitored by the MCHNs, and referred to an assessment team if they showed anomalies in social attention and communication.

Diagnoses at 24-months were made in accordance with Diagnostic and Statistical Manual IV-TR (American Psychiatric Association 2000) criteria following administration of the Autism Diagnostic Observation Schedule-Generic (ADOS-G; Lord et al. 2000), and the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter & Lecouter, 1994), by a research reliable assessor and supervising psychologist. All children also had a formal cognitive assessment using the Mullen Scales Early Learning (MSEL; Mullen, 1995). All assessments were conducted by a team of researchers trained to research reliability on the ADOS to ensure consistency of administration and scoring. The cognitive assessments were administered in a standardized manner.

As not all children from the original SACS (40%) returned for the school age follow-up, t-tests were conducted to assess for differences in early cognition (MSEL scores), and behaviour (ASD severity scores), between those children who did and did not return for follow-up. There were no differences in early cognition ( $p = .70$ ), or autism severity ( $p = .08$ ), at 24-months, between those who did and did not return, and no differences in cognition ( $p = .24$ ), or autism severity ( $p = .18$ ), at 48 months, between those who did and did not return at school age. Thus, the school age sample albeit smaller, is representative of the original SACS cohort. All children were between the ages of 7 and 9-years ( $M = 8.41$ ) at follow-up.

The comparison group comprised 37 children (32 males, 5 females) who received a community-based diagnosis of ASD after 3-years of age, and prior to school entry (age 5-years). These children formed the *later diagnosis* group, and were recruited via advertising on social media,

university blogs and following invitation to a participant registry. A requirement of the current study was that all DSM-IV-TR (American Psychiatric Association 2000) based ASD diagnoses, had been confirmed by a developmental pediatrician. Children in the later diagnosis group were also aged between 7 and 9-years ( $M=7.80$ ) and all had been born within the same years as the SACS cohort. None of the children from the later diagnosis cohort were involved in the SACS, which comprised children who were identified within 17 LGA's in Melbourne. The later diagnosed children had all received independent diagnoses from either a clinical psychologist or paediatrician in the community, and lived outside of these LGA's.

Participant characteristics are presented in Table 1. Although the comparison group had a higher proportion of males, child gender did not differ significantly between the two groups  $\chi^2(1)=2.75, p=.16, \phi=0.09$ .

As apparent in Table 1, children in the SACS cohort were significantly younger at age of diagnosis compared to children in the comparison group,  $t(37)=-12.25, p<.01, d=-2.84$ . Those diagnosed earlier accessed EI at a significantly younger age (2.6 vs. 3.4 years),  $t(75)=-4.70, p<.01, d=-1.06$ , and received significantly more EI, 12-months on average,  $t(75)=4.17, p<.01, d=0.94$ , compared to children

diagnosed after 3-years. These large effect sizes show the magnitude of differences in age of diagnosis and amount of intervention received between the groups. Speech therapy and occupational therapy were the most common types of intervention accessed for all children, irrespective of age of diagnosis.

**Family Characteristics**

The families of children diagnosed early and late reported similar annual family incomes,  $\chi^2(9)=14.86, p=.09, \phi=0.43$ . Further, parental education was not found to differ significantly between the two groups for mothers,  $\chi^2(5)=8.55, p=.13, \phi=0.33$ , or fathers,  $\chi^2(6)=11.23, p=.08, \phi=0.38$ .

**Measures**

The Wechsler Abbreviated Scale Intelligence (WASI; Wechsler 2004) was administered to children in each group at school age to provide a brief and reliable measure of cognition. A Verbal Intelligence Quotient (VIQ) was derived from the similarities and vocabulary subtests; the block design and matrix reasoning subtests provided a measure of Performance IQ (PIQ).

The ADOS-2 (Lord et al. 2012), is a semi-structured play-based assessment that was conducted by an unfamiliar adult to assess social communicative skills, play and other behaviours at school age. Due to differences in language abilities, significantly more lower level modules were administered to children in the later diagnosis group,  $\chi^2(2)=8.42, p=.01, \phi=0.31$ .

A total score is derived from the sum of the Social Affect (SA) scores combined with the sum of the Restricted Repetitive Behavior scores (RRB). To allow for comparability across age and different modules of the ADOS, the revised algorithm procedure (Gotham et al. 2009) was employed to ascertain symptom severity and diagnostic classification at school age. Children were classified into one of three classification ranges on the basis of the ADOS total cut-off score (SA+RRB): *non-spectrum*, *ASD* or *Autism*. The ADOS total score, as well as the SA and RRB domain scores were considered separately; this is recommended to provide a clearer picture of the two ASD dimensions of the ADOS (Hus et al. 2014).

The Vineland Adaptive Behaviour Scales-II (VABS; Sparrow et al. 2005) was used to obtain a standardized parent report measure of adaptive skills. The VABS comprises three domains: communication, daily living, and socialization. These are summed to create an Adaptive Behaviour Composite (ABC) score. Problem behaviours were also assessed but are not included in the ABC score.

**Table 1** Participant characteristics

Variables	Group	
	Early diagnosis (SACS) $n=48$	Later diagnosis (comparison) $n=37$
Mean age at diagnosis (years)	24.04 (1.40)	40.00 (7.88)
Current mean age (years)	8.41 (0.55)	7.80 (0.95)
Early intervention history		
Age commenced (months)	30.00 (0.68)	42.00 (0.87)
Duration (total years)	3.15 (1.07)	2.27 (0.77)
Early intervention type		
Group	55%	70%
Speech therapy	93%	82%
Occupational therapy	67%	73%
Psychology	32%	42%
ABA therapy	14%	12%
ESDM	0%	32%
AEIOU	0%	12%

Figures in parentheses represent standard deviations. Mean age 'current'= mean age in years at school assessment. 'Group' refers to intervention delivered to a small group of children in a community setting rather than one-to-one therapies

ABA Applied Behavioral Analysis, ESDM Early Start Denver Model are both evidence based intervention approaches

AEIOU is a foundation for children with autism offering a range of targeted community interventions including speech therapy, occupational and play therapies and behavioral intervention

Parents completed a Demographic Questionnaire, which required them to document any EI received including type, intensity, duration in years, and the age EI commenced. Parents also reported on their child's current school placement as well as any therapy their child was continuing to receive into their school years.

## Procedure

Written consent was obtained from all parents upon arrival at the testing session. They completed the Demographic Questionnaire and the VABS while their child was assessed in a separate room. The examiner (first author) and child were seated at a table in a quiet room, with the ADOS administered first followed by the WASI. Parents were present when ADOS modules 1 and 2 were administered, as is standard protocol. All assessments were conducted in a standardized manner by the first author, who was trained to research reliability on the ADOS, and was unaware of children's previous test scores. With parental permission, all sessions were digitally recorded to assist with scoring of tests. A report summarizing the assessment for each child was sent to the family following the assessment.

## Data Analysis

Chi square analyses assessed for group differences on categorical variables such as age, parental education, ID at school age, and the amount of ongoing supports being received. Groups were compared on their autism severity and cognition at school age using independent samples *t* tests. Correlation analyses assessed the association between EI characteristics and cognitive and behavioral outcomes at school age. Group differences on the three subdomains of the Vineland were analysed using a Multivariate Analysis of Variance.

## Results

Table 2 provides current school placement details and information about the ongoing support of children at school age for the early and later diagnosis groups.

Children who received an early diagnosis were receiving less ongoing support at school age when compared to children diagnosed later, with a significant, albeit weak, effect,  $\chi^2(1) = 4.13, p < .05, \phi = 0.22$ . Although more children diagnosed 'early' were attending mainstream education settings

**Table 2** Current school placement and ongoing therapy

	Early diagnosis (SACS) <i>n</i> = 48	Late diagnosis (comparison) <i>n</i> = 37
Private therapy ongoing		
Speech therapy	31.2%	19.3%
Occupational therapy	10.4%	17.2%
Social skills training	12.6%	16.2%
ABA therapy	0%	14.8%
Psychology	6%	21%
Total receiving ongoing therapy	60.2%	88.5%
School placement		
Mainstream	77.1%	57.6%
Specialist education	14.6%	12%
Autism specific school	4%	21%
Combination	4%	1%
Home schooling	0%	3%

School Placement 'combination' = mainstream and special education part time

Current Therapy 'combination' = receiving in school and private therapies. ABA Applied Behaviour Analysis

compared to children diagnosed after 3-years, this difference was not significant,  $\chi^2(4) = 7.87, p = .09, \phi = 0.31$ , but the effect size was moderate.

## Cognition

The cognitive scores from the WASI administered at school age are presented in Table 3. As evident here, children who were diagnosed early had a significantly higher FSIQ than children in the later diagnosis group,  $t(83) = 2.75, p < .05, d = 0.59$ ; this effect was moderate and was mostly attributable to their higher VIQ,  $t(83) = 2.96, p < .05, d = 0.64$ , which produced a moderate effect size. Although their PIQ was also higher, the difference between the two groups was not significant, indicating a strong trend instead,  $t(83) = 1.88, p = .06, d = 0.40$ , with a moderate effect size.

Within group correlations revealed that cognition at school age (FSIQ) was not associated with the total duration of EI received (in years) for children diagnosed early,  $r(42) = 0.265, p = .08$ , or later,  $r(31) = -0.163, p = .36$ . However, age EI began was significantly associated with FSIQ at school age for children diagnosed early,  $r(42) = -0.461, p < .05$ , but not for children diagnosed later,  $r(31) = 0.007, p = .97$ .

The proportion of children with an ID (FSIQ < 70) at school age was also examined in each group. There was a significantly higher proportion of children with an ID who were diagnosed later (24%) compared to those diagnosed

**Table 3** Mean (SD) cognitive scores at school age

	Early diagnosis (SACS)	Later diagnosis (comparison)	Group differences
FSIQ	102.71 (19.55)	89.57 (19.55)	$t(83)=2.75, p<.05, d=0.59$
VIQ	99.40 (21.67)	84.84 (21.67)	$t(83)=2.96, p<.05, d=0.64$
PIQ	104.81 (18.41)	96.00 (24.86)	$t(83)=1.88, p=.06, d=0.40$

Standard Deviations are presented in parentheses

PIQ WASI Performance Intelligence Quotient, VIQ WASI Verbal Intelligence Quotient

**Table 4** ADOS administration and total scores

	Early diagnosis (SACS)	Later Diagnosis (comparison)
Module 1	0%	16.2%
Module 2	14.6%	10.8%
Module 3	85.4%	73%
ADOS SA score	8.23 (4.65)	9.45 (4.85)
ADOS RRB score	3.40 (2.18)	4.48 (2.17)
ADOS severity score	6.20 (2.68)	6.87 (2.65)

SACS Social Attention and Communication Study, SA Social Affect total domain score on ADOS, RRB Restricted Repetitive Behaviors total domain score on ADOS, ADOS Total Score SA+RRB, ADOS Autism Diagnostic Observation Schedule

early (8%),  $\chi^2(1)=4.12, p=.04, \phi=0.22$ , albeit with a small effect.

**Autism Severity**

Table 4 presents the proportion of children assessed using each module of the ADOS at school age, as well as their SA and RRB domain scores, and overall severity score. Thirteen of the children diagnosed early (27%) scored below cut-off on the ADOS at school age compared to six children (16.2%) in the later diagnosis group. The two groups were first compared on the calibrated total ADOS severity score which indicated no significant difference between the groups,  $t(82)=-1.66, p=.10, d=-0.036$ . Following the recommendation by Hus, Gotham and Lord (2014), separate investigation of the SA and RRB scores were also conducted. Children diagnosed later demonstrated significantly more RRB's,  $t(82)=-2.26, p=.03, d=-0.49$ , with a moderate effect size. There were no differences between the groups on SA,  $t(65)=0.35, p=.73, d=-0.08$ .

Within group correlations found no significant associations between the age children began their EI and autism severity in children diagnosed early  $r=-0.030, p=.85$ , or later  $r=-0.11, p=.54$ . Similarly, the amount of EI received (in years), was not significantly associated with autism severity at school age for children diagnosed early  $r=-0.23, p=.13$ , or later  $r=-0.13, p=.46$ .

**Table 5** Mean (SD) adaptive behaviour scores

	Early diagnosis (SACS) $n=48$	Later diagnosis (comparison) $n=37$
Domain scores		
Communication	75.48 (11.11)	73.56 (14.21)
Daily living	72.45 (12.75)	70.83 (12.43)
Socialization	77.06 (14.58)	71.83 (15.26)
ABC score	73.69 (11.35)	70.13 (13.58)
Maladaptive behaviour	19.19 (2.61)	19.63 (2.25)

ABC Vineland Adaptive Behaviour Composite Score

**Adaptive Behaviour**

Overall cognitive abilities were significantly correlated with Adaptive Behaviour (VABS, ABC composite score), in children diagnosed early,  $r(31)=0.516, p<.01$ , and later,  $r(28)=0.509, p<.05$ . The ABC was not associated with the amount of EI received in children diagnosed early,  $r(30)=0.268, p=.14$ , or later,  $r(27)=0.092, p=.64$ . Further, the age children commenced EI was not significantly associated with adaptive functioning at school age for children diagnosed early,  $r(30)=0.208, p=.26$ , or later,  $r(27)=0.093, p=.63$ .

Although children diagnosed early had slightly higher scores on each of the Vineland domains (see Table 5), no significant group differences were found on the MANOVA used to analyse the domain scores of communication, daily living or socialisation,  $F(3,59)=1.03, p=.38, \eta^2=0.05$ . Similarly, the groups did not differ on their overall ABC Score,  $t(61)=1.14, p=.26, d=0.28$ , or on their maladaptive behaviors,  $t(59)=-0.70, p=.48, d=-0.18$ .

**Discussion**

The current study investigated the school age outcomes of children who were diagnosed with ASD early (at 24-months) and later (after 3-years) in their development. The cognitive and behavioural outcomes at school age were compared across the two groups who were matched on age, with all

children currently between 7 and 9-years. The children diagnosed at 24-months, may have been advantaged by earlier access to intervention. They commenced intervention significantly earlier than children diagnosed later (11-months on average), and concomitantly accessed significantly more EI overall (10-months more on average).

### Cognition and Language

As hypothesized, children diagnosed earlier had better overall cognitive abilities at school age compared with those diagnosed later, which was also highlighted by a significantly smaller proportion of children (8%), meeting criteria for an ID (IQ < 70), compared to the later diagnosed group (24%). It is possible that earlier access to intervention may have positively affected the cognitive development of children diagnosed early. While the amount of EI received did not correlate with cognitive outcomes at school age in either group, the age of EI onset was related to cognition at school age, but only in the early diagnosis group.

These findings are consistent with the neuroplasticity theory whereby earlier learning experiences modify the developing brain (Dawson 2008) thus, enhancing early development (Edwards and Silva 2008). There is evidence of a dose–response relationship in the ABA intervention literature, where children who received high intensity behavioural intervention experienced better outcomes, than children who received a lower-intensity delivery of the same intervention (Granpeesheh et al. 2010). While the amount of intervention is arguably important, other researchers present an opposing view, suggesting that *more* intervention is not necessarily better (Hebbler et al. 2007; Weitlauf et al. 2014). Given the mix of EI received by children in the current samples, the amount of intervention received may have been less influential in altering the early learning trajectory than the age of EI onset, as was found in the current study. It is possible that by commencing EI significantly earlier than their later diagnosed counterparts, the ability of children diagnosed early to benefit from EI may have been maximized by neuroplasticity, with more opportunity for these early learning experiences to alter brain development. Others have also attributed positive developmental outcomes to beginning EI at a younger age (Harris and Handleman 2000; MacDonald et al. 2014; Vivanti and Dissanayake 2016). Collectively, these findings reiterate the importance of beginning intervention at the earliest possible opportunity after diagnosis, to promote lasting developmental gains.

While children diagnosed early did have significantly more access to intervention, there was an average waiting time of 6-months between diagnosis and commencing therapy; children diagnosed later began services almost immediately after diagnosis. This lag between diagnosis and beginning intervention may be a reflection of the high

demand for services, which result in waiting lists. While this is not a major concern, if the wait times had been comparable between groups, the differences may have been larger emphasizing the need to minimize wait times between diagnosis and commencement of EI.

The higher cognitive scores may be attributed to the language subscales of the WASI, which clearly differentiated the two groups, with children diagnosed early having higher VIQs compared to children diagnosed later. This strength in the language abilities of the earlier diagnosed ‘SACS’ cohort is particularly interesting, as the early developmental profiles of this group was marked by difficulties in receptive language at age 24-months, compared to children with other developmental and/or language delays (see Barbaro and Dissanayake 2012). Overall, 42/48 children (87.5%) tested with a RL DQ < 70 on the MSEL at 24-months, depicting a pronounced delay in early receptive language. It appears that an early diagnosis may have been advantageous for cognitive and language outcomes, irrespective of the early receptive language difficulties seen at 24-months in children identified through SACS.

Unfortunately, early cognitive data was not available on the later diagnosis group for similar comparisons over time. As the early language abilities of children diagnosed later were unknown at the time of diagnosis, early language may have made as much of a contribution to their school age outcomes as the later age of diagnosis, or the amount of intervention they had received. It is also worth recognizing that the two areas where children diagnosed early made the most gains are those targeted by their intervention. Higher VIQ scores and lack of ID was perhaps the most striking difference between groups, and speech pathology was the most prominent type of therapy received by children diagnosed early. However, further research is needed to substantiate this possible relationship.

The difference in language abilities between the groups at school age is also reflected in the different ADOS modules used to assess autism symptoms. In the earlier diagnosed SACS cohort, a small proportion of children (14%) were assessed using Module 2, with the majority of children assessed using Module 3 as appropriate for children with phrase speech (85.4%); no Module 1 assessments were conducted in the SACS cohort. Difficulties with expressive language were more prevalent in children diagnosed later, with 27% of these children assessed using lower-level modules (16.2% Module 1; 10.8% Module 2) and a smaller proportion of children assessed using Module 3 (73%).

### Autism Severity

No differences were found between the two groups on overall autism severity as measured by the ADOS. However, when examined separately, children in the later diagnosis

group showed higher levels of RRB's than those diagnosed early. A small number of children diagnosed early (27%), and later (16%), tested below the algorithm cut-off on the ADOS at school age. These findings are comparable with other studies that have also reported between 11% (Sigman et al. 1999; Sauter et al. 2007; Turner et al. 2006) and 30% (Turner and Stone 2007) of children, no longer meeting criteria for autism by school age. 'Optimal outcomes' were reported in a sample of individuals whom despite having a history of ASD, tested within the normal range of functioning in the areas of language, facial recognition, communication and social interaction and demonstrated no autism symptoms at outcome (Fein et al. 2013). Further evidence of this was provided by, Orinstein et al. (2015), who found that children who had received EI between the age of 2 and 3-years, were more likely to experience 'optimal outcomes', differentiating them from children who continued to meet cut-off for High Functioning Autism. Collectively, these findings further substantiate the premise of the current study regarding the onset of EI in relation to later developmental outcomes at school age.

### Adaptive Functioning

Consistent with Baghdadli et al. (2012) and Bolte and Poustka (2002), adaptive and cognitive functioning were strongly interrelated at school age in both groups. However, contrary to expectations, adaptive functioning did not differentiate the groups at school age, and these outcomes were not associated with the amount of EI received, or the age when EI commenced. Children in both groups presented with very similar abilities in the areas of communication, socialisation and daily living skills, according to parental report. Although adaptive behaviours and cognition were highly correlated in both groups, higher overall cognitive and verbal abilities, found in children diagnosed early, did not translate into improved adaptive functioning at outcome. This finding contrasts with those of McGovern and Sigman (2005) and Szatmari et al. (2003) who found more cognitively able individuals also demonstrated better adaptive skills. As such, the relationship between intellectual and adaptive behaviour patterns in ASD remains controversial, where outcomes vary according to IQ and severity of ASD symptomatology. Irrespective of age of diagnosis, all children in the current study presented with higher cognitive relative to adaptive functioning skills at school age, a profile of functioning that has been commonly described in other ASD samples (Bolte and Poustka 2002; Freeman et al. 1999; Joseph et al. 2000; Matson et al. 2009). This provides further evidence that IQ is more stable over time in individuals with ASD, with more variability likely in adaptive outcomes.

### Age of Diagnosis in Relation to Later Outcomes

In light of the current findings, denoting the importance of early ASD diagnoses for later outcomes, it is important to consider factors that may have contributed to the later age of diagnosis of children in the comparison group. One argument could pertain to less salient or severe symptomatology for children in the later diagnosis group, which may not have raised early concerns for parents. Another consideration is that the social communication difficulties, fundamental for a diagnosis of ASD, may not have presented until children began to attend daycare or preschool. As children with ASD can find social environments overwhelming and confusing (Bauminger and Kasari 2000), difficulties interacting with peers may begin to emerge in these social settings, raising some of the first concerns of ASD. However, given that the age of children in the later diagnosis group is within the average age of diagnosis of children younger than 7-years in Australia (49-months), as found by Bent et al. (2015), it is more likely that the absence of routine surveillance for ASD necessary for the early detection and subsequent diagnosis of ASD, contributed to the later diagnoses in the comparison group.

### Ongoing Support and School Placement

Although there was no significant difference in school placement between the two groups, it is interesting to note that a higher proportion of children diagnosed early were attending mainstream settings, relative to children diagnosed later (77 vs. 57% respectively). Mainstream school placement of children diagnosed early in particular, is higher than that reported in some other studies. For example, Towle et al. (2014) reported that half of their sample (55%) attended mainstream classrooms, this rate is lower and more comparable with the mainstream attendance of children diagnosed later (57%). Although school placement is an important factor to consider and has been used as a marker of *optimal outcome* (Harris and Handleman 2000; Lovaas 1987), ongoing support at school age is perhaps a better indicator of current outcome and anticipated long-term prognosis. In the current study, there were more children diagnosed early who no longer required any ongoing intervention in support of their development at school age, compared to children diagnosed later (40 vs. 12% respectively). This finding is consistent with the view that earlier access to intervention may have promoted positive cognitive and language outcomes, as well as increased independence, reducing the need for ongoing support.

The findings reported here lend support to the financial argument currently guiding the delivery of EI (Cunha et al. 2016; Perez-Johnson and Maynard 2007). Early investment in high quality early childhood intervention services is



important in order to reduce the need for costly expenditure associated with ongoing interventions later in life.

### Study Limitations

Prior to concluding, it is important to acknowledge an important limitation in this study, which used a comparison group (later diagnosis group), that was recruited independently of the SACS sample used here. While this opens up the possibility of an ascertainment bias, caution was exercised to ensure that children in the comparison group did not differ in age (and were thus from the same birth cohort as our early diagnosis group), or demographic status in terms of family income and parental education. However, no baseline data were available on this later diagnosis group, which prevented us from controlling for potential baseline differences between groups in our analyses comparing groups on their school age outcomes. A further limitation is the retrospective nature of the information detailing the duration of EI received (in years) and the age of EI commencement which was obtained via parent report, and thus, subject to imperfections in recall after several years. These limitations prevent any firm conclusions regarding the impact of age of diagnosis on children's school age outcomes, as reported here. Future research that employs a longitudinal study design is needed to ascertain equivalence at baseline and outcomes in order to provide strong evidence of the impact of ASD diagnostic age on later development.

### Conclusion

Children diagnosed early at 2-years had better cognitive and language outcomes at school age relative to those diagnosed after age 3. This outcome may be the result of earlier access to EI, as fewer of these children met criteria for an ID and also required less ongoing support at school age compared to children diagnosed later. However, as the early cognitive and behavioural characteristics were not available at baseline on the later diagnosis group, we cannot ascribe these group differences at school age to the age of ASD diagnosis.

Nonetheless, the current findings lend support to the importance of reducing the age of ASD diagnosis so that children can access EI services in their most critical early years to maximize early learning experiences while neural plasticity is at its greatest. Earlier detection and subsequent diagnosis, coupled with EI, provides the most promise for a positive outcome at school age, which may lead to improved long-term prognosis for many individuals with an ASD. Access to EI as soon as possible post-diagnosis serves to reduce the need for school supports, and may reduce the whole of life costs required for the ongoing care of individuals with Autism Spectrum Disorder.

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### Compliance with Ethical Standards

**Ethics Approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

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