

EARLY IDENTIFICATION IN AUTISM: SUBTYPES BASED ON CHILD, FAMILY, AND
COMMUNITY CHARACTERISTICS

By

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EARLY IDENTIFICATION IN AUTISM: SUBTYPES BASED ON CHILD, FAMILY, AND COMMUNITY CHARACTERISTICS

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Abstract

Background. Disparities exist in the early identification of underserved children with ASD. Research suggests early parent concerns may be predictive of eventual child diagnosis and may aid in earlier identification of children with ASD. Our study used a large medical university sample to examine latent subtypes of children with an eventual ASD diagnosis based on parent concerns and socio-demographics.

Methods. Prior to a diagnostic evaluation, parents reported their top three concerns on intake paperwork for 712 children 12 months- 12 years of age. Parent concerns were coded into eight concern categories. We performed a latent class analysis to examine subtypes based on parent concerns, child (i.e., age and gender), family (i.e., socioeconomic status), and community characteristics (i.e., access to service providers). We used a MANOVA to examine latent class differences by age at the diagnostic evaluation and age of a parent's first concern.

Results. Parent concerns and socio-demographics distinguished five latent classes. Two subtypes were identified younger (i.e., 3.5 years of age) and were differentiated by two parent concerns: communication and medical concerns. One of the younger subtypes included non-white, Hispanic children utilizing Medicaid. One subtype was identified around kindergarten and was differentiated by stereotyped and by developmental parent concerns. Lastly, two subtypes were identified at an older age (i.e., 9 years of age) with either developmental concerns, or social and behavior concerns. One of the oldest subtypes was characterized by females with ASD.

Conclusion. Our study suggests that children with communication concerns are most likely identified by parents earlier, regardless of race, ethnicity, or SES. However, our findings point to the difficulty in identifying females with ASD, as well as children with social, behavior, and stereotyped parent concerns.

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Introduction

Early identification is crucial to the developmental trajectories of children with ASD because early intervention services can facilitate optimal outcomes (Dawson, 2008; Rutter, 2006). With the rising awareness of autism spectrum disorders (ASD), the American Academy of Pediatrics (AAP) now urges practitioners to screen all children between the ages of 18 and 24 months for ASD (Johnson & Myers, 2007). The AAP recommendations highlight the importance of listening closely to parent concerns as an effective strategy to identify children earlier, given that parent concerns often predict children who later receive a diagnosis of ASD (American Academy of Pediatrics, 2010, 2014).

While the AAP guidelines have led to increased rates of developmental screenings during pediatric visits and earlier identification of ASD (e.g., DosReis, Weiner, Johnson, & Newschaffer, 2006; Radecki, Sand-Loud, O'Connor, Sharp, & Olson, 2011), many children still receive later diagnoses. Although the goal in early identification is that a child with ASD will have an initial diagnostic evaluation by 3 years (Healthy People 2020, 2017), the average age of diagnosis is 4-5 years (CDC, 2014). Even though rates of diagnoses are similar across children from various backgrounds, disparities exist in the early identification for underserved (i.e., low-income, rural, or racial/ethnic minorities) families as well as for girls with ASD (e.g., Daniels & Mandell, 2014; Lai, Lombardo, Auyeung, Chakrabarti, & Baron-Cohen, 2015; Tek & Landa, 2012). Research suggests that parent concerns are an important piece in the early identification of ASD (e.g., Hess & Landa, 2012; Johnson & Myers, 2007; Ozonoff et al., 2009); however, it is unclear how parent concerns are considered with various family constellations. Therefore, the current study used a large sample of children with an eventual diagnosis of ASD to investigate if

there are latent subtypes (i.e., groups who are similar across various indicators) of children with an eventual ASD diagnosis based on early parent concerns and socio-demographics.

Parent Concerns in Early Detection

Much of the early detection literature focuses on parent concerns preceding a diagnosis of ASD (i.e., retrospectively and prospectively). Studies indicate that early behavioral signs of ASD emerge around 12-14 months (Gaspar de Alba & Bodfish, 2011; Guinchat et al., 2011; Hess & Landa, 2012; Ozonoff et al., 2009). Further, when parents recall their initial concerns they most frequently report concerns of social, gross motor, language, and repetitive behaviors/ interests (Gaspar de Alba & Bodfish, 2011; Guinchat et al., 2011). Parents with a child who receives an ASD diagnosis report early communication and behavior concerns, and later (i.e., 36 months), social development concerns (Hess & Landa, 2012; Ozonoff et al., 2009).

Parent concerns also differentiate children with ASD from children with other diagnoses. Specifically, parent reported concerns of communication or social concerns were more predictive of children with ASD (Wallisch, Little, Dean, & Dunn, under review); whereas, behavioral concerns were more predictive of children with developmental delays (Horovitz, Matson, & Sipes, 2011; Little, Wallisch, Salley, & Jamison, 2016). Additionally, specific types of parent concerns are also associated with an earlier or later diagnosis of ASD. When parents report initial concerns of verbal or nonverbal communication, children were younger, received an ASD diagnosis earlier, and received intervention services earlier (Zablotsky et al., 2017). When parents reported child behavior concerns, the child was usually older and received a later diagnosis. Zablotsky et al. (2017) indicates parents may not report behavioral concerns until the behaviors are no longer developmentally appropriate. Few studies have yet to utilize parent

concerns and family (i.e., race/ethnicity, SES), child (i.e., gender, age), and community (i.e., access to service providers) characteristics.

Child Gender

We have yet to understand the developmental profiles of females with ASD. Since ASD is diagnosed more frequently in males than females, early identification methods, autism assessments, and interventions are largely based on data related to males (Kogan et al., 2009; Lai et al., 2015; Rynkiewicz et al., 2016). This results in male bias in the diagnostic process and ASD profile, and is a critical barrier to identifying girls with ASD (Dean, Harwood, & Kasari, 2017; Rynkiewicz et al., 2016). Females with ASD exhibit less salient characteristics than males and are often misdiagnosed, under-identified, and identified later (Begeer, et al., 2013; Lai, Lombardo, Auyeung, Chakrabarti, & Baron-Cohen, 2015). In contrast, few studies have investigated early parent concerns for males compared to females with ASD. By examining subtypes we may better understand the variability in early parent concerns across gender.

Family Characteristics

Longstanding research indicates SES as a strong social determinant of health (van Zon, Bültmann, Mendes de Leon, & Reijneveld, 2015). For children with ASD, poverty is associated with negative outcomes and later diagnoses (Pulcini, Zima, Kelleher, & Houtrow, 2017). Some studies found differences in the prevalence of ASD across SES, with a greater prevalence of ASD in high SES families (Durkin et al., 2010; Thomas et al., 2012). Others have reported the prevalence has shifted from being disproportionately associated with wealthier families to more homogenous across SES, perhaps because of the increased public awareness of ASD (Fountain, King, & Bearman, 2011). Although this trend is encouraging, some research suggests that low SES children are still diagnosed later as compared to high SES families (e.g., Mandell, Morales,

Xie, Lawer, & Stahmer, 2010). Further, children eligible for Medicaid, a proxy for SES, were approximately 3.4 times more likely to receive a different diagnosis prior to an ASD diagnosis (Mandell et al., 2007). Overall, disparities exist in the age of identification for children who are Medicaid eligible; therefore, understanding the distinct early subtypes among children who have Medicaid insurance may aid in earlier identification.

Significant racial disparities exist with identification and early service utilization (Irvin, McBee, Boyd, Hume, & Odom, 2012; Mandell et al., 2009). Late identification of ASD for children of racial and ethnic minorities can relate to numerous factors including educational, financial, and cultural differences (Tek & Landa, 2012). African Americans (AA) and Hispanics, were less likely than white children to receive documentation of ASD. Additionally, AA children received a diagnosis approximately 1.4 years later than white children and spent approximately eight months receiving mental health treatments before a diagnosis of ASD (Mandell et al., 2007; Rosenberg, Landa, Law, Stuart, & Law, 2011). Children from Asian and white families were more likely to receive an ASD diagnosis earlier (Mandell et al., 2010), and evidence about Latino children is unclear (Fountain et al., 2011; Shattuck et al., 2009; Mandell et al., 2010). Given the variability in identification of ASD, a logical next step is to understand the heterogeneity of ASD within specific communities.

There is a need to identify underserved children with ASD earlier. If we better understand how early parent concerns and child, family, and community characteristics amalgamate into subtypes of ASD, we may better identify children earlier. In other words, if we are better able to understand parent concerns, we may utilize these concerns across diverse groups to improve early identification. Therefore, the purpose of this study is to use a large medical university sample of children with an eventual diagnosis of ASD to investigate subtypes of children based

on early parent concerns and child, family, and community characteristics to aid in the identification and diagnostic process for children with ASD. Research questions include: 1) among children with ASD, how do early parent concerns, child (i.e., age and gender), family (i.e., race/ethnicity, SES), and community (i.e., provider access) characteristics group by subtypes; 2) to what extent do subtypes of children with ASD differ by chronological age (CA) at the diagnostic evaluation and age at which a parent first became concerned?

Methods

Participants

Data was drawn from a medical university child diagnostic center in a large metropolitan area. The sample included children ($n= 712$), 12 months to 12 years-11 months old ($M= 66.68$; $SD= 34.28$) who received a diagnostic evaluation between 2000-2015 and were later diagnosed with ASD (see Table 1). All children received a diagnostic evaluation at a medical university diagnostic center with a multi-disciplinary team. The evaluation included a battery of standardized assessments, behavioral reports, a medical history review, and a clinical diagnostic interview. All children with ASD received an Autism Diagnostic Observation Scale (ADOS; Lord, Rutter, DiLavore, & Risi, 2008) which is a gold standard diagnostic tool for assessing symptoms of ASD.

Measures

Parent Concerns. Prior to a diagnostic evaluation parents completed intake paperwork for developmental history. Within the intake forms, parents described their top three concerns about their child. Two researchers coded these concerns using a coding system (1=present, 0=absent) adapted from Ozonoff et al. (2009). Coders examined percent agreement with 20% of the dataset and achieved 89% agreement. Some parent concern statements described two concern categories

(e.g., why is my child not talking or walking?) in one statement. In these instances, both concerns were accounted for (See Table 2 for coding procedures).

Age of First Concern. Parents reported age of first concern (AOFC) from a checklist including: 1) birth, 2) 0-6 months, 3) 6 months- 1 year, 4) 1- 1.5 years, 5) 1.5- 2 years, 6) 2- 3 years, 7) 3- 4 years, 8) 4-5 years, and 9) other. We used the upper limit of each of the nine categories in data analysis.

Family Socioeconomic Status. Medicaid is a federal and state funded government program for low-income families (Centers for Medicare & Medicaid Services, 2017). Therefore, we used Medicaid insurance usage as an indicator of SES (i.e., Medicaid or Non-Medicaid). Parents reported insurance information prior to a diagnostic evaluation so Medicaid was most likely due to income only.

Family Race and Ethnicity. Parents selected all that apply from a checklist of racial and ethnic categories including: African American (AA), American Indian or Alaska Native, Asian, Hispanic, Native Hawaiian or Other Pacific Island, White, two or more races, and other/unknown. We condensed these codes into two dichotomous variables, one variable for race (i.e., white and non-white) and one variable for ethnicity (i.e., Hispanic and non-Hispanic) with non-white and Hispanic children considered underserved (National Institutes of Health, 2010).

Access to Service Providers. The Centers for Disease Control and Prevention (CDC) provides the number of child health providers per 10,000 children in each county across the United States. Our accessibility variable reflected this metric to characterize accessibility to service providers.

Data Analysis

To address the first research question (i.e., how early parent concerns, child, family, and community characteristics group by subtypes), we used latent class analysis (LCA). LCA, also

referred to as mixture modeling, analyzes subtypes of a heterogeneous population (Kline, 2016). The aim of LCA is to find clusters of individuals with similar characteristics and parse the heterogeneity of populations (Muthén, 2002). Class membership is determined by patterns of observed indicators (Muthén & Muthén, 2017). We examined the heterogeneity of children with ASD based on parent concerns and multiple socio-demographics to identify classes (see Table 5). We used MPlus Version 7.14 for the LCA analysis (Muthén & Muthén, 2015).

We completed the following seven steps when selecting a model and class solution: 1) we examined the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). Lower AIC and BIC are indicative of better model fit (Nylund, Asparouhov, & Muthén, 2007); 2) we analyzed entropy, which follows a continuum from zero to one (values approaching one represent a better model fit) (Celeux & Soromenho, 1996); 3) we compared the Vuong-Lo-Mendell Rubin (VLMR) likelihood, the Lo-Mendell-Rubin (LMR) adjusted test, and the Bootstrap Likelihood Ratio Test (BLRT). The VLMR and LMR compare the current model to a model with one less class; 4) we examined the percentage of individuals in each class to ensure all classes included more than 5% of the sample (Bámaca-Colbert & Gayles, 2010; Nylund, Asparouhov, & Muthén, 2007); 5) we ensured the mean conditional probability scores (how closely a child fits their class) for each latent class were greater than 70%. Scores greater than 70% indicate better model fit; 6) we compared the results of each model to current evidence related to the early profiles of children with ASD; and 7) we followed up the LCA with univariate z-tests to determine whether latent classes were significantly different on observed indicators (See Appendix A).

To address the second research question (i.e., the extent to which subtypes of children with ASD differ by CA at the diagnostic evaluation and AOFC), we used a Multivariate Analysis

of Variance (MANOVA) in SPSS Version 24 (IBM, 2013). We used post-hoc analyses to examine the differences in means between each latent class.

Results

For research question one, we examined latent classes, based on child, family, and community characteristics. We excluded motor ($n= 59$; 8.3%) and sensory ($n= 46$; 6.5%) parent concerns, due to less than 10% of the sample reporting these. We compared the LCA fit statistics for a two to a seven class solution (see Table 4) and chose the five class solution. The six class solution showed promising fit indices; however, contained classes representing less than 5% of the sample and was not selected (step 4 in model selection). Mean conditional probabilities for the five class solution ranged from 89.14- 98.58. The five classes included: 1) *Let's Start Connecting* (e.g., due to parent concerns related to children connecting with peers), 2) *Let's Start Talking* (e.g., due to parent concerns related to children not talking), 3) *Let's Start Learning* (e.g., due to concerns related to children being developmentally behind), 4) *Let's Start Regulating* (e.g., due to concerns related to eating and sleeping), and 5) *Let's Start Adapting* (e.g., due to parent concerns related to rigidity in routines) (See Figure 1).

Latent class one (LC1), *Let's Start Connecting*, ($n=149$; 20.93%) was characterized by older children at the diagnostic ($M=107.19$ mos.; $SD=22.57$) with behavior and social concerns. Further, LC1 consisted of males and white children who had moderate access to service providers ($M= 49.01$; $SD= 5.67$ per 10,000 children). **The second latent class (LC2), *Let's Start Talking***, ($n=139$; 19.52%) was classified by the youngest children at evaluation ($M=44.97$ mos.; $SD=15.85$) who have a higher probability of communication parent concerns. Additionally, children using Medicaid, Hispanic children and non-white children had the highest probability of membership in LC2. Families in LC2 had lower access to service providers compared to other

latent classes ($M= 21.62$; $SD= 5.34$ per 10,000 children). **The third latent class (LC3), *Let's Start Learning***, ($n=72$; 10.11%) was distinguished by older girls who are white ($M=105.57$ mos.; $SD=24.13$) with a lower probability of parent concerns. Children in LC3 had the second highest probability of developmental parent concerns. Lastly, children in LC3 had the lowest access to service providers compared to other latent classes ($M= 21.64$; $SD= 6.70$; 10,000 children). **The fourth latent class (LC4), *Let's Start Regulating***, ($n=302$; 42.42%) was characterized by younger children at the evaluation ($M= 47.18$ mos.; $SD= 16.67$) with medical/medication concerns. Children in LC4 also had the second highest probability of communication parent concerns. Further, LC4 consisted of males and white children with moderate access to service providers ($M= 51.02$, $SD= 4.66$ per 10,000 children). **The fifth latent class (LC5), *Let's Start Adapting***, ($n=50$; 7%) was distinguished by older children at the evaluation ($M=68.06$ mos.; $SD=36.88$) who had the highest probability of development and stereotyped behavior parent concerns. Children in LC5 were more likely white, had the second highest probability of being female, and had the highest average access to service providers compared to other latent classes ($M= 75.05$, $SD= 8.83$; per 10,000 children).

Class Differences on Chronological Age and Age of First Concern

For research question two, we examined how the latent classes, or subtypes, differed by CA at the diagnostic evaluation and AOFC. MANOVA results indicated a significant main effect [$F(8, 1298)= 104.67$, $p<0.0001$]. In other words, both CA and AOFC were significantly different across latent classes. However, Levene's Test of Equality of Covariance Matrices for CA [$F(4, 650)= 32.900$, $p<0.001$] and AOFC [$F(4, 650)= 14.862$, $p<0.001$] were significant, and the sample did not follow normality assumptions, indicating we must follow-up the MANOVA with the non-parametric Kruskal-Wallis H-Test (i.e., non-parametric statistics are not bound by

the same assumptions of a MANOVA). Additionally, we used non-parametric pairwise Mann-Whitney U Tests across all comparisons as a post-hoc test. Lastly, we used a Bonferonni corrected alpha level (i.e., $p \leq 0.001$) to reduce the Type I error rate across the pairwise comparisons.

The Kruskal-Wallis H tests indicated a significant main effect for CA $\chi^2(4) = 419.363$; $p < 0.001$, as well as a main effect for AOFC $\chi^2(4) = 40.647$; $p < 0.001$. When examining post-hoc Mann-Whitney U Tests, results indicated that LC1 (AOFC $M = 42.86$ mos.; $SD = 21.72$) and LC3 (AOFC $M = 40.00$ mos.; $SD = 25.20$) were significantly ($p \leq 0.001$) older than children in LC2 (AOFC $M = 27.59$ mos.; $SD = 12.74$) and LC4 (AOFC $M = 28.64$ mos.; $SD = 13.96$) for both CA and AOFC. That is, children in LC1 and LC3 on average were older than children in LC2 and LC4 on CA and AOFC. LC5 was significantly different from all other latent classes on CA, but not significantly different from the other latent classes on AOFC ($M = 33.50$ mos.; $SD = 21.43$).

Discussion

Many socio-demographics are associated with later diagnoses of ASD (Daniels & Mandell, 2014b); however, we have yet to determine methods to identify these children earlier. While many previous studies have examined the predictive and differentiating value of parent concerns (e.g., Little et al., 2016; Ozonoff et al., 2009), gaps remain in understanding subtypes associated with parent concerns and socio-demographic features (Donohue, Childs, Richards, & Robins, 2017). These gaps are especially pressing, as a goal of Health People 2020 is to lower the age of identification for children with ASD, and the CDC's Autism and Development Disabilities Monitoring Network (ADDM) (CDC, 2016) goal is to determine differences for females and minorities and how these are changing over time. The current study adds to the literature by utilizing a novel LCA approach to parse the variability in the ASD population and

elucidate patterns of child, family, and community characteristics that interplay with distinct sets of parent concerns. Results revealed five subtypes based on child, family, and community characteristics for children with an eventual diagnosis of ASD within a large medical university sample. Our findings suggest each subtype was uniquely characterized by parent concerns and socio-demographics.

Subtypes Identified the Earliest

Two subtypes included young children, approximately 3.5 years old (i.e., LC2 and LC4) with communication concerns. Substantial evidence points to validly diagnosing ASD before age 3 (Healthy People 2020, 2017), although current diagnostic average is 4-5 years of age (Centers for Disease Control and Prevention, 2014). The two youngest subtypes in the current study were diagnosed slightly earlier than the national average and had the earliest AOFC. What is unsettling about this finding is that on average parents' first concerns occurred just after their child's second birthday, meaning it takes almost 1.5 years to a diagnosis; we need to continue to explore why there are such discrepancies between AOFC and CA at the diagnostic evaluation, even among the earliest identified subtypes.

These youngest subtypes were associated with speech and communication concerns just as prior studies have reported (e.g., Hess & Landa, 2012; Ozonoff et al., 2009). Communication concerns are developmentally earlier milestones and more observable at a younger age. Parents may readily compare their child's communication to other children earlier in development. Speech and communication parent concerns are consistent across race and ethnicity (Donohue et al., 2017), and some suggest non-white children receive concerning language and communication scores on standardized assessments (Tek & Landa, 2012). These findings are consistent with the current study, where LC2 was distinguished by including both minorities and

communication parent concerns. Since communication is more discernable at an earlier age, practitioners should pay careful attention when parents describe communication concerns.

Let's Start Talking, LC2, differentiation. LC2 differed from all latent classes by including non-white, Hispanic children utilizing Medicaid. Although the literature points to later identification of non-white and Hispanic children (Daniels & Mandell, 2014b; Mandell, 2005), our study suggests these children were identified earlier. Although there are conflicting findings across the literature, our results are consistent with some authors (Daniels & Mandell, 2014b). Other researchers suggest the contradictory literature may in part be due to differences in sampling, sampling procedures, study time period, and increased awareness of ASD overtime (Daniels & Mandell, 2014b; Fountain et al., 2011). Since the sample of the current study includes children receiving a diagnostic evaluation between 2000-2015, with the majority of the sample receiving diagnoses from 2009- 2015, our study may also follow identification trends as ASD becomes more familiar. Our study points to the narrowing of identification gaps for low SES minorities with communication related concerns with earlier diagnoses in underserved families. However, it is pertinent to continue to examine the heterogeneity of parent concerns for low SES minority groups.

Let's Start Regulating, LC4, Differentiation. LC4 was distinguished by both medical and communication concerns. Previous research suggests that medical parent concerns become less prominent as children age (Coonrod & Stone, 2004; Ozonoff et al., 2009). Additionally, parents' concerns in the current study included statements about sleeping, eating, medications, and other medical complications (e.g., seizures, gastrointestinal issues). Similar to communication concerns, it is possible that medical related concerns are prominent early in child development because they are more relevant to the daily life of the family (e.g., bedtime and

meal time routines). Furthermore, medical and medication concerns may be easier to describe and compare (e.g., hours slept, foods eaten). Taken together, parents may become more focused on child development if they are having difficulties managing daily routines.

Subtype Identified Around Kindergarten

LC5, *Let's Start Adapting*, included children who were on average 5.5 years of age (i.e., children entering kindergarten) and whose parental concerns related to stereotyped behavior and development. Our results suggest that on average, parents in LC5 were first concerned about their child at 3 years of age; however, the child did not receive a diagnostic evaluation until around 5.5 years of age (i.e., 2.5-year gap). Stereotypies may become more discernable when children age. For example, other researchers indicated that when comparing patterns of stereotypies on the repetitive and restrictive behaviors scale of the ADOS, it was easier to differentiate children with ASD when they were older. That is, children with typical development showed a decrease in stereotyped behavior, whereas toddlers with ASD continued to show stereotyped behavior through preschool (Kim & Lord, 2010). In the current study, children in LC5 had stereotyped behaviors that were coupled with development concerns. Since other research points to increased developmental concerns in children with developmental disabilities when compared to children with ASD (Little et al., 2016; Wallisch et al., under review), stereotypies may become more difficult to distinguish from other diagnoses when coupled with developmental concerns. Only 12.2% of the current sample had parents who reported stereotyped behaviors as concerning, and perhaps our sample is not capturing the breadth of stereotyped behavior. While it is surprising that a core feature of ASD was infrequently reported by parents, we need to continue to understand how the variability in stereotypies presents at early ages to facilitate earlier identification. Overall, our results suggest

that certain stereotypies are less discerning until a child enters kindergarten. Perhaps some stereotypies are more accepted in the home (e.g., following a ritual or routine, organizing toys, restricted interests) and become more noticeable with increased demands in the school environment.

Subtypes Identified the Latest

Two subtypes were diagnosed the latest (i.e., LC1 and LC3), with diagnostic evaluations occurring around 9 years of age. What is particularly concerning about both subtypes is the age at which a parent first became concerned was around 3.5 years of age. This finding is troublesome as it means parents are waiting on average 5.5 years between their first concern and their child's diagnostic confirmation.

Let's Start Connecting, LC1, Differentiation. LC1 was comprised of males with social and behavior (i.e., externalizing and internalizing) parent concerns. In previous literature, children with social and behavior concerns are often identified later (Hess & Landa, 2012; Ozonoff et al., 2009). Our findings align with these studies and suggest later identification of children with social and behavior concerns. Perhaps social difficulties are less noticeable until the social demands in classrooms increase and children begin to spend more time around peers (Hess & Landa, 2012). When parents have increased opportunities to compare their child's social abilities with other children these behaviors may become more apparent. Furthermore, certain aspects of social interactions (e.g., parallel play) and behavior (e.g. tantrums) are developmentally appropriate at a younger age, and it is not until the developmental trajectories diverge that social interactions and behaviors may become more concerning to parents.

Let's Start Learning, LC3, Differentiation. LC3 included females with ASD, with development concerns but a lower probability of other parent concerns. Our findings of late

identification for LC3 aligns with previous research that suggests females with ASD present with earlier concerns yet have a later ASD diagnosis (Begeer, Mandell, Wijnker-Holmes, Venderbosch, Rem, Stekelenburg & Koot, 2013; Lai, Lombardo, Auyeung, Chakrabarti, & Baron-Cohen, 2015; Rosenberg et al., 2011). Our study also indicates the critical need to advance methods to identify females with ASD. This study continues to point to the ‘camouflage effect’ whereby females’ use of compensatory strategies to disguise symptoms results in later identification (Dean et al., 2017). Additionally, females may present with a different developmental profile that our current assessments and diagnostic criteria are not capturing (Lai et al., 2015). Since our understanding of ASD, assessments, and interventions are largely based on data with males, practitioners are trained to identify male characteristics and have yet fully represented females in the diagnostic profile. Clearly, we are missing the early signs and parent concerns of two subtypes of children with ASD; these subtypes warrant continued exploration.

Access to Service Providers

Access to service providers is an important aspect of the diagnostic process, yet this variable had less of an impact than the type of parent concern. For example, the earliest identified subtypes had either low access (LC3) or moderate access (LC4), yet these two classes were identified around the same age. Similarly, the later identified subtypes had either lower access (LC3) or moderate access (LC1), and LC5 had the highest access, but was not identified until around kindergarten. The discrepancies between age at the diagnostic evaluation and access to service providers continues to align with previous research suggesting access to diagnostic service providers may not be a driving factor in the identification of children with ASD (Fountain et al., 2011; Mandell et al., 2010). Overall, access to service providers may not be a prominent factor in the early identification of the subtypes in this sample.

In summary, the results suggest our systems are capturing subtypes of ASD with communication parent concerns earlier, but we are missing children with social and behavior parent concerns, as well as females. Further, a substantial time gap exists between CA at the diagnostic evaluation and AOFC. When subtypes consisted of children with social and behavior concerns, or females this resulted in a 5.36- 5.46-year gap between CA at the evaluation and AOFC. This is especially concerning as it takes over 5 years for our systems to capture these children. We need to become more vigilant when listening closely to parent concerns of these subtypes (i.e., LC1 and LC3).

Strengths and Limitations

Our study adds to the literature by utilizing a novel approach to examine the diversity in parent concerns across a myriad of family, child, and community characteristics. The majority of our sample consisted of white, non-Hispanic, males who were not eligible for Medicaid insurance. While this is consistent with other study samples, having a greater representation of diverse families in the sample may facilitate a better understanding of diverse subtypes of ASD. Additionally, our coding system for parent concerns accounted for multiple parent concerns in one concern statement (e.g., my child is not talking and walking), and this may have compromised the adequacy of the coding system. Albeit, this only occurred 1.5% of the time. By including one primary concern per statement the data may provide less skewed frequencies of parent concerns. Lastly, our study did not include child scores on standardized assessments completed at the diagnostic evaluation. While child assessment scores may provide additional characteristics of subtypes, other researchers have pointed to the importance of focusing on aspects of the identification and diagnostic process that are amenable to change (Daniels &

Mandell, 2014b). Therefore, focusing on aspects of ASD identification that are modifiable may provide vital information for the development of future interventions.

Implications for Future Research

Overall, it is imperative to determine distinct aspects of the communities and diagnostic centers serving the samples included in studies to determine facilitators and inhibitors of the early identification of underserved families. There are likely additional variables that warrant exploration. Previous researchers suggested that additional community characteristics facilitated earlier identification of ASD, including: 1) close proximity to other families with ASD (Liu et al., 2010), 2) proximity to a medical university (Kalkbrenner et al., 2011; Mandell et al., 2010), and 3) increased school district revenue and services (Mandell et al., 2010). There may also be additional parent characteristics that warrant exploration. For example, higher parent education levels (Thomas, Ellis, McLaurin, Daniels, & Morrissey, 2007) and higher levels of worry with parent concerns (Daniels & Mandell, 2014b) are associated with earlier ASD diagnoses, while cultural acceptance of child behaviors is related to later identification of ASD (Tek & Landa, 2012).

Future research needs to further examine the early parent concerns of girls with ASD. Our findings point to later identification of girls with ASD and a lower probability of most parent concerns. Since research points to a male bias in our understanding of ASD (Dean et al., 2017; Lai et al., 2015), our coding system may also not fully capture the early parent concerns of females with ASD. Future research should use an inductive process to code the parent concerns of females with ASD to best capture early characteristics of females we have yet to unveil.

Conclusion

Information gleaned from this study advances our knowledge on methods to identify subtypes of children with ASD earlier. By understanding ASD subtypes based on parent concerns from diverse socio-demographics, we may better inform universal screening procedures. Our study suggests that children with speech and communication parent concerns are most likely identified earlier regardless of race, ethnicity, or SES. However, our findings point to the difficulty in identifying females with ASD, as well as children with social, behavior, and stereotyped parent concerns. Future research should examine the distinct subtypes of females with ASD. Additionally, while certain social, behavioral, and stereotyped behaviors are acceptable during early years of development, more research is needed to distinguish these parent concerns earlier in child development.

With the literature pointing to conflicting findings regarding the identification of underserved children, we advise caution in interpreting these results until further replication. Even though our study points to earlier identification of underserved populations, future research should examine specific features of diagnostic centers that are associated with earlier identification, as well as factors within the diagnostic process that are acquiescent to change. By understanding the early subtypes of parent concerns across child, family, and community characteristics, we may better identify children, tailor interventions, and meet the diverse needs of the autism spectrum.

Tables and Figures

Table 1
Participant Characteristics

Variable	Total N	% (n)	Mean (SD)	Range
Age (months)	712	--	66.68 (34.28)	15- 155
Gender (male)	712	83.8 (597)	--	--
Medicaid	712	24.7 (176)	--	--
Race= White	688	76 (541)	--	--
Race= Non-White	688	20.6 (147)	--	--
Hispanic	688	11.9 (85)	--	--
Access to service providers ^a	706	--	43.59 (16.55)	2.60- 134.60

Note. ^a= Number of diagnostic service providers per 10,000 children.

Table 2
Parent Concern Codes and Frequencies

Code	Definition	Example	% (n)
Behavior/temperament	Behavioral regulation with inward behavior regulation	“Daily tantrums sometimes lasting an hour or more.”	33.3 (237)
Motor	Motor milestones or clumsiness	“Will not stand alone.”	8.3 (59)
Development	Cognitive development and milestones	“Developmentally behind.”	18.5 (132)
Speech and communication	Intentional communication, both receptive and expressive	“Won’t try to repeat words.”	37.1 (264)
Social interactions	Social aspects such as engagement, interest in others, social or emotional reciprocity, and social attention	“My son doesn’t have friends his age.”	32.2 (229)
Stereotyped behaviors	Rigid, repetitive, or restrictive behaviors	“Difficulty with transitions.”	12.2 (87)
Medical	Related to medical symptoms and medications rather than behavioral symptoms	“Is he having seizures?”	15 (107)
Sensory aversions/preferences	Sensory interests or sensory aversion	“He smells everything.”	6.5 (46)

Note. Adapted from Ozonoff et al. (2009).

Table 3
Observed Indicators for LCA Model

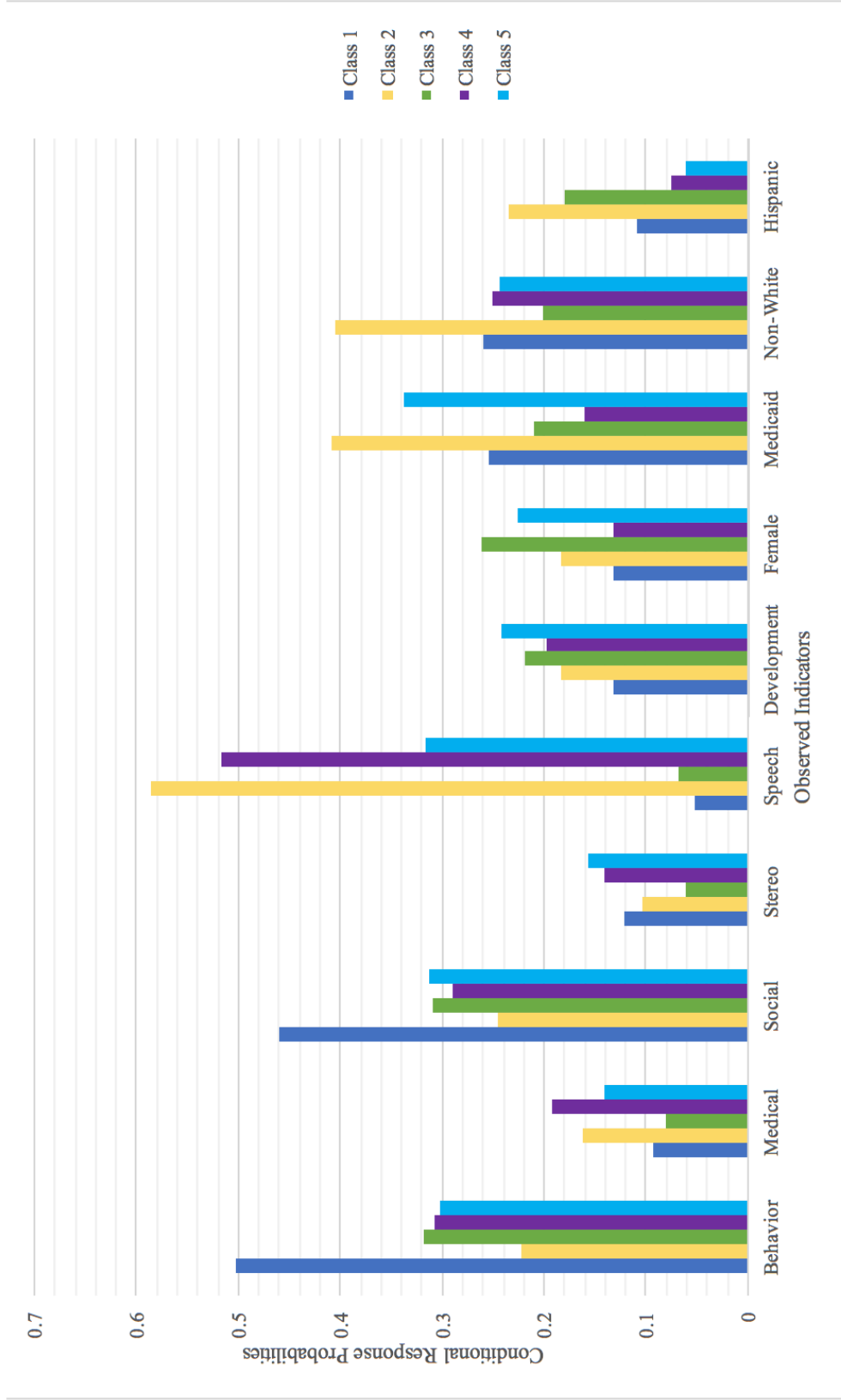
Type	Indicator	Description	Variable Type
Child	Child age	Child age at the diagnostic evaluation	Continuous
	Child gender	Child gender reflected on intake paperwork at the diagnostic evaluation	Binary
Family	Parent concerns	8 binary coded concerns (see table 2) written on intake paperwork prior to diagnostic evaluation	Binary
	Socioeconomic status	Code of parent use of Medicaid or non-Medicaid insurance for the diagnostic evaluation	Binary
	Race and ethnicity	Two binary variables, one for race (white, non-white) and one for ethnicity (Hispanic, non-Hispanic)	Binary
Community	Access to service provider	Number of pediatricians, psychiatrists, family medicine physicians, and psychologists per 10,000 children in each state county	Continuous

Table 4
LCA Fit Statistics

	Two Classes	Three Classes	Four Classes	Five Classes ^a	Six Classes ^b	Seven Classes ^b
<i>df</i>	27	40	53	66	79	92
Loglikelihood	-10007.549	-9943.106	-9886.39	-9821.938	-9788.640	-9742.023
AIC	20069.549	19966.211	19878.771	19775.938	19735.279	19668.045
BIC	20192.436	20148.935	20120.879	20077.370	20096.157	20088.309
ABIC	20106.705	20021.925	19952.591	19326.626	19845.313	19796.186
Entropy	0.805	0.832	0.849	0.886	0.888	0.912
VLMR	-10162.433	-10007.549	-9943.106	-9886.386	-9822.626	-9757.873
VLMR <i>p</i> -value	0	0.0024	0.4629	0.0026	0.0437	0.2480
LMR	306.183	127.395	112.127	127.402	67.291	31.383
LMR <i>p</i> -value	0	0.0026	0.4662	0.0028	0.0450	0.2518
BLRT	-10162.433	-10007.549	-9943.106	-9886.386	-9822.626	-9757.873
BLRT <i>p</i> -value	0	0	0	0	0	0.3750

Note. ^a= selected class solution; ^b= solution contained latent classes with <5% of the sample; *df*= degrees of freedom; AIC= Akaike Information Criterion; BIC= Bayesian Information Criterion; ABIC= Adjusted Bayesian Information Criterion; VLMR= Vuong-Lo-Mendell-Rubin Likelihood Ratio Test; LMR= Lo-Mendell-Rubin Adjusted Likelihood Ratio Test; BLRT= Bootstrap Likelihood Ratio Test.

Figure 1
 Conditional response probabilities by observed indicators across latent classes.



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Appendix A

Univariate Z-Tests

<i>Latent Class Z-tests</i>		Observed Indicators									
Class	Behavior	Medical	Social	Stereo	Speech	Development	Female	Medicaid	White	Hispanic	
1	1.263**	-0.642	0.960**	0.173	-3.251**	-0.393	-0.396	-0.707*	0.659*	-0.925*	
3	0.490	-0.787	0.315	-0.573	-2.967**	0.215	0.449	-1.280**	0.995*	-0.344	
4	0.441	0.209	0.224	0.341	-0.281	0.087	-0.394	-0.957*	0.712**	-1.334**	
5	0.416	-0.179	0.331	0.470	-1.113**	0.348	0.261	-0.308	0.748	-1.556*	

Note. Comparison group is latent class 2; * = $p < 0.05$; ** = $p < 0.01$.

Appendix B

Comprehensive Examination I

Executive function measures for children: A scoping review of ecological validity

Wallisch, A., Little, L. M., Dean, E. & Dunn, W. (2017). Executive function measures for children: A scoping review of ecological validity. *OTJR: Occupation, Participation and Health*, 38(1), 6-14. doi: 10.1177/1539449217727118

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Abstract

Background. Children use executive function (EF) skills within everyday occupations, however EF poses a difficult and complex construct to measure. Currently, many measures of EF lack applicability to daily life, or ecological validity. **Objective.** The aim of this scoping review was to examine two aspects of ecological validity across measures, assessments, and tasks of EF in children. **Methodology.** A scoping review of 355 peer-reviewed articles published between 1996-2016 was performed. **Results.** Searching revealed 43 articles addressing the ecological validity of EF measures for children, and 40 measures addressing ecological validity.

Implications. An increasing number of articles address ecological validity of EF measures. Future research should address the interplay between context and EF performance. Additionally, research should begin recognizing the importance of parental involvement in assessments, as well as ways to capture the EF strengths of children.

Introduction

Children use executive functions to complete everyday activities, however, higher order processes pose a difficult construct to measure, partially due to the wide range of skills encompassed by executive function (EF) (e.g., inhibition, working memory, shifting, and planning) (Baron, 2007; Chaytor & Schmitter-Edgecombe, 2003; Kenworthy, Yerys, Anthony, & Wallace, 2008). Furthermore, researchers argue that current methods of measuring EF lack applicability to daily life, or ecological validity (Burgess, Alderman, Evans, Emslie, & Wilson, 1998; Kenworthy et al., 2008). Therefore, this scoping review examines evidence related to the ecological validity of current tasks and behavioral assessments used to measure aspects of EF in children. Additionally, we conclude by highlighting the role of occupational therapy (OT) principles and perspectives in the context of the ecological validity of EF measures for children.

Ecological validity refers to the extent to which an assessment produces logically sound data representing individuals' interactions with their surroundings. Specifically, Chaytor & Schmitter-Edgecombe (2003) defined the concept as the degree to which results obtained through experiments and assessments are related to those obtained in authentic contexts. Furthermore, components of "representativeness" (the extent to which an assessment corresponds to situations outside the lab or clinic) and "generalizability" (the degree to which concerns on the assessment are concerns in everyday life) were added to the definition (Burgess et al., 2006 adapted from Kvavilashvili & Ellis, 2004). Ecological validity is related to how an assessment provides clinical utility beyond diagnostic utility.

There are two approaches to identify the degree of ecological validity of a measure: verisimilitude and veridicality (Chaytor & Schmitter-Edgecombe, 2003; Kenworthy et al., 2008).

Verisimilitude reflects the extent to which the theoretical foundations of an assessment mirror cognitive demands in everyday life, which typically requires the creation of new assessments with ecological goals in mind from the beginning. Verisimilitude is not a measure of discriminant validity (i.e., discriminate between those with and without a diagnosis); rather, it represents how EF aligns with tasks in real life. Therefore, assessments with a high degree of verisimilitude typically are more sensitive to performance change as one increases functional skills.

Veridicality relates to the extent to which existing assessments are empirically related to measures of everyday life. Typically, statistical analyses are used to relate the performance of a traditional assessment to a real-world assessment (Chaytor & Schmitter-Edgecombe, 2003). While some tests were not designed to test cognition as it pertains to everyday function, these assessments may still have value and predictive abilities of everyday function. In psychometric terms, veridicality is related to concurrent validity (i.e., two measures reflecting the same incidences of behavior) (Portney & Watkins, 2009), but refers solely to a degree of ecological validity. Thus, verisimilitude and veridicality provide distinct methods to further understand the complexities of ecological validity across measures of EF.

This scoping review examined two aspects of ecological validity (i.e., veridicality and verisimilitude) across measures, assessments, and tasks of EF in children (2-12 years old). We addressed the research question: What do we know from the literature about the ecological validity of current tasks and behavioral measures examining EF in children?

Methods

We conducted a scoping review to understand the breadth and depth of ecologically valid measures for children ages 2-12 years. A scoping review aims to examine the extent and range of

research regarding our topic, allowing us to map key concepts and understand research gaps surrounding ecological validity (Arksey & O'Malley, 2005). We followed a 5 step process of conducting a scoping review (Arksey & O'Malley, 2005; Levac et al., 2010), which included: 1) Identifying the research question; 2) Identifying relevant studies; 3) Study selection; 4) Charting the data; and 5) Collating, summarizing and reporting results.

Identifying Relevant Studies

We searched PubMed and PsycInfo from 1996 to September 2016. See Table 1 for search terms. To ensure that we were thorough in the search process, we conducted a forward and backward hand-search by examining the reference lists as well as articles citing an included article. We also searched the reference lists of other systematic reviews to provide a comprehensive scoping review (Arksey & O'Malley, 2005).

Inclusion. We included studies providing evidence of the ecological validity or everyday life application of assessments, tasks, or measures of EF. Additionally, we included studies that measured global EF or one aspect of EF (e.g., only inhibition). Lastly, we included studies of children 2-12 years to understand measures associated with early and middle childhood. While executive function across childhood varies due to development, many assessments also span a wide range of childhood (Anderson, 2002; Kenworthy et al., 2008).

Exclusion. We excluded intervention studies, pharmacological studies, dissertations, theses, book chapters, and reviews. We also excluded IQ assessments or studies focused solely on language processing as well as studies that used neuroimaging methods to test EF, or focused on neural mechanisms of EF. Lastly, studies pertaining to non-human subjects and studies not written in English were excluded.

Study Selection

PubMed (n=281) and PsycInfo (n=166) yielded a total of 447 articles, and when duplicates were removed (n=92 duplicates) the search yielded a total of 355 articles. A review of 100% of abstracts occurred between 2 of the authors to assure reliability in selection. Reviewers tested percentage agreement with 73.5% of the articles and achieved 95.79% agreement; the reviewers discussed the remaining 4.21% of articles and agreed on inclusion or exclusion.

Results

Characteristics of research studies

After the selection process, 43 articles matched review criteria. Approximately 86.05% (n=37 studies) occurred within the last 10 years, showing a recent surge of literature aimed towards creating and understanding the ecological validity of measures of EF. Articles on the topic of interest were found in 23 journals. Additionally, 42 different EF measures for children ages 2-12 years were examined within the studies; 6 measures were parent, caregiver, or teacher questionnaires, an additional questionnaire occurred with a battery of EF tasks, and 35 measures were clinician rated behavioral tasks. See Figure 1 for data chart.

Populations

Studies examined a wide range of conditions, including Attention Deficit Hyperactivity Disorder (ADHD; n=12), typical development (n=11), Autism Spectrum Disorder (ASD; n=7), traumatic brain injury (TBI; n=5), brain tumors (n=4), epilepsy/seizures (n=2), schizophrenia (n=1), Developmental Coordination Disorder (DCD; n=1), congenital heart disease (n=1), learning disorders (n=1), Spina Bifida (n=1), Down Syndrome (n=1), Cerebral Palsy (CP; n=1), and children born very preterm (n=1). Some studies included more than one population.

Versimilitude: Measures theoretically aligning with everyday function

Approximately 17 of the measures (42.5%) utilized a verisimilitude approach (See Table 2). We determined if a measure used a verisimilitude approach if the measure's description outlined attributes of ecological validity, and if the measure was not adapted from another task. All parent, caregiver, or teacher report questionnaires used a verisimilitude approach (n=7 measures) and aimed to understand EF behavior in real life. Two of the measures (i.e., Children's Cooking Task, Do Eat Assessment) used daily living activities to assess EF. Another assessment (i.e., Rivermead Behavioral Memory Test for Children) addressed memory relating to daily events (e.g., appointments, delivering a message). One measure utilized virtual reality to create a more real world context to assess executive function (Jaroslawska, Gathercole, Logie, & Holmes, 2016). The remaining 7 measures utilized different search, sorting, navigating, instruction following, and probability tasks.

Veridicality: Measures relating to everyday life

Approximately 23 of the measures (57.5%) used a veridicality approach (See Table 3). We determined if a measure used a veridicality approach if the measure was either a traditional measure adapted to exhibit more ecologically valid attributes, or if the traditional measure was compared to a verisimilitude measure. In 5 studies, the Behavior Rating Inventory of Executive Function (BRIEF), which is considered an ecologically valid measure, was used to compare against traditional measures such as the Rey-Osterrieth Complex Figure Task (Davies, Field, Andersen, & Pestell, 2011), Biber Cognitive Estimations Test (MacAllister, Vasserman, Coulehan, Hall, & Bender, 2016) Clinical Evaluation of Language Fundamentals, NEPSY Visual Attention, and Willoughby Computerized Battery of Executive Functioning Task (Tamm, Brenner, Bamberger, & Becker, 2016), Children's Category Test, Controlled Oral Word Association Test, Twoer, Test of Everyday Attention for Children (Payne, Hyman, Shores, &

North, 2011), Trail Making Test, and Wisconsin Card Sort Task (Vriezen & Pigott, 2002). Other studies used diagnostic rating scales of behavior (i.e., ADHD or ASD), observations, and teacher ratings to test alignment with traditional EF tasks (Floyd & Kirby, 2001; Pnevmatikos & Trikkaliotis, 2013; Solanto et al., 2001; Weis & Totten, 2004). Some studies adapted aspects of traditional measures to increase ecological validity. Specifically, de Vries & Geurts (2012) modified a traditional switch task to create a more complex task representing everyday life, and Díaz-Orueta et al. (2014) and Nolin, Stipanovic, Henry, Joyal, & Allain (2012) utilized virtual reality to replace a laboratory context with a natural school context to perform an EF task.

Discussion

The purpose of this scoping review was to examine the literature related to the ecological validity of current tasks and behavioral assessments used to measure aspects of EF in children. The increase in studies within the last 10 years demonstrates an emerging importance on testing the ecological validity of measures of EF for children. Findings suggest that the ecological validity of measures were tested on a wide variety of populations for EF differences, specifically 14 populations. Of these populations, children with ADHD, ASD or a TBI were the most widely examined diagnostic groups. Clearly illustrating the significance of understanding EF in the daily lives of children.

Our findings showed the BRIEF/BRIEF-P/BRIEF-SR (n=17 studies) and the BADS-C (n=7 studies) as the most widely cited assessments throughout this review, which aligns with a previous review by Kenworthy et al. (2008). The BRIEF and the BADS-C both utilize questionnaires, and provide standardized developmental norms of executive function in children (Kenworthy et al., 2008). Thus, when reviewed measures assessed the veridicality of a traditional assessment many utilized correlations with the BRIEF. However, these veridicality measures

were all found to have null associations with the BRIEF (n=10), except one measure demonstrated partial null findings (i.e., some subtests showed veridicality and others were null). Other authors discuss null findings with the BRIEF (e.g. McAuley, Chen, Goos, Schachar, & Crosbie, 2010) and propose it is unclear if null measures truly lack ecological validity, or if differences in measurement format reduces the potential for ecological validity (i.e., parent ratings versus a task) (McAuley et al., 2010; Chevignard, Soo, Galvin, Catroppa, & Eren, 2012).

Although parent ratings provide pertinent information and insight into everyday child behavior, many issues arise when relying heavily on parent ratings to determine the ecological validity of tasks. Research indicates inconsistencies on rating scales from different informants (i.e., parents, teachers, and self-report) (Achenbach, McConaughy, & Howell, 1987; DiBartolo & Grills, 2006), thus a potential disadvantage to heavily relying on the BRIEF to examine ecological validity of tasks. Chevignard et al. (2012) argue two different types of measurements may assess different underlying constructs of executive function. Thus, tasks and questionnaires may provide more applicable information when taken together, rather than separately.

Measures of EF vary greatly; some measures use navigating and/or sorting (e.g., Key Search Task and Battersea Multitask Paradigm,) while others examine function in an everyday task (e.g. BRIEF, The Children's Cooking Task). Findings from the current analysis suggest that many of the reviewed measures guided by verisimilitude occurred within a structured environment, therefore potentially reducing ecological validity. Additionally, those measures guided by veridicality adapted aspects of traditional assessments to reflect more real life scenarios (e.g. Virtual Continuous Performance Test, Gender Emotion Switch Task), however we argue these adaptations still may not truly reflect performance in everyday life. This argument is analogous to Chevignard et al. (2012), who indicated many paper-pencil assessments

of executive function were considered ecologically valid, however performance under a restricted environment may not predict performance in everyday life. Therefore, executive function remains a difficult construct to measure and we should continue to develop innovative methods to better depict everyday life.

Additionally, only one battery of tasks included in this review used parent report (i.e., BADS-C), whereas no other tasks accounted for parent insight. Parents provide the opportunity to elucidate a child's daily behavior within authentic contexts, the input of parent, caregiver, and teacher report during the assessment process is necessary to further understand EF in real life contexts (Anderson, 2002). Overall, parent insight was under utilized when assessing child EF, and is paramount to measuring EF in an ecologically valid manner.

Lastly, increased research is needed to understand the interplay between context and EF in children. The measures reviewed rarely aimed to measure EF and contextual features. Previous recommendations for increasing ecological validity in measurement emphasizes the importance of environmental assessments (Olson, Jacobson, & Van Oot, 2013). By understanding the various EF demands within myriad contexts, we may better pinpoint a child's EF abilities, and elucidate the relationship between measures and everyday life.

Limitations and Future Directions

In this scoping review, we aimed to understand the ecological validity of assessments for children. While it was beyond the realm of this review, examining differences in reliability, validity and standardization among measures may be useful to further understand assessments and ecological validity. Furthermore, including additional databases (e.g., Educational Resources Information Center [ERIC], Excerpta Medica database [EMBASE]) may have resulted in increased evidence reviewed in the current study. Moreover, expanding search terms (e.g., test,

scale, instrument), and including other forms of literature (e.g., dissertations, theses, book chapters), may have expanded the search and resulted in additional literature. Lastly, we only included studies regarding measurements with ecological validity components; however analyzing all EF measures for ecological validity may have provided additional depth and understanding of EF in everyday life.

Additionally, all reviewed assessments measured deficits in EF. A holistic assessment approach, however, would gather information of individual strengths and limitations during tasks that require EF. Children often use strategies and coping mechanisms to circumvent EF challenges; future research may contribute to an understanding of children's strengths and a basis for intervention.

Conclusion

Performance of daily tasks within natural contexts is central to OT practice, and the ideology of OT coincides with the ecological validity press in other fields. Dialogue reflecting issues of measurement is not new in the area of occupational therapy (OT). However, discussion of ecologically valid measures remains less prominent. Coster & Khetani (2008) described issues and potential suggestions to increase the validity and usefulness of participation measures, and these issues align with those posing a risk to ecological validity. Specifically, Coster & Khetani (2008) depict the potential advantage of context specific measures, as well as parent involvement when designing measures. Increased parental involvement, and creating measurements sensitive to different contexts, may be advantageous when creating more ecologically valid measures of EF. Thus, guiding OT measures by ecological validity principles may assist in generating future measures more sensitive to each child's executive function performance in daily life.

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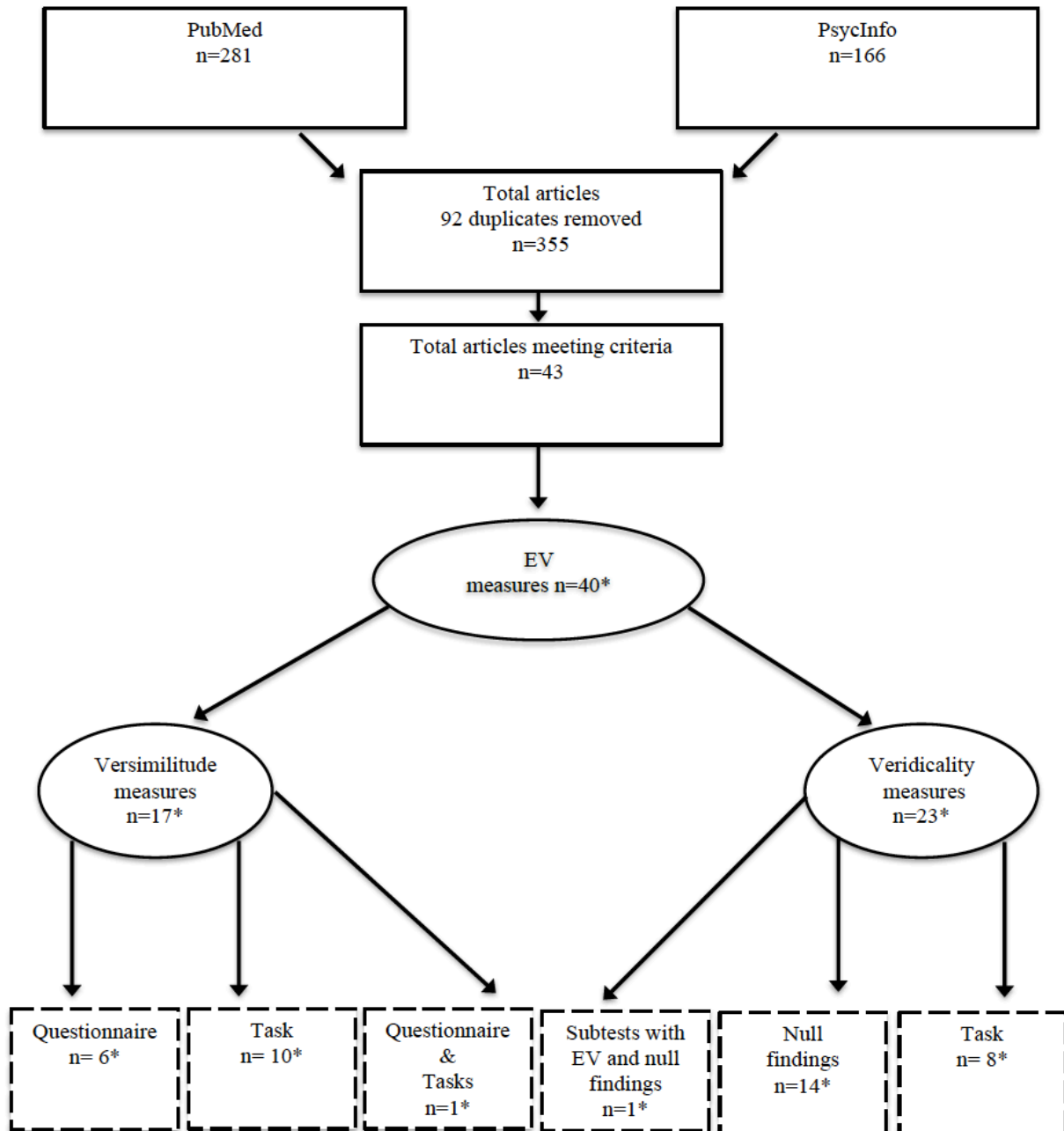
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Table 1. Search Terms

Population	Behavior	Property	Type
children, pediatric, kid	executive function, executive control, cognitive control, inhibition, planning, shifting, cognitive flexibility, working memory	ecological validity, real life, real world, authentic context, natural context, authentic environment, natural environment, everyday life	assessment, task, paradigm, measure

Figure 1. Step 4: Charting the Data



Note. EV= ecological validity; *= refers to measures instead of articles

Table 2. Measures with Verisimilitude Evidence

Measure	Articles	Age in yrs	Diagnostic population	Format
Behavioral Assessment of Dysexecutive Syndrome- Child	Baron (2007); de Almeida, Macedo, Lopes, & Monteiro (2014); Gilboa, Rosenblum, Fattal-Valevski, Toledano-Alhadeff, & Josman (2014); Roy, Allain, Roulin, Fournet, & Le Gall (2015); Siu & Zhou (2014); White, Burgess, & Hill (2009); D. L. Williams, Mazefsky, Walker, Minshew, & Goldstein (2014)	8-15	Developmental and neurological disorders; ADHD; ASD	Task and questionnaire
Rivermead Behavioral Memory Test for Children	Chen, Tsai, Hsu, Ma, & Lai (2013)	5-10	DCD	Task
The Children's Cooking Task	Chevignard, Catroppa, Galvin, & Anderson (2010)	8-20	TBI	Task
Iowa Gambling Task- child	Crone & van der Molen (2004)	6-25	TD	Task
Behavior Rating Inventory of Executive Function	Fournet et al. (2015); Gerstle, Beebe, Drotar, Cassidy, & Marino (2016); Gilboa et al. (2014); Rosenthal et al. (2013); van den Bergh, Scheeren, Begeer, Koot, & Geurts (2014); Wehrle et al. (2016); Whittingham, Bodimeade, Lloyd, & Boyd (2014); Wolfe et al. (2013)	5-18	TBI, ASD, brain tumors; CHD; children born very preterm	Questionnaire
Behavior Rating Inventory of Executive Function- Preschool	Isquith, Gioia, & Espy (2004); Pritchard, Kalback, McCurdy, & Capone (2015); Smithson et al. (2013)	2-5	TD; DS	Questionnaire
Behavior Rating Inventory of	Li, Cao, Shao, & Xue (2014)	9-20	Schizophrenia	Questionnaire

Executive Function-Self Report	Goulden & Silver (2009)	10-12	ADHD, learning disorders, epilepsy, TBI, HIV, brain tumors, TD, developmental disorders	Questionnaire
Children's Executive Function Scale	Jaroslawska et al. (2016)	7-11	TD	Task
Real-world following-instructions task	Kronenberger, Castellanos, & Pisoni (2016)	6-17	Spina bifida	Questionnaire
Learning, Executive, and Attention Functioning Scale	Lawrence et al., 2002, 2004)	6-12	ADHD	Task
Route Tasks	Lui & Tannock, (2007)	7-12	TD	Task
Key Search Task	Mackinlay, Charman, & Karmiloff-Smith (2006)	12	ASD	Task
Battersea Multitask Paradigm	Rosenblum, Frisch, Deutsch-Castel, & Josman (2015)	5-9	ADHD	Task
Do Eat assessment	Rosetti et al. (2016)	5-12	ADHD	Task
Ball-Search Field Task	Van Lieferringe et al. (2016)	6-16	ADHD	Questionnaire
Cognition and Motivation in Everyday Life	White et al. (2009)	8-46	ASD	Task
Modified Hayling Sentence Completion Task				

Note. ADHD= Attention Deficit Hyperactive Disorder; TD= typically developing; TBI= traumatic brain injury; ASD= Autism Spectrum Disorder; DCD= Developmental Coordination Disorder; DS= Down Syndrome; CHD= Congenital Heart Disease

Table 3. Measures with Evidence of Veridicality

Measure	Articles	Age in yrs	Diagnostic population	Format	Examining Ecological Validity
Rey-Osterrieth Complex Figure	Davies, Field, Andersen, & Pestell (2011)	6-17	Brain injuries	Task	BRIEF*
Gender Emotion Switch Task	de Vries & Geurts (2012)	8-12	ASD	Task	Adapted a traditional switch task
Virtual Continuous Performance Test	Diaz-Orueta et al. (2014); Nolin, Martin, & Bouchard (2009)	6-16	ADHD	Task	Adapted the Conner's Continuous Performance task
Tower Go/NoGo task	Floyd & Kirby (2001)	3-5	TD	Task	Behavioral Assessment System for Children (BASC)*
Pinball Go/NoGo task	Floyd & Kirby (2001)	3-5	TD	Task	Behavioral Assessment System for Children (BASC)
Dog and Dragon Go/NoGo task	Floyd & Kirby (2001)	3-5	TD	Task	Behavioral Assessment System for Children (BASC)*
Snack Delay	Floyd & Kirby (2001)	3-5	TD	Task	Behavioral Assessment System for Children (BASC)
Tongue Delay	Floyd & Kirby (2001)	3-5	TD	Task	Behavioral Assessment System for Children (BASC)
Shapes Stroop	Floyd & Kirby (2001)	3-5	TD	Task	Behavioral Assessment System for Children (BASC)
Children's Category Test	Payne, Hyman, Shores, & North (2011)	6-16	Brain tumor	Task	BRIEF*
Controlled Oral Word Association Test	Payne et al. (2011)	6-16	Brain tumor	Task	BRIEF*
Tower	Payne et al. (2011)	6-16	Brain tumor	Task	BRIEF*
Test of Everyday Attention for Children	Payne et al. (2011)	6-16	Brain tumor	Task	BRIEF ⁺
Biber Cognitive Estimations Test	MacAllister, Vasserma, Coulehan, Hall, & Bender (2016)	7-16	Epilepsy	Task	BRIEF*

Go/NoGo Emotions	Pnevmatikos & Trikkaliotis (2013)	8-12	TD	Task	Adapted from a traditional go/no-go
Stop Signal Paradigm	Solanto et al. (2001)	7-10	ADHD	Task	SNAP-IV*, Classroom Observation Code, Conner's Parent and Teacher Questionnaires*
Choice-Delay Task	Solanto et al. (2001)	7-10	ADHD	Task	SNAP-IV, Classroom Observation Code, Conner's Parent and Teacher Questionnaires*
Clinical Evaluation of Language Fundamentals	Tamm et al. (2016)	4	ADHD	Task	BRIEF-P*
NEPSY Visual Attention	Tamm et al. (2016)	4	ADHD	Task	BRIEF-P*
Willoughby Computerized Battery of Executive Functioning Tasks	Tamm et al. (2016)	4	ADHD	Task	BRIEF-P*
Trail Making Test	Vriezen & Pigott (2002)	4-14	TBI	Task	BRIEF*
Wisconsin Cart Sort Task	Vriezen & Pigott (2002)	4-14	TBI	Task	BRIEF*
Continuous Performance Test-II	Weis & Totten (2004)	6-8	TD; ADHD	Task	Analogue task coded observation, classroom observations, parent/teacher report of ADHD symptoms*

Note. ADHD= Attention Deficit Hyperactive Disorder; TD= typically developing; TBI= traumatic brain injury; ASD= Autism Spectrum Disorder; *=null findings; += partial null findings.

Appendix C

Comprehensive Exam II

Child eating behavior and inhibitory control: An examination of convergent validity

Introduction

Inhibition is the ability to suppress unwanted thoughts, actions, and emotions within our daily lives (Munakata et al., 2011). Inhibition is an aspect of executive function which encompasses our higher-order, non-automatic, and goal-directed cognitive processes (Sanderson & Allen, 2013; Welsh & Pennington, 1988; Chikazoe et al., 2009). Many studies demonstrate executive function and inhibition in controlled situations (e.g., Bari & Robbins, 2013; Christ, Holt, White, & Green, 2007; Sanderson & Allen, 2013); however, understanding inhibition related to real life situations may allow us to more precisely distinguish the intricacies of higher order processes as they relate to individuals' everyday lives.

Research suggests inhibition plays a critical role in eating behavior (Loeber, Grosshans, Herpertz, Kiefer, & Herpertz, 2013). Specifically, a variety of eating patterns stem from inhibition or cognitive control including: disinhibited eating (i.e., restraint breaking down when confronted by emotional or external eating cues), binge eating (i.e., a large quantity of food intake in one sitting, often with a sense of loss of control), and emotional eating (i.e., consuming high calorie foods in response to emotional states) (Carnell, Gibson, Benson, Ochner, & Geliebter, 2012). Variations in inhibitory control often times are related to obesity, anorexia, and bulimia, thus clearly an important construct when measuring eating behavior in children (Carnell et al., 2012; Lock, Garrett, Beenhakker, & Reiss, 2011).

Methods for assessing inhibition and executive function in eating behavior are often criticized for the lack of applicability to daily life, or ecological validity (Burgess et al., 2006; Gioia, Isquith, Guy, & Kenworthy, 2000). Daily life typically requires more complex processes than elicited by structured, controlled tasks; therefore, task results may not transfer across contexts (Burgess, Alderman, Evans, Emslie, & Wilson, 1998; Shallice & Burgess, 1991). To

reduce concerns of generalizability, ecological validity is recognized as a critical component of measurement. However, very few inhibitory control measures for children are theoretically driven by ecological validity, and sparse research depicts the ecological validity of traditional measures or adapted traditional measures (Kenworthy, Yerys, Anthony, & Wallace, 2008a; Olson, Jacobson, & Van Oot, 2013). Of the ecologically valid assessments of executive function for children, most utilize parent questionnaires, and few ecologically valid tasks exist for children (Wallisch, Little, Dean & Dunn, under review). Therefore, it is critical to design assessments that reflect inhibitory control within everyday contexts of eating.

Delay tasks provide one method to assess inhibitory control. Here, individuals are typically required to suppress a prepotent response at designated times (Sanderson & Allen, 2007). One specific delay paradigm is the go/no-go task, which requires individuals to respond to predetermined 'go' stimuli and not respond, or inhibit, to predetermined 'no-go' stimuli. Different types of go/no-go tasks exist for children, with some more task-oriented (e.g., stacking blocks) and others more computer-based (e.g., clicking a button to shapes, letters or colors) (Christ et al., 2007; Floyd & Kirby, 2001; Simpson et al., 2012). However, the go/no-go task was not designed with ecological validity in mind, and more research is needed to understand how the task relates to everyday life.

Previous studies have used the go/no-go task to measure inhibition related to food stimuli (Houben & Jansen, 2015; Veling, van Koningsbruggen, Aarts, & Stroebe, 2014; Watson & Garvey, 2013). Specifically, these go/no-go tasks used food images compared to nonfood images, or empty plates. One study observed participant differences in physiological responses (i.e., event-related potential [ERP]) between food images and nonfood images as well as differences in responses between men and women (Watson & Garvey, 2013). Results indicated

that food related stimuli recruited different cortical activations during no-go responses in comparison to non-food. Additionally, women demonstrated increased physiological responses associated with increased cognitive control in comparison to men while viewing food images. Fewer studies have used the go/no-go task to measure inhibitory control related to children's eating behavior. For instance, Nederkoorn, Coelho, Guerrieri, Houben, & Jansen (2012) examined a stop signal task, similar to the go/no-go task, and results indicated overweight children demonstrated increased challenges when inhibiting to food related stimuli. Overall, the go/no-go task has been used to establish associations between inhibitory control and eating behavior among adults while fewer studies have investigated this relationship among children.

The abovementioned studies have used the go/no-go task as a measure of inhibitory control related to eating behavior; however, very little research has examined the measurement properties of the go/no-go task (Duckworth & Kern, 2011; Langenecker, Zubieta, Young, Akil, & Nielson, 2007). Particularly, the wide variety of go and no-go stimuli, and differences in task designs and complexities may measure different processes (Simmonds, Pekar, & Mostofsky, 2008). Schulz et al. (2007) found moderate convergent validity of a go/no-go task with emotional stimuli (e.g., happy and sad faces) when compared with a traditional non-emotional go/no-go task. Similar to the emotional stimuli adaptations, many other adaptations exist in the literature, however sparse literature has tested convergent validity. Therefore, it remains unclear if each adaptation taps the inhibitory mechanisms hypothesized.

In addition to utilizing the go/no-go task to measure inhibition related to food, other researchers are beginning to use food related go/no-go tasks as a potential inhibition training method. For instance, when individuals asked to refrain from responding (i.e., 'no-go' response) to chocolate images, consumed less chocolate following the task trial in comparison to

individuals with ‘no-go’ responses to nonfood images (Houben & Jansen, 2015). Moreover, researchers coupled a go/no-go task with palatable food images and a diet program, and indicated the go/no-go primarily facilitated weight loss (Veling et al., 2014). Similarly, researchers found children consumed less food post- go/no-go inhibitory training (Jiang, He, Guan, & He, 2016). Overall, the go/no-go task is used to measure and train inhibitory control related to food, yet the measurement properties of food related tasks remains unclear. Therefore, in order to develop valid inhibitory control measures and potential intervention tasks, we need to elucidate the constructs the go/no-go task measures.

Clearly, there is limited research aiming to measure inhibition as related to child eating behavior. This may be partially due to a lack of studies that have examined the convergent and ecological validity of go/no-go tasks using food stimuli with children. The abovementioned tasks used generic palatable food stimuli to evoke inhibition; however, children’s eating behavior is highly variable, whereas preferred foods may create higher inhibitory demands for children. While the literature describes inhibitory control as an important construct related to understanding food motivated behavior in children, many aspects related to measuring inhibitory control related to child eating behavior remain questionable, including: 1) the ecological validity of the go/no-go task; 2) the convergent validity of the go/no-go task when stimuli are adapted to food; and 3) the convergent validity of the go/no-go task when a tailored approach is used to determine stimuli. Therefore, we addressed two research questions: 1) What is the association (i.e., convergent validity) between a traditional go/no-go task (i.e., shape stimuli) to food go/no-go tasks (i.e., Food Preference and Food Aversion go/no-go tasks); and 2) What is the association of three go/no-go tasks (i.e., shapes, food preference, and food aversion) with the

Behavior Rating Index of Executive Function (BRIEF), a traditional ecologically valid parent questionnaire of everyday executive function behavior in children?

Methods

Participants

We recruited subjects from a database of individuals who previously participated in studies at the University of Kansas Medical Center. We included children ages of 4-12 years of age (mean=94.64 months; SD= 27.06; n=24 females; n=20 males). Child Body Mass Index (BMI) ranged from 12.38-23.27 (mean=17.06; SD=2.50). Children were excluded if they were diagnosed with any neurological, psychological, or eating disorders. Initial screening phone calls occurred prior to study procedures to ensure children met inclusion criteria. Parents reported on and children verified their preferred and aversive food prior to starting study tasks (See Table 1).

Procedures

Parents identified a preferred and aversive food for their child, and each child verified parent selections. All testing procedures occurred in a quiet room and children were seated in front of a computer screen, while parents completed questionnaires in a separate room. We explained the rules of the go/no-go task, and provided a short practice trial where children were shown each shape once and prompted if needed to follow rules. Following the practice trial children were allowed to ask any questions. The three go/no-go tasks were presented in the same order for each child: Shapes go/no-go task, Food Preference go/no-go task, and Food Aversion go/no-go task.

Measures

Shapes Go/No-Go Task (adapted from Christ et al., 2007). Children were shown four shapes (i.e., square, circle, triangle, diamond) and were instructed to click the mouse when three shapes

appeared (i.e., circle, triangle, diamond) but not press the mouse when the square appeared. The task consisted of 75% ‘go’ opportunities (i.e., child should click the mouse) and 25% ‘no go’ opportunities (i.e., child should suppress a response and not click the mouse). Each trial allowed children to either respond or not respond within 2,000 ms. The interstimulus interval was a black and white crosshairs which appeared for 1,000 ms to reorient children. Children completed 60 Go/No-Go trials total; each shape appeared 15 times at random.

Food Preference go/no-go Task. Children followed the same procedures as in the Shapes go/no-go Task, however children were shown four foods instead of shapes. To adapt the paradigm, we used standardized neutral images of grapes, toast with peanut butter, and a bagel. The fourth image was an individualized image of the child’s favorite food, which was pre-determined and selected prior to testing. Children were instructed to not click the mouse when their favorite food appeared, and to click the mouse when the neutral food images appeared (i.e., grapes, toast with peanut butter, bagel). This paradigm was designed to test inhibition for children’s responses to their favorite foods versus neutral food images.

Food Aversion Go/No-Go Task. The Food Aversion go/no-go task followed the same procedures as the Shapes go/no-go tasks and the Food Preference go/no-go task. However, children were shown a food aversive to them instead of a preferred food, and instructed to not click the mouse when the aversive food appeared. Children were asked to click the mouse when the neutral food images appeared (i.e., grapes, toast with peanut butter, bagel).

The Behavior Rating Index of Executive Function (BRIEF) (Gioia, Isquith, Guy & Kenworthy, 2000). The BRIEF is an 86-item questionnaire for parents of school-aged children. The BRIEF assesses executive function abilities in the home environment with 9 subscales including: Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize,

Organization of Materials, and Monitor. The BRIEF provides an overall Global Executive Composite score and two indices: Behavioral Regulation Index (i.e., the ability to shift cognition and modulate emotions and behaviors through inhibitory control) and the Metacognition Index (i.e., the ability to initiate plan, organize and sustain future-oriented problem solving in working memory) (Gioia, Isquith, Guy & Kenworthy, 2000). Overall, higher scores on the BRIEF reflect greater differences in executive function abilities among children.

Data Analysis

We used SPSS 22.0 (IBM, 2013) to analyze data. To understand performance effects, or to determine if performance was stable across the three tasks, we calculated mean response times (RTs) when correctly responding to a ‘go’ trial. To address our first research question (i.e., the convergent validity of the three go/no-go tasks), we used Pearson correlations to determine associations among the three go/no-go tasks. Specifically, we examined associations between *the number of inhibition errors* (i.e., a child clicked the mouse during a ‘no go’ trial) and *error rate* (i.e., number of errors divided by total number of trials, and converted into a percent). To address our second research question (i.e., ecological validity of the three go/no-go tasks), we used Pearson correlations to examine associations between the three go/no-go tasks and the BRIEF. Specifically, we examined correlations between *error rates* and *inhibition errors* on the three go/no-go tasks, and *raw BRIEF scores* on each of the nine subscales (i.e., Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor), two indices (i.e., Metacognition and Behavior Regulation), and the Global Executive Composite score.

Results

Descriptive statistics comparing the go/no-go tasks indicated that children responded in a similar manner across different stimuli, and did not exhibit performance effects across the three tasks. Specifically, RTs were slightly faster on the Shapes go/no-go task ($M= 627.46\text{ms}$; $SD= 114.45$; $\text{range}=371.89\text{-}898.27$) and the Food Preference go/no-go task ($M= 686.95\text{ms}$; $SD= 140.06$; $\text{range}=399.82\text{-}1067.33$), however still similar to the Food Aversion go/no-go task ($M= 692.70\text{ms}$; $SD= 149.83$; $\text{range}=334.45\text{-}1010.72$). Additionally, children demonstrated similar patterns of errors on all go/no-go tasks. For instance, on the Shapes go/no-go task children exhibited the greatest amount of errors ($\text{mean}=7.58$; $SD= 7.04$; $\text{range}=0\%\text{-}33.33\%$), followed by the Food Aversion go/no-go task ($\text{mean}= 6.44$; $SD= 7.66$; $\text{range}=0\%\text{-}28.33\%$), with the Food Preference go/no-go task demonstrating the fewest errors ($\text{mean}= 6.25$; $SD=7.28$; $\text{range}= 0\%\text{-}33.33\%$).

Overall, the three go/no-go tasks were positively correlated among inhibition errors and percent error rate (See Table 2). The Shapes go/no-go task and Food Preference go/no-go task were moderately correlated with regard to the percent error rate ($r= 0.599$, $p<0.01$), and number of inhibition errors ($r= 0.357$, $p<0.05$). Correlations between the Shapes go/no-go task and Food Aversion go/no-go task showed significance in percent error rate ($r= 0.684$, $p<0.01$) and number of inhibition errors ($r= 0.391$, $p<0.01$). Lastly, the Food Preference go/no-go and Food Aversion go/no-go tasks were highly correlated with regard to the percent error rate ($r= 0.853$, $p<0.01$) and the number of inhibition errors ($r= 0.638$, $p<0.01$).

Results comparing the BRIEF and the three tasks indicated fewer statistically significant correlations (See Table 2 and 3). Significant correlations included Shapes go/no-go task inhibition errors with the BRIEF Initiate subscale ($r= -0.315$, $p<0.05$), and Shapes go/no-go task percent error rate with the BRIEF Inhibit subscale ($r= 0.306$, $p<0.05$). Results of the BRIEF and

the Food Preference go/no-go task indicated one statistically significant association between the Behavior Regulation Index with the percent error rate ($r= 0.376, p<0.05$). In addition, the BRIEF Inhibit subscale was significantly associated with the Food Preference go/no-go tasks percent error rate ($r= 0.417, p<0.01$). The Food Aversion go/no-go task was not significantly correlated with any of the BRIEF scores. Go/no-go task scores were not highly associated with the BRIEF indices or composite.

Conclusions

The present study examined the convergent validity of two novel food go/no-go tasks with a traditional go/no-go task as well as the ecological validity of the go/no-go tasks in comparison to the BRIEF. Overall, the three go/no-go tasks demonstrated statistically significant correlations, therefore illustrating moderate convergent validity (Crocker & Algina, 2008). The Food Preference and Food Aversion go/no-go tasks illustrated the highest convergent validity. Therefore, tasks with similar stimuli (i.e., food) were more closely related than tasks with different stimuli (i.e., shapes). The results indicated the novel food go/no-go tasks utilizing a tailored approach with child specific food preferences and food aversions measures inhibitory control in a similar way to a traditional go/no-go task. Other researchers created modifications to the go/no-go task and illustrated moderate convergent validity with other neuropsychological executive function assessments (Duckworth & Kern, 2011; Langenecker et al., 2007), or between a traditional go/no-go task and an adapted go/no-go task (Schulz et al., 2007). Overall, even when adapting the stimuli, the basic constructs of the go/no-go tasks were maintained.

To date, very little research aims to examine the ecological validity of the go/no-go task. Our study utilized the BRIEF, an executive function measure considered ecologically valid (Kenworthy, Yerys, Anthony, & Wallace, 2008b), to compare with the go/no-go tasks. Our

results indicated none of the go/no-go tasks illustrated high associations among the BRIEF. Previous research suggests statistically significant correlations between a go/no-go task and teacher ratings on the Behavioral Assessment System for Children (BASC) (i.e., an ecologically valid scale) (Floyd & Kirby, 2001). However, significant correlations only occurred with one form of the go/no-go task (i.e., Pinball go/no-go) and not other versions (i.e., stacking blocks and Dog-Dragon go/no-go). Additionally, Mahone et al.,(2002) used a geometric pattern go/no-go task and demonstrated significant correlations only with the BRIEF Inhibit subscale. Whereas, Bodnar, Prahme, Cutting, Denckla, & Mahone (2007), found no correlations between a geometric pattern go/no-go and the BRIEF. Overall, within these few studies the go/no-go task exhibits low to moderate correlations with ecologically valid measures.

The BRIEF is frequently used to examine the ecological validity of other tasks, however previous research indicates lower correlations may relate more to differences in measurement properties, rather than differences in ecological validity (e.g., McAuley, Chen, Goos, Schachar, & Crosbie, 2010). For instance, most questionnaires focus on executive function more broadly, whereas tasks typically focus on one specific executive function process (i.e., inhibition). Additionally, tasks are more structured and prompted by an investigator, whereas questionnaires are not (Chevignard, Soo, Galvin, Catroppa, & Eren, 2012; Toplak, West, & Stanovich, 2013). When examining correlations between performance-based tasks and behavior ratings, Toplak et al. (2013) found only 24% were statistically significant, and the median correlation was 0.19. Over half of the correlations examined were reported between the BRIEF and other executive function performance-based tasks (e.g., Stop Signal Task, Stroop Task, Tower of London), and the mean r -value was 0.15. Clearly, different types of assessments measure different constructs associated with executive function. Therefore, the low correlations observed in our study may be

due to differences in measurement properties, or the go/no-go tasks and the BRIEF may measure different aspects of inhibition.

Research suggests parent and teacher behavior rating measures are considered more predictive of behavior as compared to performance based tasks (Miranda, Colomer, Mercader, Fernández, & Presentación, 2015; Toplak, Bucciarelli, Jain, & Tannock, 2008). However, other researchers indicate inconsistencies in measures when reported by parents or teachers. For instance, DiBartolo & Grills (2006) indicated poor agreement between parent report, teacher report, child report, and child performance when measuring anxiety. The highest agreement occurred between child report of anxiety and child performance. Additionally, Achenbach, McConaughy, & Howell (1987) found similar results when comparing parent, mental health providers, observers, peers and the child, indicating we must be aware that different informants, provide critical, but different information. Clearly, there may be inconsistencies between the child performance on the go/no-go task, and parents report of child executive function behaviors; when taken together, the two types of measures may provide a fuller picture of a child's behavior in everyday life.

The BRIEF examines many aspects of executive function in children, however our study's tasks aimed to measure inhibitory control related to child eating behavior. Executive function behaviors related to eating may differ from behavior in other activities and contexts. The BRIEF does not address executive function behaviors related to eating, potentially impacting the degree of correlations with go/no-go tasks specifically related to food. Thus, to continue to understand inhibitory control related to eating behavior, we need to examine children's performance as well as devise assessments aimed at understanding parent ratings of inhibition related specifically to eating.

In conclusion, when adapting stimuli and using a tailored approach to elicit inhibitory control, the convergent validity of the three go/no-go tasks was moderate. Although, the Food Preference go/no-go task and Food Aversion go/no-go task were constructed with attributes of ecological validity (i.e., child specific foods), the tasks did not demonstrate high correlations with the BRIEF. However, low correlations with the BRIEF are not uncommon, as performance-based tasks and behavior ratings may differ substantially in how behavior is measured. Additionally, the BRIEF aims to measure executive function, but may not capture executive function in the context of eating. Therefore, more research is warranted to understand parent ratings of inhibition related to eating, as well as devising methods to use both performance-based and parent ratings to better capture eating behavior in everyday life.

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Table 1. Child selected preferred and aversive foods

Preferred Foods	n (%)	Aversive Foods	n (%)
Cheesecake	1 (2.27%)	Broccoli	5 (11.36%)
Cherry tomatoes	1 (2.27%)	Mustard	2 (4.54%)
Pizza	9 (20.45%)	Mashed potatoes	1 (2.27%)
Candy	1 (2.27%)	Eggplant	1 (2.27%)
Baby corn	1 (2.27%)	Eggs	2 (4.54%)
Chocolate cake	1 (2.27%)	Spinach	1 (2.27%)
Macaroni and cheese	9 (20.45%)	Salad	2 (4.54%)
Chips	1 (2.27%)	Strawberries	1 (2.27%)
Mandarin oranges	1 (2.27%)	Peas	3 (6.81%)
Strawberries	1 (2.27%)	Sour cream	1 (2.27%)
Tacos	5 (11.36%)	Tomatoes	3 (6.81%)
Cheeseburger	2 (4.54%)	Avocados	1 (2.27%)
Apples	1 (2.27%)	Bell peppers	1 (2.27%)
Bananas	1 (2.27%)	Bread	1 (2.27%)
Peanut butter and jelly	1 (2.27%)	Spaghetti	1 (2.27%)
Shrimp	1 (2.27%)	Grapefruit	1 (2.27%)
Hot dogs	1 (2.27%)	Mushrooms	1 (2.27%)
Ice cream	3 (6.81%)	Stuffing	1 (2.27%)
Sweet potatoes	1 (2.27%)	Chili	1 (2.27%)
Peaches	1 (2.27%)	Soups	3 (6.81%)
Grilled cheese	1 (2.27%)	Pesto	1 (2.27%)
		Alfredo	1 (2.27%)
		Sweet potatoes	1 (2.27%)
		Hamburgers	1 (2.27%)
		Green beans	1 (2.27%)
		Lasagna	1 (2.27%)
		Peanut butter	1 (2.27%)
		Tacos	1 (2.27%)
		Pickles	2 (4.54%)
		Onions	1 (2.27%)

Table 2. Go/no-go correlations with BRIEF Indices and Composite

	Shape inhibit errors	Shape error rate	FP inhibit error	FP error rate	FA inhibit error	FA error rate	BR Index	MC Index	GE Comp
Shape inhibit error	1.00								
Shape error rate	0.763**	1.00							
FP inhibit errors	0.357*	0.339*	1.00						
FP error rate	0.272	0.599**	0.778**	1.00					
FA inhibit errors	0.391**	0.353*	0.630**	0.549**	1.00				
FA error rate	0.442**	0.684**	0.638**	0.853**	0.735**	1.00			
BR Index	0.058	0.242	0.221	0.376*	0.238	0.265	1.00		
MC Index	-0.234	-0.093	-0.192	-0.006	-0.212	-0.116	0.627**	1.00	
GE Comp	-0.137	0.045	-0.052	0.148	-0.043	0.033	0.847**	0.945**	1.00

Note. *= $p < 0.05$; **= $p < 0.01$; FP= food preference; FA= food aversion; BR= Behavioral Regulation; MC= Metacognition; GE Comp= Global Executive Composite Score

Table 3. Go/no-go correlations with BRIEF subscales

	Shape inhibit error	Shape error rate	FP inhibit error	FP error rate	FA inhibit error	FA error rate
Inhibit	0.055	0.306*	0.199	0.417**	0.105	0.243
Shift	0.035	0.046	0.245	0.262	0.192	0.099
Emotional control	0.052	0.0216	0.141	0.271	0.281	0.279
Initiate	-0.315*	-0.154	-0.124	0.010	-0.017	-0.117
Working memory	-0.221	-0.036	-0.062	0.138	-0.159	0.012
Plan	-0.156	-0.106	-0.189	-0.116	-0.216	-0.198
Organization	-0.153	-0.058	-0.224	0.031	-0.244	-0.034
Monitor	-0.125	-0.108	-0.003	-0.005	-0.012	-0.160

Note. * = $p < 0.05$; ** = $p < 0.01$; FP = food preference; FA = food aversion

Appendix D
Comprehensive Exam III

Early caregiver concerns: Differentiating diagnoses in young children

Introduction

Approximately 15% of children are diagnosed with a developmental disorder (Boyle et al., 2011) and studies consistently demonstrate that early identification and early intervention ameliorate the symptoms of many childhood conditions (Zwaigenbaum et al., 2009; Zwaigenbaum, 2010). The American Academy of Pediatrics early screening guidelines recommend that practitioners listen closely to parents concerns (American Academy of Pediatrics, 2014; Johnson & Myers, 2007), as research shows that parent concerns often precede a diagnosis of a neurodevelopmental disorder such as ASD (Zablotsky et al., 2017) and ADHD (Mulhern, Dworkin, & Berstein, 1994). With increased public awareness of developmental disorders, parents are more conscious of symptoms and their report represents a vital component of early screening and diagnosing efforts.

Studies have shown that parent specific concerns may be predictive of a diagnosis of ASD (Gaspar de Alba & Bodfish, 2011; Ozonoff et al., 2010; Young, Brewer, & Pattison, 2003; Zwaigenbaum et al., 2009) as well as differentiate children with ASD from other developmental disorders (i.e., Horovitz, Matson, & Sipes, 2011; Little, Wallisch, Salley, & Jamison, 2016). However, if we better understand the early parent concerns of a wider range of diagnoses, we may better devise screening tools to differentiate children's areas of developmental difficulties earlier, thus providing more targeted intervention approaches. Therefore, this study investigated the extent to which parent concerns differentiated multiple diagnostic categories in a large community-based sample of children aged 12 months-12 years.

To date, many studies have examined how parent concerns may be used in the early identification of children with ASD. For example, Young et al. (2003) examined parent recall of concerns in 153 families of children with ASD. On average, parents reported initial concerns

when children were 13 months; most frequent concerns included social and gross motor skills. Other researchers used surveys to collect parent recall, and results indicated the most common ASD related concerns included language, social skills, and repetitive behaviors and interests (Gaspar de Alba & Bodfish, 2011; Guinchat et al., 2012). Overall, studies suggest that parents detect differences in behavior around a child's first birthday, and concerns related to ASD usually involve social skills and repetitive behaviors.

Other studies used prospective designs to longitudinally examine concerns of high-risk infant siblings with ASD. Research suggests that parents report more concerns at an earlier age (i.e., 12-14 months) when the parent had an older child with ASD (Hess & Landa, 2012; Ozonoff et al., 2009). Additionally, high-risk siblings who later received a diagnosis of ASD, had significantly more ASD-related parent concerns (Hess & Landa, 2012). Overall, at age 14- 24 months parents most frequently reported concerns related to communication, behavior/temperament, whereas social development concerns were most frequently reported at 36 months (Hess & Landa, 2012; Ozonoff et al., 2009). In another study, Zablotsky et al. (2017) found that parents who reported communication, movement, and gesture concerns obtained a diagnosis of ASD for their children earlier than those that reported concerns related to behavior difficulties.

Fewer studies have examined differences in parent concerns for children with ASD versus those with developmental delays. For example, Horovitz, Matson, and Sipes (2011) examined a sample of 1393 toddlers aged 17-37 months and caregiver concerns related to communication and behavior. Results indicated children with ASD were diagnosed significantly earlier, and demonstrated significantly higher scores on repetitive behavior in comparison to children with developmental delays. Whereas, communication concerns were not significantly

different between the two groups. However, this study examined two areas of concerns (i.e., communication and behavior), and we may miss critical concerns leading to earlier identification of children with ASD when restricted to two areas of behavior.

Screening guidelines consistently urge practitioners to use parent concerns to gain a better understanding of a child's developmental profile (Nelson, Nygren, Walker, & Panoscha, 2006). Parent concerns provide critical information for the diagnostic process, and some studies suggest that parent concerns provide information at a similar accuracy to screening tests (Glascoe, 2000; Young, Davis, Schoen, & Parker, 1998). However, literature on the utility of early parent concerns in detecting developmental delays has primarily focused on children with ASD and very few studies have examined the predictive value of parent concerns in specific diagnostic populations. Research aimed at understanding how parental concerns differentiate multiple diagnoses may further add value to the utility of early parent concerns, and by understanding parent concerns for various diagnostic populations, we may better identify children earlier. Therefore, the aim of this study was to examine the extent to which specific parent concerns predicted a broad range of diagnostic categories among a community sample of children ages 12 months to 12 years.

Methods

Participants

Data was drawn from a university-based child diagnostic center in a large metropolitan area. The sample included $n=1083$ children 12 months-12 years ($M= 65.51$; $SD= 30.66$), including children with ASD ($n=594$), ADHD ($n= 171$), ASD and ADHD ($n= 89$), conduct disorders ($n= 88$), developmental delays ($n= 80$), and speech and language disorders ($n= 61$) (see Table 1).

Measures

Parent Concerns. Prior to a diagnostic evaluation, parents completed intake paperwork for developmental history and behavioral information. On the intake form, parents were asked to describe their top three concerns about their child. Two researchers coded these concerns from an adapted coding system used by Ozonoff et al. (2009) including the following categories: 1) internalizing behavior, 2) externalizing behavior, 3) medication questions, 4) motor, 5) general development, 6) speech/communication, 7) social interactions, 8) stereotyped behaviors, 9) medical, and 10) sensory aversions/preferences (See Table 2). Coders examined percent agreement with 20% of the dataset and achieved 89% inter-rater reliability. Each parent concern was entered as a binary variable depicting if the concern was indicated or not indicated by the child's parent, with each child receiving a maximum of three concerns.

Child Diagnosis. The diagnostic evaluation occurred in a community based diagnostic center with a multi-disciplinary team and included a battery of standardized assessments, behavioral reports, a medical history review, and a clinical diagnostic interview. As data was collected from 2000-2015, children were diagnosed with either the Diagnostic Statistic Manual of Mental Health Disorders fourth edition (DSM-IV) or Diagnostic Statistic Manual of Mental Health Disorders fifth edition (DSM-V) criteria. A subset of diagnoses, such as Tourette's Syndrome, were excluded from analysis due to small sample sizes (i.e., 50 children or less). Final diagnostic categories included: ASD, ADHD, ASD and ADHD, conduct disorders, developmental delays, and speech and language disorders.

Data Analysis

Given the variability of CA among the different diagnostic groups and the potential impact of age on findings, we first used analysis of variance (ANOVA) to test if there were

significant differences in age that may impact the overall model. To address the research question (i.e., examining how parent concerns predict child diagnosis), we used multinomial logistic regression using SPSS version 24 (IBM, 2013). Outcomes included the six diagnostic categories (i.e., ASD, ADHD, ASD and ADHD, conduct disorders, developmental delays, and speech and language disorders) and predictors included ten parent concern variables. All variables were complete, with no missing data included in analysis. In a multinomial logistic regression, one group must serve as a comparison group. In the current analysis, children with ASD acted as the primary comparison group as more literature describes parent concerns predicting a diagnosis of ASD and the ASD group had the largest sample size.

Results

ANOVA results showed significant differences in CA among diagnostic groups ($F(5, 1077) = 29.822, p < 0.001$). Therefore, we controlled for CA in all subsequent models. A model with eight parent concerns in predicting child diagnosis was the most parsimonious model. We excluded sensory preferences/aversions ($\chi^2 = 6.56(5), p = 0.256$) and internalizing behavior ($\chi^2 = 5.98(5), p < 0.308$) parent concern variables from the final model, as these two concerns were the least significant in the model overall and demonstrated no significant alpha levels associated with the Wald χ^2 statistic when comparing child diagnostic categories.

Results indicated an overall significant model ($\chi^2 = 318.523, df = 45, p < 0.001$; Cox and Snell = 0.255; Nagelkerke = 0.272). Within the overall model, child age at diagnostic evaluation ($\chi^2 = 86.58, df = 5, p < 0.001$) and parent concerns related to social ($\chi^2 = 28.30, df = 5, p < 0.001$), speech ($\chi^2 = 38.63, df = 5, p < 0.001$), motor ($\chi^2 = 17.05, df = 5, p < 0.01$), general development ($\chi^2 = 20.15, df = 5, p < 0.001$), and externalizing ($\chi^2 = 43.23, df = 5, p < 0.001$) were significant predictors. Medication ($\chi^2 = 7.03, df = 5, p = 0.219$), medical ($\chi^2 = 10.62, df = 5, p < 0.059$), and stereotyped

behavior ($x^2= 9.02$, $df=5$, $p<0.108$) parent concerns were not significant predictors in the overall model, however demonstrated significant alpha levels associated with Wald x^2 when comparing diagnoses. The main effect of each parent concern was examined with all other parent concern variables and child CA held constant.

ASD diagnostic Comparisons

In this section, we summarize findings related to children across diagnoses by using the ASD group as the primary comparison group and controlling for CA (see Table 3). Results indicated that as compared to children with ASD, those with ADHD had significantly more externalizing (Wald $x^2= 19.81$, $\text{Exp}(B)= 2.34$, $df= 5$, $p<0.001$), and general development concerns (Wald $x^2= 13.70$, $\text{Exp}(B)= 2.23$, $df= 5$, $p<0.001$) as well as fewer social interaction concerns (Wald $x^2= 7.933$, $\text{Exp}(B)= 0.542$, $df= 5$, $p<0.01$). Children with both ASD and ADHD had a higher likelihood of externalizing (Wald $x^2= 8.09$, $\text{Exp}(B)=2.00$, $df= 5$, $p<0.01$), medication (Wald $x^2= 5.51$, $\text{Exp}(B)= 3.41$, $df= 5$, $p<0.05$), and general development (Wald $x^2= 7.61$, $\text{Exp}(B)= 2.14$, $df= 5$, $p<0.01$) parent concerns. Additionally, children with conduct disorders had significantly more externalizing (Wald $x^2= 26.44$, $\text{Exp}(B)= 3.52$, $df= 5$, $p<0.001$) and medical concerns (Wald $x^2= 9.68$, $\text{Exp}(B)= 2.50$, $df= 5$, $p<0.01$), as well as fewer speech/communication concerns (Wald $x^2= 12.207$, $\text{Exp}(B)= 0.352$, $df= 5$, $p<0.001$). Children with developmental delays had significantly more motor concerns (Wald $x^2=7.50$, $\text{Exp}(B)= 2.47$, $df= 5$, $p<0.01$) and fewer social interaction parent concerns (Wald $x^2=10.675$, $\text{Exp}(B)= 0.298$, $df= 5$, $p<0.001$). Lastly, children with speech and language disorders were more likely to have speech/communication (Wald $x^2= 13.13$, $\text{Exp}(B)= 3.19$, $df= 5$, $p<0.001$) and less likely to have social interaction (Wald $x^2= 5.340$, $\text{Exp}(B)= 0.432$, $df= 5$, $p<0.05$) parent concerns in comparison to children with ASD.

Discussion

Previous literature indicates parents are vigilant observers of child behavior and provide key insight to early child development (Guinchat et al., 2012). The idea of utilizing early parent concerns as a predictor of eventual child diagnosis is prominent in the ASD literature, with research suggesting parent concerns provide critical information for early identification of children with ASD (Johnson & Myers, 2007). While previous studies have examined how parent concerns differentiate children with ASD from children with other developmental disabilities, few studies have investigated how parent concerns differentiate ASD from multiple diagnoses. We examined the predictive value of eight types of parent concerns preceding a diagnosis of ASD, ADHD, ASD and ADHD, conduct disorders, developmental delays, and speech and language disorders. Results indicated that parent concerns preceding a diagnostic evaluation significantly differ among children with various diagnoses, clearly indicating the clinical value of parent reports of concerning child behaviors. Parent concerns that differentiate diagnostic groups often aligned with core diagnostic criteria, suggesting regardless of a parent's knowledge of diagnostic criteria their observations of child behavior are exceptionally insightful.

Overall, results revealed that parents of children with ASD are more likely to be concerned about social interaction and speech/communication, and are not as concerned with externalizing behavior, medication, motor skills, general development, and medical issues. The American Academy of Pediatrics indicates that parent concerns related to speech, communication, and social development are often "red flags" for a diagnosis of ASD (Johnson & Myers, 2007). Consistent with the American Academy of Pediatrics, findings from this study indicate children with ASD were significantly more likely to have social parent concerns in comparison to all other diagnostic categories, except children with both ASD and ADHD.

Additionally, children with ASD had a higher likelihood of speech/communication parent concerns in comparison to all other diagnostic categories, except children with speech and language disorders. Similarly, other studies also indicate social and speech/communication parent concerns predict a child's diagnosis of ASD (Chawarska et al., 2007; Gaspar de Alba & Bodfish, 2011; Hess & Landa, 2012; Ozonoff et al., 2009; R. L. Young et al., 2003). Our findings align with the literature, however speech/communication concerns may not be as prominent for children with ASD when compared to children with speech and language disorders. This is an important consideration in the diagnostic process; the social interaction concerns of parents of children with an eventual diagnosis of speech and language disorders must be evaluated.

Children with ASD were significantly less likely to have parents reporting concerns of externalizing behavior in comparison to children receiving a diagnosis of ADHD, both ASD and ADHD, and conduct disorders. Previous research indicates that children with ASD are less likely to exhibit outward behavior parent concerns in comparison to other diagnoses (Little et al., 2016); however, when parents do report externalizing behavior as concerning, children with ASD are often identified later (Zablotsky et al., 2017). Externalizing parent concerns are central to the diagnostic criteria of ADHD, as types of externalizing parent concerns may represent hyperactivity, impulsivity, or inattentiveness. Research suggests that parents are more likely to seek evaluations when a child's behavioral symptoms become more pronounced (Bussing, Zima, Gary, & Garvan, 2003), and children were more likely to receive a diagnosis of ADHD when parents report behavioral concerns related to hyperactivity, impulsivity, and inattentiveness (Gimpel & Kuhn, 2000). Additionally, externalizing behaviors are a central diagnostic feature of conduct disorders, and the literature suggests children with conduct disorders have a high

prevalence of comorbid diagnoses, with a strong risk for ADHD (Maughan, Rowe, Messer, Goodman, & Meltzer, 2004). Our findings suggest that externalizing parent concerns are less salient for children with ASD, however may be an important aspect of screening tools in the detection of children with ADHD and conduct disorders.

As expected, children with both ASD and ADHD showed an amalgamation of parent concerns observed for children with ASD (i.e., higher likelihood of social concerns), as well as for children with ADHD (i.e., higher likelihood of externalizing and general development concerns). However, children with both a diagnosis of ADHD and ASD were the only group where parents were more likely to report concerns or questions about medications, compared to other diagnostic groups. The literature indicates controversies with comorbid diagnoses of ASD and ADHD, as children with ASD are likely to show symptoms of ADHD, and it is unclear if these symptoms should result in a comorbid diagnosis or are representative of ASD (Gargaro, Rinehart, Bradshaw, Tonge, & Sheppard, 2011). In addition to diagnostic controversies, medication utilization for children with ASD and ADHD also remains unclear (Goldstein & Schwebach, 2004; Santosh, Baird, Pityaratstian, Tavare, & Gringras, 2006), and with rates of medication use in ASD populations at approximately 45%- 83% (Aman et al., 2009), and 69% for children with ADHD (Visser et al., 2014), parents may be more aware of potential medication possibilities for behavioral concerns.

Findings showed a lower likelihood of general development concerns for children with ASD, whereas children with ADHD, both ASD and ADHD, and developmental delays had a higher rate of general development concerns. Similarly, children with ASD were less likely to have parent concerns related to motor development compared to children with developmental delays. When children receive a diagnosis of either ADHD or developmental delay, this may

include a myriad of delays related to learning, cognition, and motor development. Previous studies suggest children exhibiting more difficult temperaments and multiple delays are more vulnerable to a diagnosis of ADHD (Nederkoom, Coelho, Guerrieri, Houben, & Jansen, 2012). Additionally, research also indicates children with developmental delays are more likely to have cognitive development parent concerns in comparison to children with ASD (Little et al., 2016). Overall, our findings are consistent with previous literature and parent concerns related to general development are more likely to occur in children with an eventual diagnosis of ADHD or developmental delay.

Limitations and Future Directions

The current study has several strengths and potential future directions for research. First, our study included a large diagnostic population with multiple diagnostic categories. Although our study included uneven diagnostic sample sizes, the diagnostic group sizes were representative of diagnostic populations, with a rising prevalence of ASD (Boyd, McCarty, & Sethi, 2014), and a higher prevalence of ADHD (Leslie, Weckerly, Plemmons, Landsverk, & Eastman, 2004) and conduct disorders (Kessler et al., 2005). Our sample included one group with a comorbidity (i.e., ASD and ADHD); however future investigations may aim to understand predictors and differentiators associated with additional comorbid diagnostic categories. Research suggests comorbidities are highly present in children with ASD (Simonoff et al., 2008), ADHD (Klassen, Katzman, & Chokka, 2010), and conduct disorders (Maughan et al., 2004). By understanding predictors associated with comorbid diagnoses we may better screen children earlier and increase the accuracy in early identification. Furthermore, by understanding parent concerns of children who do not receive a diagnosis, we may increase the utility of parent concerns in early identification.

Second, high interrater agreement and reliability was achieved when coding parent concerns, however the current study was limited to three parent concerns. Future research may expand the number and types of concerns included to gather greater specificity in parent report. Furthermore, the current study examined parent concerns preceding a diagnostic evaluation, whereas longitudinally tracking parent concerns may glean insight into the developmental trajectories of diagnostic groups. Lastly, to continue to understand the utility of parent concerns in early identification, examining how these align with standardized developmental measures may further support early screening guidelines.

Conclusion

Overall, our results confirm the predictive value of parent concerns for multiple diagnostic groups. While we know certain types of parent concerns may predict ASD, fewer studies have examined how parent concerns predict and differentiate multiple diagnoses. With increased evidence that parents are expert observers of child behavior, it is critical to capture how these behavioral observations align with diagnostic criteria. The current study indicates that the parent concerns of children with varying diagnoses clearly align with diagnostic criteria. Children with ASD were differentiated from five other diagnostic categories by social and language concerns. Children with ADHD and conduct disorders were distinct in the parent concerns related to externalizing behavior, and the concerns of children with speech and language disorders were related to verbal abilities. These findings clearly indicate that the more we understand and incorporate parent concerns into the screening and diagnostic process, we can differentiate children with multiple diagnoses, contributing to an earlier targeted intervention approach.

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Table 1. Participant Characteristics

	n	Gender (male) % (n)	Age (months) mean (Range)
ASD	594	82.8 (492)	91.69 (15-144)
ADHD	171	77.2 (132)	82.61 (37-143)
ASD, ADHD	89	91 (81)	84.83 (27-143)
Conduct	88	72.7 (64)	59.25 (19-123)
Delays	80	66.3 (53)	47.54 (12-101)
Speech/language	61	85.2 (52)	59.11 (18-135)
Overall Sample	1083	874 (80.7)	65.51 (12-144)

Note. ASD= Autism spectrum disorders; ADHD= Attention-deficit/hyperactive disorder

Table 2. Parent Concern Codes

Code	Definition	Example
Internalizing behavior	Concerns with inward behavior regulation	“She exhibits signs of stress and anxiety.”
Externalizing behavior	Concerns with outward behavior regulation	“Daily tantrums sometimes lasting an hour or more.”
Medication	Concerns and questions about medication for symptoms	“Will he be on medication his whole life?”
Motor	Concerns with motor milestones or clumsiness	“He will not stand alone.”
Development	Developmental milestones and cognitive development	“Developmentally behind.”
Speech/communication	Concerns with intentional communication, both receptive and expressive	“Won’t try to repeat words.”
Social interactions	Concerns with social engagement, social interests, social reciprocity, and social attention	“My son doesn’t have friends his age.”
Stereotyped behaviors	Concerns about rigid, repetitive, restrictive, or self-injurious behaviors	“Rocks and chants constantly.”
Medical	Questions or concerns related to medical symptoms rather than behavioral symptoms	“Is he having seizures?”
Sensory aversions/preferences	Concerns about sensory interests or sensory aversion	“He smells everything.”

Note. Adapted from Ozonoff et al. (2009).

Table 3. Diagnoses by Parent Concerns

Parent Concern	ADHD		ASD, ADHD		Conduct Disorders		DD		SLD	
	β	<i>P</i>	β	<i>P</i>	β	<i>P</i>	β	<i>P</i>	β	<i>P</i>
Externalizing	0.849	<0.001***	0.693	0.004**	1.258	<0.001***	0.065	0.823	0.005	0.988
Medication	0.876	0.063	1.227	0.019**	0.811	0.243	0.839	0.297	0.811	0.283
Motor	-0.638	0.167	0.018	0.969	-1.778	0.083	0.906	0.006**	-0.434	0.430
General Development	0.801	<0.001***	0.760	0.006**	0.140	0.661	0.605	0.032*	0.592	0.064
Speech/Communication	-0.626	0.011**	-0.339	0.279	-1.044	<0.001***	0.082	0.755	1.160	<0.001***
Social Interactions	-0.612	0.005**	-0.301	0.252	-0.872	0.005**	-1.211	0.001***	-0.839	0.021*
Stereotyped	-0.540	0.112	-0.254	0.531	0.559	0.074	-0.240	0.555	-0.586	0.277
Medical	0.301	0.285	0.191	0.611	0.915	0.002**	-0.176	0.635	0.372	0.295

Note. Reference group includes children with ASD. DD= developmental delays; SLD= speech and language disorders; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.