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Longitudinal Microanalysis of the Vineland Adaptive Behavior Scales in Autism Spectrum Disorder: Implications for Adult Outcomes

A dissertation submitted in partial

satisfaction of the requirements for the

degree Doctor of Philosophy in Education

by

Elaine Bethany Clarke

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ABSTRACT OF THE DISSERTATION

Longitudinal Microanalysis of the Vineland Adaptive Behavior Scales in Autism Spectrum Disorder: Implications for Adult Outcomes

by

Elaine Bethany Clarke

Doctor of Philosophy in Education

University of California, Los Angeles, 2024

Professor Catherine Lord Morrison, Chair

Many studies have documented adaptive behavior deficits in individuals with autism spectrum disorder (ASD). A considerable body of work has also catalogued challenges in adult outcome attainment amongst autistic individuals; notably, relatively strong adaptive function is associated with a higher likelihood of attaining some adult outcomes in this population. To date, little work has examined whether competency in *specific* adaptive behaviors increases the likelihood of attaining adult outcomes. This study sought to address this gap via item set and item-level analyses of scores from a common adaptive behavior measure, the Vineland Adaptative Behavior Scales, from ages 5, 9, 14, and 18 in a well-characterized longitudinal cohort. Item sets related to cooking and personal hygiene predicted adult employment and subjective well-being at multiple ages. Individual items related to community skills (i.e., money management, rules, rights, and safety, restaurant skills, etc.) emerged as significant predictors of adult employment, social relationships, living status, and subjective well-being. Implications for adaptive behavior interventions are discussed.

The dissertation of Elaine Bethany Clarke is approved.

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Dedication

To my brother, John. You are the reason I choose to do this work.

To my parents, Barbara and Mark. You have faced the lifetime of challenges that come with raising a child with substantial disabilities with assurance and grace. Your commitment to John and to one another humbles me.

Finally, to my husband, Michael, and our daughter, Beatrice. You are everything that I wanted.

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Finally, I am enormously grateful to the adults and their families that comprise the Longitudinal Study of Autism. You have let autism researchers into your homes for longer than I have been alive, and your contributions have meaningfully shaped the scientific understanding of autism as a lifelong condition. I am humbled to be a small part of that legacy. Getting to know some of you was one of the highlights of my graduate school experience. Learning from you will always be an honor.

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CLINICAL EXPERIENCE

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- Generate progress notes to document treatment sessions and to monitor treatment gains.
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Child and Adult Neurodevelopmental (CAN) Clinic, UCLA (2021-2022)

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UCLA PEERS Clinic (2021-2022)

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- Presented to community partners to spread awareness of recent-onset psychosis.

Introduction

"[Adaptive behavior] may be defined as the functional ability of the human organism for exercising personal independence and social responsibility."

—E.A. Doll, 1953 (p. 10)

"Adaptive behavior is defined by the expectations or standards of other people. The adequacy of an individual's adaptive behavior is judged by those who live, work, and interact with the individual."

—Sparrow, Balla, & Cicchetti, 1984 (p. 6)

"The only definition on which authors seem to agree is that adaptive behavior is what adaptive behavior scales measure."

—J.C. Jenkinson, 1996 (p. 99)

Success in adult life is contingent upon the completion of small, but meaningful, daily tasks. We must get dressed, prepare meals, and pay our bills, and if we neglect these tasks, the consequences can be considerable. Broadly, the completion of age-salient daily tasks necessary for personal independence can be defined as adaptive behavior[1](Sparrow & Cicchetti, 1985). Attempts to understand and define the concept of adaptive behavior have not always been straightforward. It is generally agreed that adaptive behavior encompasses activities of daily living (preparing meals, personal hygiene, household chores), communication (giving and following instructions, reading, and writing), and social skills (playing appropriately with peers, engaging in small talk, attending social gatherings)—in short, many broad aspects of life functioning (Harrison & Oakland, 2015; Sparrow et al., 2005). However, there is less than

[1] This construct is also sometimes referred to as "adaptive functioning," and these terms will be used interchangeably.

universal agreement as to which aspects of life functioning should be included in conceptualizations of adaptive behavior (see Methodological Considerations section, below).

As a developmental construct, expectations for competency in adaptive behavior vary with age and across cultures (Floyd et al., 2015). For example, some cultural groups expect women to be far more proficient in household tasks than men. Further, adaptive behavior is developmental in nature (Tassé et al., 2012). We would not expect an average two-year-old to be able to follow complex instructions, dress themselves, or meaningfully participate in a five-minute conversation, for example, but would expect an average ten-year-old to do such things, and it would be cause for concern if an average eighteen-year-old could not do such things. In brief, the definition of adaptive functioning is a moving target, and measures of adaptive behavior can provide only an approximation of this nuanced construct.

Despite the relevance of good adaptive functioning to self-sufficiency, the skills necessary to complete most daily life tasks are almost never explicitly taught. For the general population, concrete instruction in these skills is often not necessary. Rather, as children age and their desire for autonomy and self-agency increases, they learn to pick out clothes, make snacks, and save for purchases with limited input from caregivers and other adults. Yet just because these skills come naturally to many does not mean they are simple. Poor adaptive functioning can inhibit opportunities for independence as well as the attainment of outcomes associated with adult life in the general population—such as establishing a career, living independently, and starting a family (Freeman et al., 1999; Smith et al., 2012).

For individuals with developmental conditions such as autism spectrum disorder (ASD), seemingly basic life tasks can be challenging to master. In accordance with mixed preferences, we refer to this population interchangeably as “individuals with autism” and “autistic

individuals" throughout. Currently, characteristics of autism are conceptualized under two core categories: social communication and restricted and repetitive behaviors (RRBs; American Psychiatric Association, 2022). Social communication impairments can include deficits in eye contact, limited facial expressions and gestures, and difficulty maintaining relationships. RRBs include stereotyped motor movements, repetitive use of objects, and unusual sensory interests. About 1 in 36 children in the United States have a diagnosis of autism (Maenner et al., 2020), though the worldwide prevalence of the disorder is thought to be closer to 1 in 100 children (Zeidan et al., 2022). Autism is typically identified in childhood; however, it is generally a lifelong condition. The behavioral phenotype of autism is not static, and symptoms can change markedly across development (Bal et al., 2019; Seltzer et al., 2003). Thus, life course approaches are integral to understanding autism.

Prior work has thoroughly described adaptive functioning profiles characteristic of autism, but the understanding of why adaptive functioning impairments are so pronounced in this population remains limited. Poor adaptive functioning is linked to a lower likelihood of achieving many outcomes, such as attending post-secondary education (Clarke, McCauley, et al., 2021), obtaining and maintaining employment (McCauley, Pickles, et al., 2020; Taylor et al., 2014), and living independently (Dudley et al., 2019; Lord et al., 2020) amongst adults with autism. However, given the broad array of behaviors that comprise adaptive functioning, it is unclear whether certain adaptive behaviors are more imperative to success in adulthood than others. Research is needed to identify *specific* adaptive behaviors most predictive of positive adult outcomes for individuals with autism.

To better understand associations between specific adaptive behaviors and adult outcomes in autism, this dissertation leveraged the Longitudinal Study of Autism (LSA; Lord et

al., 2006), a longitudinal cohort with data on adaptive functioning at multiple timepoints from ages 2 to 30 and data on adult outcomes from approximately age 33. First, multiple hierarchical and binary logistic regression were used to identify daily living skills (DLS) item sets within the Vineland Adaptive Behavior Scales (VABS; Sparrow et al., 1984, 2005) that, controlling for IQ, autism symptomology, and other salient factors, predict attainment of four distinct adult outcomes: residential status, employment, friendships, and subjective well-being. Then, individual DLS items were input into eXtreme gradient boosting (XGBoost) supervised classifier machine learning models to identify specific Vineland items from the four timepoints of interest (ages 5, 9, 14, and 18) predictive of obtaining each of these adult outcomes. Through these microanalyses of VABS DLS scores, this dissertation highlights specific daily living skills that may be most critical to supporting adult outcomes in autistic individuals.

Autism "Profile" of Adaptive Behavior

For decades, studies of autism have noted deficits in adaptive functioning relative to cognitive ability (Freeman et al., 1988; Volkmar et al., 1987). Autistic individuals display impairments in adaptive behaviors greater than those that would be expected from or explained by cognitive ability (Alvares et al., 2019; Carter et al., 1998). Given the variety of adaptive behavior measures, and the different scores from the same measures used to quantify adaptive functioning in autism, it is somewhat remarkable that the literature has so consistently identified adaptive functioning deficits in autism.

As the "gold-standard" measure of adaptive behavior, the Vineland Adaptive Behavior Scales (VABS; Sparrow & Cicchetti, 1985) is the most frequently used assessment (Floyd et al., 2015). Other standardized measures of adaptive behavior include the Adaptive Behavior Assessment System (ABAS; Harrison & Oakland, 2017) and the TEACCH Transition

Assessment Profile (TTAP; Mesibov et al., 2007). Despite its widespread use, the VABS is by no means perfect (see Methodological Considerations section, below). One challenge to characterizing adaptive behavior in autism is that the Vineland produces a range of scores, each of which presents a somewhat different picture of an individual's adaptive behavior (Farmer et al., 2020; Floyd et al., 2015). Unfortunately, there is little consensus as to which scores are most informative in characterizing adaptive behavior (Farmer et al., 2018; Volkmar et al., 1987).

The Vineland is comprised of four domains: Communication, Daily Living Skills (DLS), Socialization, and Motor Skills. Though gross and fine motor skills are important to the development of (and competency in) adaptive behaviors, a thorough treatment on this aspect of adaptive function is beyond the scope of this dissertation. The Communication, Daily Living Skills, and Socialization domains of the Vineland can each be further divided into three subdomains, and each subdomain is comprised of multiple item sets (Table 1). The VABS produces Socialization, Communication, Daily Living Skills domain-level scores, as well as an overall adaptive behavior composite (ABC) scores (Sparrow et al., 2005). Domain and ABC raw scores can be transformed into standardized scores, which follow a normal distribution, or into age equivalence scores, which approximate the chronological age of typical development that is closest to a particular score (Sparrow & Cicchetti, 1985). VABS standardized scores tend to decrease over time in autistic individuals (Farmer et al., 2018), while raw and age equivalence scores tend to increase, though at a slower rate than is seen in the general population (Bal et al., 2015; Glover et al., 2022). Unless otherwise noted, the studies presented below assessed adaptive behavior using the VABS. The VABS scores analyzed by each study are also specified. Though this dissertation focuses on daily living skills, studies examining ABC scores and Communication and Socialization domain scores are also considered below.

On average, individuals with autism show considerable weakness in the Socialization domain, some weakness in the Communication domain, and relative strength in the Daily Living Skills domain. This pattern has historically been referred to as the "autism profile," of adaptive functioning (Carter et al. 1998; Kraijer 2000; Volkmar et al. 1993). Weaknesses in adaptive functioning associated with autism emerge early in development, with some evidence that these deficits are present by the end of the first two years of life (Bradshaw et al., 2019). These deficits appear to persist at least through early adulthood (Bal et al., 2015; Kraper et al., 2017), and perhaps across the life course (Farmer et al., 2018).

Additionally, a pattern of impaired adaptive functioning appears to be especially pronounced in autistic individuals with average or better IQ. Though individuals with autism and comorbid ID frequently show limited adaptive skills, these deficits are generally commensurate with their delays in cognitive functioning (Kanne et al., 2011; Perry et al., 2009). This contrasts with autistic individuals with more intact cognitive functioning, who generally have much poorer adaptive functioning than peers in the general population with similar cognitive abilities (Alvares et al., 2019; Klin et al., 2007). Several studies of autistic individuals with average or better IQs have found Socialization and Daily Living Skills domain scores are particularly impaired, while Communication domain scores, though still lower than would be expected from cognitive ability, are a relative strength (Duncan et al., 2018; Glover et al., 2022; Klin et al., 2007).

Despite multiple investigations of this adaptive and cognitive functioning discrepancy in autism, there is limited understanding as to *why* this profile is present in the autistic population. One examination of deficits in Daily Living Skills age equivalence scores relative to cognitive ability in autistic adolescents with normal IQ found that only ten percent of this apparent "gap" was explained by age, maternal education, sex, and autism symptomology, suggesting that

demographic and some individual-level characteristics are not strongly related to adaptive behavior (Duncan & Bishop, 2015). But the field still lacks an explanation as to why adaptive behaviors are so difficult for people with autism to master.

Compared to the general population or those with other developmental conditions, individuals with autism tend to have a wider range of raw scores on the Socialization, Communication, and Daily Living Skills domains of the Vineland (Balboni et al., 2016; Carter et al., 1998). This spread may be indicative of "splinter skills," or narrow aspects of adaptive functioning in which an autistic person excels to a degree that would not be expected from their average adaptive functioning (Balboni et al., 2016). Individuals can simultaneously exhibit pronounced weakness and strengths within specific domains of adaptive functioning (Paul et al., 2004). Such variability, though clinically meaningful, may not be captured in domain or even subdomain scores (Carter et al., 1998; Ventola et al., 2014). Thus, valuable information about an autistic person's adaptive competencies and limitations that could inform accommodations and treatment goals may be lost if only Vineland ABC and domain standard scores are considered.

Longitudinal Investigations

Most studies of adaptive functioning in autism have been cross-sectional (Balboni et al., 2016; Kanne et al., 2011; Klin et al., 2007) and focused only on childhood (Carter et al., 1998; Ventola et al., 2014; Volkmar et al., 1987). However, to understand the range of adaptive functioning present and ways in which adaptive behaviors change over time in a developmental condition like autism, longitudinal approaches are needed (Gentles et al., 2023). The last decade has seen an increase in longitudinal studies of adaptive functioning in autism. This work has consistently identified relatively high verbal and non-verbal IQ (Bal et al., 2015; Clarke, McCauley, et al., 2021; Freeman et al., 1999) and low autism symptom severity (Bal et al., 2015;

Di Rezze et al., 2019; Farmer et al., 2018) as predictors of faster growth in adaptive behavior. Like most cross-sectional studies, much of the longitudinal work on adaptive behavior has also focused on early childhood and school-aged children; there is limited data on adaptive functioning trajectories after early adulthood (Piven & Rabins, 2011).

One short-term longitudinal study of Socialization, Communication, and Daily Living Skills standard scores development from 12-36 months in toddlers at genetically high and lower risk for autism found high-risk toddlers had a significantly higher likelihood of having a discrepant adaptive functioning profile (Bradshaw et al., 2019). Adaptive skills were significantly lower than cognitive skills in the high-risk toddlers compared to the lower risk-toddlers. The likelihood of developing an adaptive/cognitive functioning discrepancy increased with age (Bradshaw et al., 2019). Another study examining changes in Daily Living Skills raw scores in early childhood, from ages 2-5, in 161 children with autism identified higher cognitive ability at study entry as a predictor of faster improvements in DLS and higher autism symptom severity as a predictor of slower improvements in DLS (Green & Carter, 2014).

Using group-based trajectory modeling (Nagin et al., 2018), several independent longitudinal studies have identified a two-group model as the best fit for describing adaptive behavior growth in autism. An accelerated longitudinal natural history study of 105 children aged 3-8 identified two distinct trajectory groups of ABC standard score growth (Farmer et al., 2018). The first trajectory group, comprising just over one-quarter, 27%, of the sample, was characterized by stability in ABC standard scores. In contrast, the second trajectory group, comprising 73% of the sample, had lower ABC standard scores at the beginning of the study, and their standard scores declined with increasing age (Farmer et al., 2018). Interestingly, for

participants in both adaptive behavior trajectory groups, scores on measures of IQ and autism symptom severity either improved or remained stable over the four-year study period.

Analyses of Communication, Socialization, and DLS domain age equivalence scores from 106 participants in the EpiTED cohort (Baghdadli et al., 2012) followed from ages 5-21 also identified two trajectory groups of adaptive behavior growth (Baghdadli et al., 2018). For all three Vineland domains, approximately 20% of participants followed a "High-Growth" increasing quadratic trajectory, while the remaining 80% of participants followed a "Low-Growth" linear trajectory. Both trajectory groups' age equivalence domain scores lagged behind those expected based on participants' chronological ages at all timepoints (Baghdadli et al., 2018). Notably, 90% of the sample followed the same trajectory (either "High-Growth" or "Low-Growth") for the Communication, Socialization, and Daily Living Skills Vineland domains.

Two other independent longitudinal studies—both of which examined growth in Daily Living Skills only—identified similar trajectory groups to those described by Farmer and colleagues (2018) and Baghdadli and colleagues (2018). In prior analyses of the same dataset used in this dissertation, the LSA sample (Lord et al., 2020a), group-based trajectory modeling identified two distinct trajectories of daily living skills growth in 253 individuals with autism from ages 2-21, a "High-DLS" quadratic trajectory that comprised 34% of the sample and was characterized by faster gains, and a "Low-DLS" linear trajectory that comprised 66% of the sample and was characterized by slow gains. Both trajectory groups had DLS-AE scores far below those expected for participants' chronological ages at all timepoints (Bal et al., 2015). The Vineland DLS age equivalence scores of participants in the slow adaptive behavior trajectory increased by about 2.5 months each year; in contrast, DLS age equivalence scores in the high

trajectory increased by about 8.8 months each year (Bal et al., 2015). These trajectories were replicated in a subsequent analysis from ages 2-26 (Clarke, McCauley, et al., 2021). Notably, the subsequent analysis found evidence for plateauing or declining DLS scores in both trajectory groups with increasing age.

Similarly, analyses of 406 autistic individuals from the Adolescents and Adults with Autism (AAA) sample (Seltzer et al., 2003) also identified separate "Low-DLS" and "High-DLS" trajectory groups, as well as declines in adaptive functioning in adulthood (Hong et al., 2023; Smith et al., 2012). The AAA sample includes a larger age range, from 10-52 at outset, than those used in the Farmer et al. (2018) and Bal et al. (2015) studies, and measured DLS using raw scores from the Waisman Activities of Daily Living (W-ADL; Maenner et al., 2013) scale rather than the Vineland. Given these methodological differences, the patterns of adaptive behavior growth described across these four samples are remarkably similar.

Analyses of ABC standard scores in 421 individuals followed from ages 3 to 6.5 as part of the Pathways study (Szatmari et al., 2015) suggested that a three-group model, rather than a two-group model, best characterized adaptive behavior growth in younger autistic children (Di Rezze et al., 2019; Szatmari et al., 2015). Amongst Pathways participants, 30% of the sample followed a "Low and Worsening" trajectory of adaptive behavior growth, 50% followed a "Moderate and Stable" trajectory, and the remaining 20% followed a "High and Improving" trajectory. Though Szatmari and colleagues were interested in possible changes in ABC standard scores within their sample, standard scores in all three groups were remarkably stable. ABC scores of the "High and Improving" trajectory, which experienced the greatest rate of change of any trajectory group, improved an average of only 5 points over the study period (Szatmari et al., 2015). This may suggest that the utility of Vineland standard scores for characterizing change in

adaptive behavior over time is limited. Further, using standard scores as a metric of change provides little insight into specific adaptive behaviors that may have improved.

Another study in the Pathways sample of DLS domain scores only indicated that a younger age of diagnosis and fewer restricted and repetitive behaviors at diagnosis were associated with faster growth in daily living skills in childhood (Di Rezze et al., 2019). Additionally, a study of trajectories of RRB development in the Pathways sample found that having relatively few RRBs from ages 3-10 was associated with having significantly higher Vineland ABC standard scores at age 10 (Baribeau et al., 2021). Finally, a recent follow-up analysis of DLS, Socialization, and Communication standard scores in the Pathways sample extending out to age 15 identified a four-group model of adaptive behavior growth; all four trajectory groups experienced declines in domain-level standard scores by adolescence (Chen et al., 2023). Chen and colleagues also identified "turning points" in their domain level trajectories, one at approximately age 5 and one at approximately age 9. Prior to the first turning point at age 5, domain level standard scores in the Pathways sample increased on average, then decreased or plateaued after the first turning point, and finally decreased at a faster rate following the second turning point at age nine (Chen et al., 2023). With these turning points in mind, this dissertation will examine DLS data from ages 5 and 9 in the LSA sample, as well as ages 14 and 18.

In short, longitudinal examinations of adaptive behavior growth suggest that standard scores remain stable or decrease with increasing age (Chen et al., 2023; Farmer et al., 2018; Szatmari et al., 2015). In contrast, Vineland raw and age equivalence scores increase with increasing age, though at a slower pace than is seen in typical development (Baghdadli et al., 2012, 2018; Bal et al., 2015; Freeman et al., 1999). High IQ and low autism symptom severity in early childhood and early adulthood are positively associated with adaptive behavior growth (Bal

et al., 2015; Freeman et al., 1999; Szatmari et al., 2015). Evidence from the LSA sample (Bal et al., 2015; Clarke, McCauley, et al., 2021; Clarke & Lord, 2023) and the AAA sample (Hong et al., 2023; Smith et al., 2012) suggests that many young adults with autism make limited or no gains in adaptive behavior in the early years of adulthood. This stagnation in adaptive behavior growth appears to be tied to the transition out of the school system, which is often associated with considerable service loss for this population (Laxman et al., 2019; Shattuck et al., 2011). As increasing numbers of individuals with childhood autism diagnoses enter adulthood (Roux et al., 2013) and as more autistic individuals receive first-time diagnoses as adults (Happé et al., 2016), studies of daily living skills and other domains of adaptive behavior across the life course and in relation to adult outcomes become increasingly imperative.

Adaptive Functioning and Adult Outcomes

In recent years, there has been increasing emphasis on studying autism in adulthood. Rates of autism diagnosis and awareness of autism as a developmental condition rose dramatically in the 1990's and early 2000's (Rosen et al., 2021; Zablotsky et al., 2019; Zeidan et al., 2022). Thus, many individuals with autism diagnosed as children have entered adulthood relatively recently. In the United States, it is estimated that between 50,000-100,000 people with autism turn 18 each year (Roux et al., 2015). Additionally, rates of adult autism diagnosis are increasing (Happé et al., 2016). Together, these factors have resulted in a growing body of work on the experiences and outcomes of adults with autism.

The literature on the achievement of outcomes associated with adult life in the general population—namely, living independently, having a paid job, and having friends and romantic partners—amongst adults with autism is discouraging. A recent meta-analysis of 18 adult outcome studies by Mason and colleagues (2021) noted, "it does seem to be safe to conclude that

approximately 50% of autistic people will struggle to achieve, and only around 20% will achieve, traditional markers of objective functioning" (p. 3174). Analyses of a nationally-representative sample, the National Longitudinal Transition Study (NLST-2) indicated that two years after exiting high school, students with autism were the least likely of all students with disabilities to be employed and to pursue secondary education (Shattuck et al., 2012) and were at considerable risk of experiencing social isolation (Orsmond et al., 2013). Notably, these challenges persist even as academic achievement (Kim et al., 2018) and core symptoms of autism improve in adulthood (Bal et al., 2019; Seltzer et al., 2003, 2004).

Given the adaptive functioning deficits characteristic of autism, perhaps these adult outcome findings are unsurprising. Adaptive behavior is critical to independence and quality of life across the life course, and this may be especially true in adulthood (Duncan et al., 2018). Individuals who struggle to complete household chores or basic self-care, for example, will have great difficulty living independently. Similarly, people who are unable to engage in small talk or conversational turn-taking will have difficulty establishing and maintaining friendships and romantic relationships. Without competent adaptive functioning, it may be difficult or even impossible to achieve many of aspects of adult life frequently taken for granted by the general population.

In longitudinal outcome studies, IQ in childhood frequently emerges as one of the strongest, if not the strongest predictor of attaining many adult outcomes (Howlin et al., 2004; Magiati et al., 2014; Pickles et al., 2020) Yet many adults with autism and average cognitive ability struggle to obtain employment, friendships, and to live independently (M. A. Farley et al., 2009; Hickey et al., 2024; Pugliese et al., 2015; Taylor et al., 2015). One examination of the AAA sample found that autistic adults with average cognitive ability were three times more

likely to have no daytime activities than adults with autism and comorbid ID (Taylor & Seltzer, 2010). A 40-year follow-up study of 60 autistic adults with average cognitive ability diagnosed in childhood found only 17% of the sample could be characterized as having "Good" or "Very Good" outcomes, meaning adults were employed, living independently, and had friends with either no ("Very Good") or limited ("Good") support (Howlin et al., 2013). The majority of this sample, 60%, had "Poor" or "Very Poor" outcomes, meaning adults were not employed, not living independently and did not have friendships ("Very Poor") or had attained only one of these outcomes with extensive support ("Poor"; Howlin et al., 2013). In a separate study of 41 autistic adults with average cognitive ability diagnosed in childhood using the same outcome rating system (Howlin et al., 2004), a larger minority of participants, 49%, were characterized as having "Good" or "Very Good" outcomes (Farley et al, 2009). Vineland ABC standard scores were a stronger predictor of achieving adult outcomes than IQ in this sample. These findings suggests average cognitive ability is important, but not sufficient, for adults with autism to achieve outcomes associated with adult life in the general population (Howlin & Magiati, 2017; Iwasa et al., 2022).

Findings from several existing studies underscore the importance of adaptive behavior in supporting adult outcomes in autism (Howlin et al., 2004; Mason et al., 2021). Some investigations have examined the predictive utility of scores on adaptive behavior measures for adult outcomes, though the specific aspects of adaptive behavior investigated as predictors have varied from study to study. In one prior analysis of the LSA sample, level of adaptive functioning was used as an adult outcome measure in this population (McCauley, Pickles, et al., 2020). Specifically, for autistic adults with IQ of less than 70, having a Daily Living Skills age equivalence score of 8 years or higher was used as indicator of adult success, the rationale being

that an age equivalence score of 8 years denoted the ability to complete some basic household chores and personal hygiene activities without assistance (McCauley, Pickles, et al., 2020). Separate work in the LSA sample indicated that, controlling for IQ, high Socialization age equivalence scores at age 14 predicted participants' likelihood of employment and of having at least one reciprocal friendship in early adulthood (Clarke & Lord, 2023). An analysis of the AAA sample (Seltzer et al., 2003) focused on employment outcomes found that higher daily living skills as measured by the W-ADL (Maenner et al., 2013) and higher cognitive ability were associated with increased likelihood of independent paid employment (Taylor et al., 2014).

In addition to cognitive ability and adaptive functioning, studies have also found autism symptom severity and contextual factors are associated with the likelihood of achieving adult outcomes (Lord et al., 2020b; McCauley, Pickles, et al., 2020; Taylor et al., 2014; Zachor & Ben-Itzchak, 2020). A separate examination of the LSA sample—again, controlling for IQ—found participants with relatively high DLS age equivalence scores had increased likelihood of attending post-secondary education; however, low autism symptomology was the only significant predictor of employment (Clarke, McCauley, et al., 2021). A study of 89 Australian autistic adults found that high family socioeconomic status was associated with poorer daily living skills, as measured by the Index of Social Competence (McConkey & Walsh, 1982). In turn, poorer daily living skills were associated with decreased likelihood of paid employment and living independently (Gray et al., 2014).

Findings from several other groups have suggested the saliency of community- and family-level factors to adult outcomes. In a study of 169 autistic adults living in Utah, more than three-quarters of whom had an IQ of 70 or lower, 80% of the sample was employed and 59% regularly attended social gatherings (Farley et al., 2018). One explanation the authors posed for

these relatively high rates of positive outcomes was the participants' broader social context, specifically, the prominence of the Mormon religious faith in Utah, and that faith group's emphasis on acceptance and community involvement (Farley et al., 2018; Mason et al., 2021). Similarly, a recent study of 170 Japanese autistic adults found their sample engaged in recreational and daily activities at similar rates to same-aged peers in the general population, and only 30% of participants were characterized as having "Poor" or "Very Poor" outcomes; again, the authors credited participants' cultural context as a contributing factor to these relatively positive findings (Iwasa et al., 2022).

Considered as a whole, the adult outcome literature underscores that no single characteristic can predict adult success for autistic individuals. However, adaptive functioning consistently emerges as a predictor of attaining many adult outcomes, and may be especially important for adults with average or better cognitive abilities (Farley et al., 2009; Howlin et al., 2013). Additional work is needed to better understand how interactions between adaptive behavior and other personal characteristics influence adult outcomes.

Few studies have examined associations between specific adaptive behaviors and adult outcomes, yet such investigations could be critical to informing interventions to improve independence amongst adults with autism (Glover et al., 2022; Teh et al., 2023). For example, establishing whether doing laundry or washing dishes is a stronger predictor of living independently could help clinicians tailor treatment goals for autistic adults. Similarly, detailed investigations of the timing of adaptive behavior development could facilitate the design of more efficacious interventions. For example, identifying which adaptive behaviors from age 14 are most predictive of independent employment in adulthood could inform adult transition planning and other school-based interventions (Burke et al., 2019; Cimera et al., 2013). This dissertation

leveraged a supervised machine learning approach to shed light on these important areas of investigation.

In addition to examining living status, employment, and the presence of friendships—some of the most commonly studied adult outcomes in autism to date (Mason et al., 2021), this dissertation also examines subjective well-being. In recent years, adult outcome studies have been criticized for placing too much emphasis on indicators of success that may not be attainable or meaningful for individuals with autism. Some autistic self-advocates have argued the achievement of one or more of these outcomes is not necessary to leading a fulfilling adult life (Pukki et al., 2022). There is some evidence that autistic adults do not derive as much satisfaction from employment as their typical peers (Black et al., 2019), and some autistic adults report little or no interest in having friends or romantic partners, for example. One recent study of autistic young adults with average or better IQ found that the majority, 57%, of participants reported subjective satisfaction in their vocational, social, and living status outcomes, despite many of these individuals not meeting "normative" expectations in these outcome areas (Orsmond et al., 2024).

Moreover, for individuals with autism and comorbid ID, who are estimated to represent between 30-50% of people with autism (Baio et al., 2018; Zeidan et al., 2022), living independently and/or finding paid employment may not be realistic outcomes in adulthood. Thus, there is a need for studies that conceptualize positive adult outcomes for individuals with autism more holistically (Lounds Taylor, 2017). This dissertation uses a composite subjective well-being measure used in previous analyses studies of the LSA sample (Clarke, Sterrett, et al., 2021; McCauley, Pickles, et al., 2020) as a more holistic and inclusive indicator of adult outcome in this heterogenous population.

Theoretical Considerations: Developmental Cascades of Adaptive Functioning

This dissertation uses a developmental cascades theoretical framework. The notion of developmental cascades stems from the work of several developmental theorists, most notably, Sameroff's transactional model of development (Sameroff, 2009; Sameroff, 2000). In brief, the transactional model asserts ongoing interactions between a child and their caregivers, peers, and others, drive changes in that child's behavior throughout their development. The concept of developmental cascades expands this basic premise to describe how success or challenges in development may compound over time (Lord et al., 2022; Mundy & Bullen, 2022).

A developmental cascades framework assumes that an individual's experiences and performance in one aspect of development will impact their future performance in other aspects of development (Masten & Cicchetti, 2010). Cascades can be positive or negative. For example, studies of the general population have found that social competence (i.e., being well-liked by peers and teachers) in late childhood and adolescence is associated with increased likelihood of employment and stable romantic relationships in adulthood (Masten et al., 2004, 2010); in other words, childhood social competence promotes positive cascades that improve the likelihood of adult success. In contrast, a lack of social competence (i.e., not being popular with peers and teachers) in childhood and adolescence predicts increased mental health challenges (Romppanen et al., 2021) and decreased likelihood of having friendships in adulthood (Burt et al., 2008; Schulenberg et al., 2004) for the general population. Thus, developmental cascades can result in "snowball effects" across development, with small advantages or disadvantages early in life resulting in outsized effects in years to come.

As depicted in Figure 1, impaired adaptive functioning and limited adult outcomes seen in autism can be understood as a negative developmental cascade, in which childhood

impairments in adaptive functioning compound over time and make it increasingly challenging to attain outcomes associated with adult life in the general population. Clearly, many other behavioral and demographic characteristics also influence and can be influenced by this negative cascade. Some such characteristics are included in Figure 1 and will be examined in the proposed dissertation, but there are likely many others as well. Figure 1 illustrates a theoretical model, not a proposed structural equation model (SEM).

One logical extension of developmental cascades is that the timing of an intervention that improves adaptive behavior may be just as or even more important as its content and execution in interrupting negative cascades and promoting positive ones (Bradshaw et al., 2022; Cox et al., 2010). Thus, understanding how adaptive behavior changes across different stages of development, and associations between the timing of such changes and the attainment of adult outcomes, could have particularly important implications for interventions to support adaptive function in autism.

Methodological Considerations

Despite its relatively long history as a psychological construct, adaptive behavior remains loosely defined in some respects. Prominent assessments of adaptive behavior are less psychometrically rigorous than many assessments of intelligence, for example (Floyd et al., 2015). Given that adaptive behavior norms are defined at least in part by the expectations of one's society and social partners (Sparrow et al., 1984), a degree of fluidity in the definition and assessment of adaptive behavior is perhaps unavoidable. As cultural expectations for adaptive functioning shift, measures of adaptive behavior must be updated regularly to reflect changing sociocultural norms. Since the publication of the first edition of the Vineland Adaptive Behavior Scales—which is generally considered the "gold-standard" assessment for adaptive functioning

(Price et al., 2018; Tassé et al., 2012)—in 1984, two major revisions have been released, one in 2005 (Sparrow et al., 2005) and one in 2016 (Sparrow et al., 2016), to reflect changes in cultural expectations for adaptive behavior. Unfortunately, little work has examined how revisions to the Vineland and other adaptive behavior measures influence assessment and scoring.

One study compared domain and total scores from the Vineland-II and Vineland-3 caregiver interview in 106 autistic individuals (Farmer et al., 2020). Both versions of the Vineland were administered no more than one week apart. The authors found that on average, Vineland-3 total ABC and domain standard scores were lower than Vineland-II scores. These differences were larger for individuals with lower cognitive abilities, and if scores were compared across assessment versions, could be interpreted as clinically significant differences. In their discussion of these results, Farmer and colleagues (2020) raise a troubling question:

Which is a truer reflection of the adaptive function of the individual, the higher Vineland-II score or the lower Vineland-3 score? Unfortunately, there is no external gold standard for evaluation of adaptive behavior, so we are unable to judge the editions' respective validity. (p. 7)

Given the widespread use of the Vineland, further investigations of discrepancies between different editions and administration formats of the VABS are warranted.

This dissertation uses data from administrations of the first and second editions of the Vineland clinician-interview. Few to no prior studies have examined differences in standardized or raw scores between the Vineland's first and second editions. By using raw DLS item scores, analyses for this project will not be impacted by the shifts in standard scores Farmer and colleagues (2020) observed between the second and third editions of the VABS. Additionally, only DLS items that remained consistent across the first and second editions of the VABS were included in the current analyses (see *Measures* section, below). However, the inclusion of data

from multiple versions of the Vineland is a limitation of this dissertation. Additional work is needed to better understand how differences between Vineland editions impact assessment scoring and interpretation.

Further, the Vineland, and many other adaptive behavior assessments, rely on informant report (i.e., parent, teacher, self; Alexander & Reynolds, 2020; Floyd et al., 2015). In other words, unlike intelligence tests or some measures of autism symptomology, such as the Autism Diagnostic Observation Schedule (Lord et al., 2012), which attempt to directly measure components of the constructs of interest, assessments of adaptive behavior typically consist of structured interviews or surveys, rather than direct observations of behavior (Hangauer et al., 2013; Sparrow et al., 2005). Though methods for assessing adaptive behavior via direct observation exist, they are time-intensive, not widely used, and many of these procedures are not standardized (the TEACCH Transition Assessment Profile [TTAP] is a notable exception to the last comment; Mesibov et al., 2007). This reliance on informant-report is another notable limitation of the Vineland and, by extension, this dissertation.

The majority of research that has used the VABS to characterize adaptive behavior in autism has examined ABC or domain-level scores only. Though important to providing an overall picture of adaptive functioning, these summary scores do not give insight into strengths and weaknesses in specific adaptive behaviors. In contrast, item-level "micro-analyses" of Vineland scores can provide a more detailed perspective on adaptive behavior in autism (Ventola et al., 2014). However, few studies have taken an item-level approach. Existing "micro-analyses" are cross-sectional, based on small samples, and use fairly unsophisticated statistical approaches. Insights and remaining questions from existing item-level analyses are detailed below.

Item-Level "Micro" Analyses

Many authors have highlighted the potential utility of item-level analyses for characterizing autism specific deficits in adaptive functioning and salient intervention targets. However, relatively few studies have leveraged this approach. To date, only five published studies have analyzed item-level Vineland data in autism. All of these studies were cross-sectional and only one (Teh et al., 2023) included autistic adults; the remaining studies focused exclusively on children and adolescents (Balboni et al., 2016; Glover et al., 2022; Paul et al., 2004; Ventola et al., 2014).

Teh and colleagues examined daily living skills in autistic individuals aged 16-35 (2023). They applied a novel coding system to the VABS-3 caregiver interview to identify reasons why participants could not perform items rated 0, indicating the autistic individual "Never or Seldom" completed that skill independently. The most cited reason was lack of opportunity to learn or implement the skill in question (Teh et al., 2023). This suggests that many autistic adults may be capable of completing more daily living skills if given sufficient chances to learn and practice. These results also highlight the potentially malleable nature of adaptive behavior.

Only one of the studies focused on children and adolescents attempted to identify specific adaptive behaviors relevant to success in adult life (Glover et al., 2022). Glover and colleagues examined item-level scores on the Daily Living Skills domain of the VABS-3 in 151 adolescents (*m* age = 16.4, SD = 1.4) with average or better cognitive ability. These adolescents showed relative weakness on items from the Personal and Domestic subdomains; proficiency in these subdomains was not correlated with cognitive ability. Specifically, items relating to household chores, food preparation, and earning and managing money represented areas of greatest weakness for this sample. In contrast, adaptive behaviors in the Community subdomain—specifically, items relating to safety at home and in the community, money use and management,

and use of technology—were areas of relative strength; proficiency on Community subdomain items was positively correlated with cognitive ability (Glover et al., 2022). These results suggest that interventions focused on household chores and money management, among other adaptive behaviors, may be especially impactful for adolescents with autism, though future work in separate samples and longitudinal work is needed to confirm this.

The three other studies employing item-level analyses attempted to identify Vineland items that best distinguished children with autism from children with other developmental conditions (Balboni et al., 2016; Paul et al., 2004; Ventola et al., 2014). Thus, the focus of these projects was quite different from that of this dissertation. A comparison of item-level raw scores in children with autism and children with Pervasive Developmental Disorder, Not Otherwise Specified (PDD-NOS) found significant between-group differences in the Expressive Language subdomain of the Communication domain (Paul et al., 2004). Specifically, children with PDD-NOS had higher raw scores on items assessing question asking, use of prepositions, and speaking in sentences compared to children with autism. In contrast, item-level scores on the Socialization and Daily Living Skills domains did not significantly differ by diagnostic group (Paul et al., 2004). In a study comparing item-level scores in preschoolers with autism and preschoolers with non-autism developmental conditions, items assessing play skills from the Socialization domain and items assessing following instructions, beginning to talk, and speech skills from the Communication domain best distinguished children with autism and children with other developmental conditions (Balboni et al., 2016). Finally, analyses of item-level scores on the Socialization domain only in children with autism and children with other developmental conditions under age 3 found 9 items that significantly differed between the two groups (Ventola et al., 2014). Unsurprisingly, these 9 items assessed behaviors characteristically impaired in

autism, such as responding to the voice of a caregiver, showing interest in unfamiliar children, and imitating simple and complex actions (Ventola et al., 2014).

In short, though item-level analyses have consistently found differences in Vineland scores between children with autism and children with other developmental disorders, there is little consistency in the specific items or item sets identified as differing between these diagnostic groups. This may be a limitation of the cross-sectional approach employed by these studies, the use of samples of varying ages, the differing emphasis on specific domains of the Vineland, or any combination of the above. Though interesting from a measurement perspective, the question of which Vineland items may distinguish children with autism from children with other developmental conditions is of limited utility in improving the day-to-day lives of autistic individuals and their families. Notably, both individuals with autism and individuals with non-autism developmental delays show impairments in adaptive behavior and struggle to attain many outcomes in adulthood (Lord et al., 2020a; Seltzer et al., 2011). Perhaps these similarities between diagnostic groups are more significant than any differences. This dissertation includes a subset of individuals with non-autism developmental delays, and autism diagnostic status was tested as a covariate in all analyses.

Statistical Approaches

Existing item-level analyses of the Vineland have relied upon relatively simplistic statistical methods, such as Fisher's exact tests (Ventola et al., 2014), t-tests (Balboni et al., 2016; Glover et al., 2022; Teh et al., 2023), and MANOVA (Glover et al., 2022; Paul et al., 2004) to examine differences in VABS item-level scores by diagnostic groups (Balboni et al., 2016; Paul et al., 2004; Ventola et al., 2014) or by Vineland domains and subdomains (Glover et al., 2022). Including the optional Motor Skills and Maladaptive Behaviors domains, there are

502 items on the Vineland (Sparrow et al., 2016). Though the VABS is designed such that each administration consists of only a subset of items appropriate to the individual's ability level and chronological age (Sparrow et al., 2005), simplistic statistical approaches to item-level analyses necessitate large numbers of tests and increase the likelihood for Type I error.

The Current Study

This dissertation sought to identify specific daily living skills that are strongly related to the attainment of adult outcomes in autism spectrum disorder and to deepen existing knowledge of DLS development in this population. Prior work has consistently shown that higher total scores on adaptive behavior measures are associated with increased likelihood of attaining many adult outcomes (Clarke, Sterrett, et al., 2021; Farley et al., 2018; Taylor et al., 2014), but it remains unclear whether specific types of adaptive behaviors are more important to the attainment of adult outcomes than others. Further, though adaptive behavior is an inherently developmental construct and prior work has identified distinct trajectories of adaptive behavior development in autism (Baghdadli et al., 2018; Bal et al., 2015; Szatmari et al., 2015), few investigations have studied how competency in specific adaptive behaviors at specific points in development may impact outcomes later in life. From a developmental cascades perspective, we might anticipate that the timing of adaptive behavior mastery is a key aspect of the influence of adaptive behavior on later life functioning (Bradshaw et al., 2022; Masten et al., 2010). Thus, the aims of this dissertation were as follows:

1. Identify VABS DLS item sets from ages 5, 9, 14, and 18 that—controlling for IQ, autism symptomology, and other salient characteristics—predict adult outcomes at approximately age 33 via multiple hierarchical and binary logistic regression.

2. Leverage XGBoost supervised classifier machine learning models to pinpoint specific DLS items from ages 5, 9, 14, and 18 that—controlling for IQ, autism symptomology, and other salient characteristics—predict adult outcomes at approximately age 33.

Through the use of supervised machine learning, Aim 2 builds upon Aim 1 by using a more sophisticated statistical approach than prior item-level VABS microanalyses to identify individual DLS items predictive of adult outcomes while avoiding the need for a larger number of tests and subsequent increased risk of Type I error. Insights garnered from these two approaches could directly inform clinical interventions for adaptive functioning in individuals with autism from childhood through early adulthood.

Method

Sample

213 consecutive referrals under 37 months old at clinics in North Carolina and Chicago initially enrolled in a longitudinal study of autism. 192 participants were referred for autism and 21 participants were referred for non-spectrum developmental delays. 40 children of similar characteristics from Michigan joined the study at age 9 and were subsequently seen at the same times, for a total of 253 participants. In-person assessments, including the VABS, ADOS, and IQ testing, were completed at ages 2, 3, 5, 9, 18, 21, 26, and 30. Additional parent-interviews were completed via phone-interview at age 14. Adult outcomes data was collected via mailed survey packets completed by caregivers and participants capable of self-report when participants were approximately age 33. See Table 2 for descriptive information on the LSA sample.

Attrition and participants lost to follow-up over the 30 years of the LSA study has resulted in a sample of 157 participants in adulthood. This rate of attrition is comparable to that observed in other population based (Gustavson et al., 2012) and autism specific (Taylor et al.,

2014) longitudinal samples. There have been no effects of diagnosis, gender, or region on attrition at any age. There has been greater attrition in Black families and families with less maternal education, consequently, all analyses for this dissertation included race and maternal education as covariates. Currently, 19% of participants are Black, 59% reside in Census-designated rural locations, and 44% have a primary caregiver who was not college educated.

Procedure

Face-to-face visits occurred at approximately ages 2, 3, 5, 9, 18, 21, 26, and 30. Research-reliable research assistants, trainees, or clinical psychologists administered the VABS, ADOS, and other measures of interest. Caregivers and, when capable, participants completed demographic questionnaires and measures of well-being. Parents and participants over the age of 18 who were their own legal guardians signed a consent form as required by the applicable institutional review board(s) prior to each visit. All study procedures were approved by the University of North Carolina, Chapel Hill, the University of Chicago, the University of Michigan, Cornell University, and University of California, Los Angeles Institutional Review Boards, as appropriate.

Measures

Daily Living Skills

The Vineland Adaptive Behavior Scales (Sparrow et al., 2005) is considered the gold-standard measure of adaptive functioning in autism spectrum disorder and related developmental conditions and is frequently used in clinical and research settings to assess an individuals' capability for independent functioning and to monitor progress over time. As a clinician administered, caregiver-report interview, the Vineland integrates multiple perspectives on an individual's functioning. Vinelands were administered to LSA participants at nine points from

early childhood to adulthood: ages 2, 3, 5, 9, 14, 18, 21, 26, and 30. LSA participants were administered the first edition of the VABS (Sparrow et al., 1984) from ages 2-9, and the second edition of the VABS (Sparrow et al., 2005) from ages 14-30. Vineland raw item and item set scores from the Daily Living Skills (DLS) domain of the first and second editions of the VABS from ages 5, 9, 14, and 18, were analyzed for this dissertation.

Items have been revised with each edition of the Vineland. Thus, while many items are the same or quite similar in the first and second editions, other items vary markedly between editions. For ease of interpretability, only DLS items that were equivalent across the first and second editions of the Vineland were included in analyses for this dissertation. The full list of DLS items and item sets included in the current analyses are listed in Table 3.

The Vineland administration rules state that for each subdomain, four consecutive items with a score of 2 is considered basal, and four consecutive items with a score of 0 is considered ceiling. Given the large number of individual items on the Vineland and the variability seen across individuals' adaptive behaviors at various stages of development, different administrations of the Vineland can include different subsets of items. For analytic purposes, items in each subdomain that were not administered but preceeded a participant's basal items were assigned a score of 2, and items not administered that proceeded a participant's ceiling items were assigned a score of 0.

IQ

The Mullen Scales of Early Learning (Mullen, 1995) were administered at age 2. Later cognitive assessments were chosen based on participants' developmental abilities from a standard hierarchy including the Weschler Intelligence Scale for Children (WISC; Weschler, 2003), Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 2011), Differential

Abilities Scale (DAS; Elliot, 2007), and Mullen (Lord et al., 2006). Ratio IQs were calculated when raw scores fell outside deviation score ranges. Participants were first administered the test with the greatest difficulty corresponding to their ability level, estimated by past performances, verbal abilities, and adaptive skill levels assessed via parent interviews. If basal or ceiling scores were not achieved, the participant was administered the next more or less difficult measure, as appropriate (See also, Anderson et al., 2014).

Prior analyses of the LSA sample have distinguished participants that are "more cognitively able," meaning their verbal IQ is 70 or greater, and participants that are "less cognitively able," meaning their verbal IQ is less than 70 (McCauley, Pickles, et al., 2020). These two groups have non-overlapping distributions of IQ; with means slightly above 100 for the more cognitively able and in the severe to profound intellectual disability range for less cognitively able adults (Pickles et al., 2020). Of the 157 active participants in adulthood, 67 are more cognitively able (MA) and 90 are less cognitively able (LA). This dissertation examines VABS items and item sets predictive of adult outcomes for the LSA sample as a whole, as well as separately for MA and LA participants (Table 2).

Autism Symptomology

Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2012) calibrated symptom severity (CSS) scores were used to measure autism symptomology. The ADOS is a semi-structured, clinician-administered observational measure and is widely considered the "gold standard" for autism diagnosis. ADOS CSS rates an individual's autism symptoms ranging from 10 (clearest case of autism with many symptoms) to 1 (no evidence of autism). The ADOS was administered during in-person visits at ages 2, 3, 5, 9, 18, 21, and 25.

Clinicians made best-estimate diagnoses of autism, other developmental disabilities, or typical development at each in-person visit, except age 3. Despite multiple assessments, 55 individuals in this sample have never received an autism diagnosis. Prior analyses have found these diagnostic groups do not differ on a range of childhood and adult characteristics, including childhood IQ (Lord et al., 2020), and likelihood of having social contacts, living independently, and working in adulthood (Clarke & Lord, 2023; McCauley, Pickles, et al., 2020). Given considerable overlap in the challenges faced during adulthood for all individuals with developmental disabilities (Lord et al., 2020), participants with non-spectrum delays were retained in all analyses. Both participant diagnostic status and ADOS CSS scores were tested as covariates in all analyses.

Adult Outcomes

For analytic purposes, non-continuous adult outcome measures (i.e. living status, friendships) were reduced to two groups, to indicate participants who are attaining and not attaining particular outcomes. Initially, three-group indicators of all non-continuous adult outcome measures were tested, corresponding to full, partial, and no attainment of the adult outcome of interest. However, given limited numbers of participants with partial attainment of any of the adult outcomes examined here, binary indicators were used for all analyses of non-continuous adult outcome measures. Summary information on adult outcome attainment in this sample is presented in Table 4.

Employment. Data from caregiver-report and, when capable, participant self-report demographic forms were used to determine participants' employment status at approximately age 33. Respondents were prompted "Is [the participant] currently employed?" Response options included: "Regular employment with no help or support," "Supported employment (you may

have a job coach or other special help at work),” “Sheltered workshop or enclave employment,” “Day program,” “Internship or work study program," “Volunteering,” and “Prefer to specify.” If the participant was employed, respondents were also prompted to provide the participant’s job title, approximate annual salary, and place of employment. Respondents were also asked to estimate how many hours the participant worked each week. Response options included, “1-9 hours,” “10-19 hours,” “20-29 hours,” “30-39 hours,” and “40 or more hours.”

Employment data were coded using the Vocational Index (VDI) developed by Taylor and Seltzer (2012). The VDI was specifically designed to measure independence in vocational activities in adults with autism and has been used to examine vocational trajectories in previous analyses of the LSA sample (Clarke, Sterrett, et al., 2021) as well as in a separate longitudinal sample of adults with autism (Taylor and Mailick, 2014; Taylor et al., 2014). Scores on the VDI range from 1-9, with 1 indicating no participation in employment or post-secondary education activities, and 9 indicating participation in post-secondary education or competitive employment for 10 hours/week or more without supports. The VDI also includes scores specifically for individuals in volunteer, sheltered workshop and supported employment settings, making it a uniquely effective measure for understanding vocational outcomes in autism amongst individuals of varying language and IQ levels (see Taylor & Seltzer, 2012 for a full description of VDI design and scoring). In line with prior analyses of the LSA sample (Clarke et al., 2021), a modified version of the VDI that includes a score of 10 was used for the current analyses. A score of 10 was defined as participation in competitive employment for 20 hours/week or more without supports.

Living Status. Data from caregiver-report and, when capable, participant self-report demographic forms was used to determine participants’ living status at approximately age 33.

Respondents were prompted "What is [the participant's] current living situation?" Response options included: "Own home/apartment *without* supports (without assistance from care staff or caregivers)," "Own home/apartment *with* supports (with some assistance from care staff or caregivers," "Home with parent or guardian," "staffed apartment (fully supported or supervised living)," "Group home or facility (more than 15 residents," and "Other (specify)." This information was collapsed into a binary variable, with 1 indicating the participant currently lived independently outside of the family home (this included living with roommates or romantic partners) and 0 indicating the participant currently lived in the family home or in a supported residential setting (e.g., group home, or a facility with designated residential support staff).

Social Relationships. The social experiences of MA and LA participants vary substantially, given the heterogeneity in language ability and IQ seen across these subgroups. Thus, different indicators of friendship were used to assess this outcome area for MA and LA participants. For MA individuals, a positive friendship outcome was defined as having at least one mutual friendship. For LA individuals, a positive friendship outcome was defined as having at least on regular social contact outside of family members and paid staff.

The Social Emotional Functioning Interview (SEF-S & SEF-I; Rutter et al., 1988) was used to assess participants' friendships. Question 28 of the SEF, "Friends," asks respondents, "Does [the participant] have any particular friends whom he/she sees? Who are they? Do these people ever come to his/her home or does he/she usually meet them at the club, center, etc.?" The "Friends" item of the SEF is scored from 0-3, with 0 indicating the participant "has a number of different friends of roughly own age with whom they share a variety of interests and social activities," and 3 indicating the participant has "no particular friends with any shared activities."

Question 29 of the SEF, "Quality of Friendships," asks respondents, "What do [the participant] and their friends talk about when they're together? Would he/she ever confide in a friend how he/she is feeling or about his/her worries?...Would they tell each other about things that have made them feel especially pleased or happy?" The "Quality of Friendships" item is also scored from 0-3, with 0 indicating the participant has "one or more relationships with person in own age group with whom there are shared activities of personal variety and in which both participant and other person show initiative in seeking contact, and definite quality of shared enjoyment or exchanged confidences/intimacies and definite selectivity/exclusiveness of relationship," and 3 indicating the participant "has people with whom some shared activities but little or no evidence of specific pleasure in their company." A score of 8 can also be assigned for Question 29, indicating the participant has "no friends with whom shared activities."

Subjective Well-Being. Prior exploratory principal components factor analysis with varimax rotation identified a happiness factor separately in both caregiver and self-report data (McCauley, Pickles, et al., 2020). For caregiver data, the positive affect scale of the Positive and Negative Affect Scales (PANAS; Watson, Clark, & Tellegen, 1988), the total score from the Scales of Psychological Well-Being (WBQ; Ryff, 1989), and the total score from the Quality of Life Questionnaire (QLQ; Schalock & Keith, 1993) loaded onto the happiness factor (loadings of .87, .78, and .77, respectively). These same three scores loaded onto the self-report happiness factor as well (PANAS positive scale = .71, WBQ = .82, QLQ = .96). Scores on all three measures comprising the happiness factor were scaled and averaged to produce a "happiness quotient" composite score. Composite scores range from -1 to 1, with higher scores indicating greater levels of reported happiness. Prior work in the LSA sample has found participation in employment activities (Clarke, Sterrett, et al., 2021) and relatively few symptoms of

psychopathology (McCauley, Elias, et al., 2020) are associated with higher caregiver- and self-report happiness quotient scores.

Analytic Plan

Missing Data

The total LSA cohort includes 253 autistic individuals and their families, however, attrition over the more than thirty years of study has resulted in 157 active participants in adulthood. The percentage of missing data for covariates and adult outcome variables is presented in Table 5. Prior analyses of the LSA cohort have consistently found participants of color and participants whose primary caregiver has less than a 4-year college degree were more likely to be lost to attrition or follow-up than white participants with more educated caregivers (Lord et al., 2020b). Thus, race and caregiver education were tested as covariates in all analyses.

Most machine learning feature selection algorithms, including XGBoost, require complete data (Mera-Gaona et al., 2021). Given the mix of continuous and categorical covariates and adult outcome variables, multivariate imputation by chained equations (MICE) with random forest was performed via the R mice package with $m = 5$ (Buuren & Groothuis-Oudshoorn, 2010). This approach is well-suited for handling missing data in small samples (Enders, 2010).

All analyses for this dissertation were conducted separately by timepoint. This avoids the use of multilevel imputation—a computationally complex approach that would also limit the interpretability of these findings. However, a notable drawback of running analyses by timepoint is that the subset of LSA participants included varies across ages, based on which participants completed the Vineland at ages 5, 9, 14, and 18, respectively.

Aim 1

The first aim of this dissertation was to identify VABS item sets from ages 5, 9, 14, and 18 that—controlling for IQ, autism symptomology, race, gender, urbanicity, recruitment site, and maternal education—predict adult outcomes. Regression analyses were used to examine whether Vineland DLS item set mean scores at ages 5, 9, 14, and 18 predicted VDI scores (employment), the likelihood of living independently, the presence of friendships, and happiness quotient scores (subjective well-being) at approximately age 33. For continuous adult outcome variables (happiness quotient and VDI scores), multiple hierarchical regression was used. For categorical adult outcome variables (residential status, friendships), binary logistic regression was used. All Aim 1 analyses were conducted via SPSS 28.

First, separate regressions for salient demographic (i.e., race, gender, participant diagnostic status, caregiver education, recruitment site, urbanicity) and phenotypic characteristics (i.e., verbal IQ at 9, ADOS CSS score at 9) were run for each of the four adult outcomes of interest. These regressions were run separately to retain as much power as possible while testing covariates. For each adult outcome, demographic and phenotypic variables identified as significant predictors during this step were then included as covariates in all VABS DLS item set regression models.

DLS item set regression analyses at ages 5, 9, 14, and 18 were initially conducted for all LSA participants. For timepoints where VABS DLS item sets that significantly predicted adult outcomes were identified (ages 9 and 18); additional regression analyses separated by ability level (MA/LA) were also conducted. The Benjamini-Hochberg procedure was used to calculate adjusted p-values for all DLS item set analyses (Benjamini & Hochberg, 1995).

Aim 2

The second aim of this dissertation was to identify individual VABS DLS items from ages 5, 9, 14, and 18 that significantly predicted adult outcomes, controlling for salient demographic and personal characteristics via eXtreme gradient boosting (XGBoost) supervised machine learning classifier models. This algorithm was selected for several reasons. First, XGBoost is known for its superior performance in decision-tree-based modeling, and allowed for the direct comparison of the predictive utility of DLS items at distinct points in development (Choi et al., 2023; Li et al., 2024; Wang et al., 2020). XGBoost is also robust to noise and can effectively filter out irrelevant features in a dataset. Finally, XGBoost can cope with non-linear relationships between features and outcome variables, which may not be captured using simpler machine learning models.

Data Preprocessing. Continuous outcome variables (VDI scores, happiness factor scores) were transformed into dummy variables based on mean split prior to model building. Linear regression XG Boost models were initially explored for continuous outcome variables but were untenable due to the limited sample size. The percentage of missing data for covariates and adult outcome variables prior to imputation is presented in Table 5.

Model Building. Sixteen models were developed, one for predicting each adult outcome (employment, well-being, living status, and friendships) from individual daily living skills items at each timepoint of interest (ages 5, 9, 14, and 18). Datasets for each age were randomly split into a training set (80%) and a test set (20%). Hyperparameter optimization was performed on the training sets via a five-fold cross-validation grid search. To avoid data shifting between two subsets, random data split was stratified with respect to the outcome variable.

Models including verbal IQ at 9 and ability level (MA/LA) as covariates were initially explored. These models performed well, however, in most of these models, verbal IQ and ability

level were the strongest predictors by far and explained the majority of the variance in the outcomes. The presence of such variables can lead to bias and overfitting in XG Boost models, which in turn can limit generalizability (Lundberg et al., 2020). Thus, verbal IQ and ability level were not included as predictors in the final XG Boost models. Separate models for MA and LA individuals were not explored due to insufficient sample sizes.

Model performance was assessed via the area under the receiving operating curve (ROC AUC), sensitivity, specificity, negative predictive value (NPV), positive predictive value (PPV), and accuracy. ROC AUC values of 0.7 to 0.8 are considered acceptable, values of 0.8 to 0.9 are considered excellent, and values higher than 0.9 are considered outstanding (Mandrekar, 2010). The Shapley Additive exPlanations (SHAP) tree explainer method for XG Boost classifiers was used to identify the top 5 predictor variables for each model (Lundberg et al., 2020).

Results

Aim 1: How do DLS mean item set scores at ages 5, 9, 14, and 18 relate to adult outcomes?

Multiple hierarchical regressions and logistic regressions were performed to assess the ability of Vineland DLS item set scores from ages 5, 9, 14, and 18 to predict adult happiness, vocational, residential, social, and romantic outcomes. First, to identify salient demographic and phenotypic covariates for each of the five adult outcomes, separate regressions for gender, race, caregiver education, urbanicity, diagnostic status, ADOS CSS at age 9, and verbal IQ at age 9 were run for each of the outcomes of interest. Verbal IQ at age 9 was a significant predictor of VDI scores ($p < .001$), social relationships ($p < .001$), and residential status ($p < .001$). Additionally, autism diagnostic status was a significant predictor of happiness quotient scores ($p < .001$), but not of any other adult outcomes (all $p > .05$). Race, gender, maternal education, recruitment site, urbanicity and ADOS CSS at 9 were not significant predictors of any of the

adult outcomes (all p > .05). Thus, verbal IQ at age 9 was included as a covariate in the first block of all VDI, friendship, and living status outcome regression models, and diagnostic status was included as a covariate in the first block of all happiness quotient score models.

Descriptive trajectories of mean scores for item sets that predicted the same adult outcome at various ages (e.g., bathing, kitchen skills) and/or predicted multiple adult outcomes (e.g., grooming, healthcare) are displayed in Figures 2, 3, and 4. These trajectories are for illustrative purposes only; group-based trajectory analyses were not conducted.

Employment

Controlling for verbal IQ at age 9, no Vineland DLS item set mean scores from age 14 predicted VDI scores for the LSA sample as a whole. After Benjamini-Hochberg corrections, kitchen skills (β = .129, t(121) = 2.57, p = .011), toileting (β = .135, t(121) = 2.30, p = .023), bathing (β = .175, t(121) = 3.04, p = .003), and healthcare (β = .136, t(121) = 2.76, p = .007) mean item set scores from age 5 predicted VDI scores at age 33. From age 9, housekeeping (β = .184, t(149) = 2.79, p = .006), phone skills (β = .163, t(149) = 2.31, p = .025), and rules, rights, and safety (β = .301, t(149) = 3.89, p = .020) mean item set scores predicted VDI scores. Finally, at age 18, kitchen skills (β = .156, t(140) = 2.15, p = .033), and job skills (β = .241, t(140) = 3.39, p = .001) predicted VDI scores for the LSA sample as a whole.

Amongst LA participants, kitchen skills (β = .198, t(83) = 2.08, p = .040), toileting (β = .305, t(83) = 3.23, p = .002), dressing (β = .224, t(83) = 2.36, p = .020), bathing (p < .001), grooming (β = .208, t(83) = 2.18, p = .032), and healthcare (β = .262, t(83) = 2.81, p = .006) mean item set scores from age 5 were predictive of adult VDI scores. Housekeeping (β = .261, t(94) = 2.41, p = .018), grooming (β = .295, t(94) = 2.75, p = .007), phone skills (β = .239, t(94) = 2.64, p = .010), money skills (β = .289, t(94) = 3.26, p = .002), restaurant skills

(β = .210, t(94) = 2.15, p = .034), and job skills (β = .422, t(94) = 5.12, p < .001) mean item set scores at age 9 were predictive of higher VDI scores at age 33. No DLS mean item set scores from ages 14 or 18 significantly predicted VDI scores at age 33 for LA participants.

No mean item set scores from ages 5 or 14 predicted VDI scores amongst MA participants. Job skills (β = -.363, t(52) = -2.86, p = .006) mean item set scores from age 9 significantly predicted higher VDI scores at age 33, and money skills (β = .312, t(60) = 2.60, p = .012), time and dates (β = .303, t(60) = 2.53, p = .014), and job skills (β = .319, t(60) = 2.56, p = .013) mean item set scores from age 18 significantly predicted VDI scores at age 33 for MA participants.

Subjective Well-Being

Controlling for autism diagnostic status, no Vineland DLS item set mean scores from age 5 predicted happiness quotient scores for the LSA sample. After Benjamini-Hochberg corrections, from age 9, kitchen skills (β = .193, t(149) = 2.47, p = .014), dressing (β = .184, t(149) = 2.35, p = .020), bathing (β = .220, t(149) = 2.82, p = .005), and grooming (β = .186, t(149) = 2.36, p = .020) mean item set scores predicted happiness quotient scores about twenty years later, at age 26. From age 14, safety at home (β = .199, t(117) = 2.29, p = .024), bathing (β = .263, t(117) = 3.01, p = .003) and healthcare (β = .255, t(117) = 2.92, p =.004) significantly predicted happiness quotient scores. Finally, housekeeping (β = .244, t(139) = 3.12, p =.002), bathing (β = .163, t(139) = 2.04, p = .043), grooming (β = .175, t(139) = 2.18, p = .031), healthcare (β = .201, t(139) = 2.53, p = .012), money skills (β = .183, t(139) = 2.32, p = .022), rules, rights, and safety (β = .168, t(139) = 2.10, p = .037), and job skills (β = .225, t(139) = 2.89, p = .004) mean item set scores from age 18 significantly predicted happiness quotient scores about eight years later, at age 26.

Amongst LA participants, kitchen skills (β = .160, t(94) = 2.59, p = .011), housekeeping (β = .210, t(94) = 2.13, p = .035), dressing (β = .189, t(94) = 2.34, p = .021), bathing (β = .265, t(94) = 2.73, p = .008), and grooming (β = .163, t(94) = 2.23, p = .028) mean item set scores at age 9 significantly predicted happiness quotient scores at age 26. Kitchen skills (β = .245, t(63) = 2.11, p = .038) and bathing (β = .341, t(63) = 2.99, p = .004) mean item set scores remained significant predictors of happiness quotient scores for LA participants at age 14. Healthcare (β = .398, t(63) = 3.59, p < .001) mean item set scores at age 14 were also a significant predictor of happiness quotient scores. There were no mean item set scores from age 18 that significantly predicted happiness quotient scores for LA individuals.

For MA participants, no item set mean scores prior to age 18 were predictive of happiness quotient scores. At age 18, kitchen skills (β = .272, t(59) = 2.27, p = .027), housekeeping (β = .255, t(59) = 2.12, p = .038), bathing (β = .259, t(59) = 2.18, p = .033), healthcare (β = .308, t(59) = 2.63, p = .011), money skills (β = .311, t(59) = 2.64, p = .011), time and dates (β = .302, t(59) = 2.59, p = .012), restaurant skills (β = .323, t(59) = 2.78, p = .007), and job skills (β = .339, t(59) = 2.93, p = .005) mean item set scores significantly predicted happiness quotient scores at age 26 for MA individuals.

Friendships & Residential Status

After Benjamini-Hochberg corrections, controlling for verbal IQ at age 9, no Vineland DLS item set mean scores from ages 5, 9, 14, or 18 predicted the likelihood of having friends (defined as having at least one social contact outside of family members and staff for LA participants and having at least one mutual friend for MA participants), or the likelihood of living independently by age 33 for the total LSA sample. Thus, follow-up regression analyses by ability level were not conducted.

In summary, for the LSA sample as a whole, DLS mean item set scores from ages 5, 9, and 18 predicted employment at approximately age 33, and mean item set scores from ages 9, 14, and 18 predicted subjective well-being. The bathing and kitchen chores item sets predicted more adult outcomes at more ages than any other item sets. Specifically, bathing mean item set scores from age 5 predicted employment, and scores from ages 9, 14, and 18 predicted subjective well-being. Kitchen chores mean item set scores at age 5 and 18 predicted employment, and scores from age 9 predicted subjective well-being. These item sets also emerged as significant predictors in regression analyses conducted separately for MA and LA participants. Both bathing and kitchen chores from age 5 predicted employment for LA participants, and scores from both item sets at ages 9 and 14 predicted subjective well-being for LA participants also. For MA participants, bathing and kitchen chores mean item set scores from age 18 predicted subjective well-being. Finally, No DLS item sets were predictive of friendships and residential status.

Aim 2: Do specific DLS items from ages 5, 9, 14, and 18 predict adult outcomes?

Model performance metrics (ROC AUC, sensitivity, specify, NPV, PPV, and accuracy) are presented in Table 6. The top 5 predictors for models predicting employment and living status are presented in Table 7, and the top 5 predictors for models predicting social relationships and subjective well-being are presented in Table 8.

Employment

The age 9 model for predicting employment had the best fit statistics (AUC 0.912; sensitivity 0.963; specificity 0.705), followed by the age 5 model, then the age 14 model and the age 18 model (Table 6). The top 5 predictors from the age 9 model were item 18 from the community subdomain (“States value of penny, nickel, dime and quarter,”) item 16 from the community subdomain (“Demonstrates knowledge of what phone number to call in an

emergency when asked,") item 5 from the community subdomain ("Is aware of and demonstrates appropriate behavior while riding in car [for example, keeps seat belt on, refrains from distracting driver, etc.]") item 32 from the personal subdomain ("Bathes or showers and dries self,"), and item 24 from the community subdomain ("Makes telephone calls to others, using standard or cell phone.").

Living Status

Only the age 18 model predicting living status performed better than chance (Table 6). This model had good AUC and sensitivity, but relatively low specificity (AUC 0.912; sensitivity 0.939; specificity 0.444). The top 5 predictors for the age 18 model were item 36 from the community subdomain ("Notifies school or supervisor when he or she will be late or absent,") item 30 from the community subdomain ("Counts change from a purchase,") item 22 from the domestic subdomain ("Washes clothing as needed,") maternal education, and item 37 from the community subdomain ("Uses savings or checking account responsibly;" Table 7).

Social Relationships

The age 9 model for predicting friendships had the best fit statistics (AUC 0.799; sensitivity 0.769; specificity 0.777), followed by the age 14 model, then the age 18 model and finally, the age 5 model (Table 6). The top 5 predictors from the age 9 model were item 11 from the community subdomain ("Summons to the telephone the person receiving a call or indicates that the person is not available,") item 2 from the community subdomain ("Talks to familiar person on telephone,"), maternal education, item 24 from the community subdomain ("Makes telephone calls to others, using standard or cell phone,") and item 20 from the community subdomain ("Obeys traffic lights and 'Walk' and 'Don't Walk' signs."). Notably, items 2, 11, and 24 from the community subdomain comprise the phone skills item set.

Subjective Well-Being

With the exception of the age 9 model, which performed at chance, the fit statistics for models predicting happiness quotient scores improved with increasing age. The age 18 model showed the largest AUC on the test set (AUC 0.971; sensitivity 0.888; specificity 0.937). The top 5 predictors from the age 18 model were ADOS CSS score from age 9, item 22 from the domestic subdomain ("Washes clothing as needed,") item 30 from the community subdomain ("Counts change from a purchase,") item 12 from the domestic subdomain ("Uses tools, for example, a hammer to drive nails, a screwdriver to screw and unscrew screws, etc.,") and maternal education (Table 8).

In sum, for all but two of the XG Boost models described here, an item from the community subdomain of daily living skills emerged as the strongest predictor variable (Tables 6 and 7). The XG Boost models predicting subjective well-being from DLS scores at ages 5 and 18 were the only instances in the current study where community items were not the strongest predictors of adult outcome. For the age 5 subjective well-being model, item 2 from the domestic subdomain, "Helps with simple household chores," was the strongest predictor, and all top 5 predictors were items from either the domestic or personal domain of daily living skills. For the age 18 model, ADOS CSS at age 9 was the strongest predictor, followed by two items from the domestic subdomain, one community subdomain item, and maternal education (Table 8). In the item-set regression analyses, subjective well-being was also the only adult outcome examined here that was not strongly predicted by verbal IQ at age 9. Rather, autism diagnostic status emerged as a significant covariate of subjective well-being in the regression analyses.

Discussion

The earliest measure of adaptive functioning, the Vineland Social Maturity Scale, was created to measure the efficacy of a vocational and life skills training program for individuals with ID (Doll, 1953). Sound research informs sound clinical practice, and vice versa. The conceptualization of adaptive behavior has been repeatedly refined in the decades since Doll's scale was first published, yet the scores used to quantify adaptive functioning in research and in practice continue to provide only a bird's-eye view of this nuanced and highly individual construct. As a result, the considerable body of research descriptively characterizing profiles of adaptive functioning commonly associated with autism has not translated into more effective adaptive functioning interventions for people on the spectrum.

Notably, in almost all the analyses reported here, childhood verbal IQ emerged as the strongest predictor of adult outcomes. A noteworthy exception to this was subjective well-being, which appeared to be more closely associated with autism symptom severity than verbal IQ. Daily living skills predictive of adult outcomes was the focus of this dissertation, however, it is essential to recognize the importance of IQ in supporting success across the life course. Though adaptive behavior and cognitive ability are distinct constructs, they are interrelated, and many sophisticated daily living skills (i.e., managing a checking account, making appointments, filling prescriptions) require some degree of intellectual capability. Though average or better IQ by no means guarantees adaptive behavior competency, the presence of severe intellectual disability is often a considerable limitation to attaining said competency.

However, in contrast to intellectual ability, autism symptom severity, and other behavioral characteristics, adaptive behavior may be more malleable. With intervention, the adaptive functioning of individuals with autism of varying levels of ability can be improved

(Bennett & Dukes, 2013; Eldevik et al., 2010; Wong et al., 2015). Initial evidence from a daily living skills intervention for adolescents with autism yielded promising results, with participants experiencing gains in Community and Domestic subdomain scores post-treatment as well as continued gains 6 months following treatment (Duncan et al., 2018, 2021). However, this and similar intervention protocols are time and resource intensive (Wehman et al., 2019). Further, there is little to no insight about the "active ingredients" that make these interventions efficacious (Teh et al., 2023). This dissertation strove to address this gap by pinpointing specific daily living skills from ages 5, 9, 14, and 18 that predict positive adult outcomes.

Predictive Utility of Mean DLS Item Set Scores

Only employment and subjective well-being outcomes—not social relationships or living status outcomes—were significantly predicted by DLS mean item set scores in the Aim 1 regression analyses after Benjamini-Hochberg corrections. Kitchen chores and bathing mean item set scores from multiple timepoints emerged as significant predictors of both employment and subjective well-being for MA and LA participants. These results may suggest that interventions targeting skills related to personal hygiene and cooking can promote quality of life and improve the likelihood of obtaining employment for autistic adults of varying cognitive abilities. Given the diverse characteristics of MA and LA participants in this sample, it is intriguing to see that cooking and personal hygiene skills appear to be critical to adult outcome attainment for both groups.

However, it is not clear *why* daily living skills in these particular item sets promote employment and subjective well-being in adulthood. It is possible that it is not the skills themselves that increase the likelihood of attaining these outcomes. Rather, perhaps growing up in a context in which the development of such skills is actively fostered through opportunity,

expectations, and/or guided practice is the promotive factor that increases outcome attainment. Similarly, it could be that personal characteristics not measured here, such as executive function or conscientiousness are integral to the development of cooking and personal hygiene skills and are also promotive of adult employment and well-being. In short, these results provide more nuanced insight into the specific adaptive behaviors important to adult outcomes than previous work, but additional work is needed to understand what it is about these skills that supports adult outcome attainment for autistic individuals.

Even after Benjamini-Hochberg corrections, each of the item sets from the community subdomain of DLS (phone skills; rules, rights and safety; money skills; time and dates; restaurant skills; job skills) predicted either employment or subjective well-being at one or more timepoints. In contrast, some item sets from both the personal and domestic subdomains were not predictive of any adult outcomes at any timepoint. For MA participants, scores from age 18 on three community item sets, money skills, time and dates, and job skills, predicted both employment and subjective well-being outcomes. A similar pattern was seen in the XG Boost models for employment and social relationships; at all four timepoints examined here, an item from the community subdomain was the strongest predictor of employment and social relationships outcomes (Tables 6 and 7).

Strikingly, item sets from the community subdomain had the lowest mean scores in this sample, with the least amount of growth over time (Figure 4). This was true for both MA and LA participants. In fact, MA participants' mean item set scores from the community subdomain were not markedly higher than those of LA participants—this was the only subdomain in which this was the case. In contrast to item sets from the community subdomain, item sets from the personal and domestic subdomain appeared to follow a trajectory of linear increase from mid-childhood to

early adulthood, with MA participants having higher scores on average at all timepoints (Figures 2 and 3).

These results suggest that daily living skills related to navigating "the real world,"—such as answering a phone, making small purchases, and ordering in a restaurant—may be an area of relative weakness for many autistic individuals, both with and without intellectual disability. Given that many item sets and individual items from the community subdomain emerged as significant predictors of adult outcomes in the current study, the weakness observed here in community skills is concerning. Notably, for community item scores from age 18, there may be some conflation of predictor and outcome variables—some higher-level community DLS items specifically ask about the ability to maintain employment, for example.

In the Aim 1 analyses, no DLS item sets from any of the four time points predicted friendships or living status after Benjamini-Hochberg corrections. It is possible that the use of dummy variables to measure friendship and living status outcomes contributed to these null findings, as binary indicators do not allow for the same degree of nuance afforded by continuous variables, such as those used to measure subjective well-being and employment outcomes. Though the use of categorical variables to measure friendship and living status was investigated, the bimodal outcome distributions seen in this sample limited the utility of this approach. For example, most participants in this sample either lived in the family home or a group home (i.e., a fully supported residential environment) or independently—very few individuals lived in a community setting with part-time support, or in some other intermediary arrangement.

Predictive Utility of Individual DLS Items

Items from the community subdomain of daily living skills emerged as the strongest predictor variable in all but two of the XG Boost models (Tables 6 and 7). The specific

community items that most strongly predicted adult outcomes varied with age. However, given the inherently developmental nature of adaptive behavior, this variation in the predictive utility of specific items is to be expected. Reflecting this, the community items most predictive of adult outcomes in the current increased in complexity with increasing age. For example, in the social relationships models, community item 6, “Demonstrates understanding of the function of money,” was the strongest predictor at age 5, community item 11, “Summons to the telephone the person receiving a call,” was the strongest predictor at age 9, community item 20, “Obeys traffic lights and "Walk" and "Don't Walk" signs,” was the strongest predictor at age 14, and finally, community item 36, “Notifies school or supervisor when he or she will be late or absent,” was the strongest predictor at age 18. It would be strange if the same adaptive behavior had equal predictive utility at these distinct ages, given that the capabilities and societal expectations for individuals in childhood, adolescence, and early adulthood vary widely.

In addition to being less closely tied to verbal IQ and items from the community subdomain of daily living skills, on average, the XG Boost models for subjective well-being outcomes also had poorer fit statistics than the social relationships and employment models (the age 18 well-being model is a notable exception; Table 6). In contrast to the other outcomes examined here, which can be measured quite concretely (i.e., number of friendships, number of hours worked per week, etc.), well-being is a more difficult construct to quantify. Additionally, the happiness factor used to measure well-being is entirely reliant on caregiver proxy-report for LA participants in this sample. To holistically understand adult outcomes in autism, there is considerable need for reliable measures of well-being and related constructs that have been validated in this population (see *Measuring Adult Outcomes*, below).

The XG Boost models for predicting adult living status from daily living skills items at ages 5, 9, and 14 as well as the model for predicting subjective well-being from daily living skills items at age 9 performed at chance. In other words, daily living skills from these ages had little utility in predicting these two adult outcomes. At least in part, these prediction challenges may stem from the relatively small sample size used for the current analyses. A lack of variability in adult outcomes in some of the datasets may also have contributed. Because analyses for both Aims 1 and 2 were conducted separately for each timepoint of interest, the participants included in analyses at each timepoint varied somewhat based on who completed assessments at each age. For example, some participants who completed assessments at ages 5 and 9 did not complete assessments at ages 14 and 18, and vice versa. As a result of this variability across timepoints, in some datasets, very few individuals who had attained a certain adult outcome were represented. This was especially the case for living status outcomes. There were only five participants in the age 5 dataset that were living independently at age 33; in contrast, there were nine participants in the age 18 dataset that were living independently at age 33. The small sample size in combination with the small number of participants who were living independently at age 33 likely biased the XG Boost living status models to underpredict the likelihood that participants were living independently.

Verbal IQ and ability level (MA/LA) were not included as predictors in the XG Boost models reported here. Importantly, when verbal IQ was included in these models, it often emerged as the strongest predictor of the adult outcome of interest by far and explained the majority of model variance. Such variables can increase the likelihood of overfitting in machine learning models, which is why they were omitted from the final models for this dissertation (Lundberg et al., 2020). However, cognitive ability remains a very strong predictor of adult

outcomes for autistic individuals. Though daily living skills are also an important predictor of adult outcomes, it is hard to overstate the role of intellectual functioning in supporting success across the life course for individuals with autism.

Though there are many daily living skills that are not necessarily contingent on intellectual and language abilities, it is noteworthy that some of the skills that emerged as strong predictors of adult outcomes in the XG Boost models are inherently tied to intellectual and language abilities, such as being able to place phone calls (community item 24) and count change from a purchase (community item 30). The predictive utility of these skills may also reflect differing expectations from caregivers, teachers, and peers that autistic individuals with average or better IQ and fluent language abilities are subject to, as well as more opportunities to learn daily living skills compared to autistic individuals with cooccurring intellectual disability. In other words, it may not be the specifics of these skills per se that is critical to adult outcome attainment, but rather, having opportunities to learn these skills and being expected by others to perform them. For example, if a fourteen-year-old with autism is never permitted by their parents to carry money or make small purchases on their own, it is extremely unlikely they will acquire competency in money skills. Competency in many daily living skills could be attainable to autistic individuals across a range of cognitive ability, but only with sufficient opportunities for learning and practice.

The Role of Timing

As noted above, the individual daily living skills most predictive of adult outcomes tended to increase in difficulty with increasing age. However, because the samples (and by extension, outcome distributions) used for analyses varied somewhat by age, it is not possible to definitively tease apart how much of the predictive utility of the items identified in these XG

Boost models can be attributed to the timing of skill mastery, rather than the idiosyncrasies of these datasets. One key takeaway from the results of both Aim 1 and Aim 2 is that daily living skills from the community subdomain are important to target for autistic individuals of all ages and cognitive abilities. In line with a developmental cascades perspective, the community skills were most strongly predicted the adult outcomes in the current study increased in sophistication with increasing age. Learning to cross the street independently at age 9 is likely to be more beneficial than learning to cross the street independently at age 14, for example, however, this dissertation provides limited insight into how much more helpful it is to learn particular daily living skills at earlier ages. This is a considerable limitation of the current findings.

Though developmental cascades theory would suggest that mastery of a particular skill earlier in life will almost always be more advantageous to an individual's development than later mastery of that same skill, that does not mean later skill mastery is not beneficial. Given that, on average, autistic individuals acquire adaptive behavior competency more slowly than peers in the general population, there may be room for autistic individuals to measurably improve their daily living skills over a longer developmental period than that seen in the general population. For example, even if a person with autism does not learn to cross the street independently until age 22, acquiring this skill could still meaningfully enhance their functional independence, and by extension, may improve their quality of life and other adult outcomes. This possibility underscores the importance of continuing to provide intervention services to autistic individuals well after their school years, as well as the need for studies of that follow autistic individuals into middle and later adulthood. Opportunities for improvement (or decline) in adaptive functioning do not abruptly stop at a given age—similarly, adult outcomes are not stagnant, but rather, may continue to meaningfully shift across adulthood.

The Role of Opportunity

Perhaps rather than asking, "*When* do autistic individuals learn specific daily living skills?" a better (or at least, equally important) question to ask is, "What *opportunities* do autistic individuals have to learn specific daily living skills?" Regardless of whether they have autism, if an individual is never provided with occasions to learn a given daily living skill, it will be unlikely, or at least quite difficult, for that individual to acquire competency in that skill on their own. Autistic individuals may need more opportunities, even concrete instruction, to acquire such competencies compared to same-aged peers in the general population, but it would be difficult for anyone to learn a new skill without opportunities to practice.

As mentioned previously, some autistic individuals may be subject to higher expectations for their adaptive behavior competency than others, and these higher expectations may result in more opportunities to learn and practice daily living skills. These higher expectations could result from a confluence of factors, including personal traits, characteristics of the family, school, and/or work environment, and access to services and supports. For example, an autistic child with average IQ who is placed in mainstream classrooms may have higher expectations placed upon them by teachers and peers than an autistic child with co-occurring ID placed in a segregated school setting. Similarly, an autistic individual with co-occurring ID living in a family that values and expects self-sufficiency may acquire competency in daily living skills at a faster pace than an autistic individual with average cognitive abilities whose family does not value self-sufficiency. In both these cases, expectations for adaptive function inform opportunity for daily living skills practice.

With this in mind, it is notable that maternal education emerged as one of the top 5 predictor variables in three XG Boost models: social relationships at 9, and subjective well-being

and living status at 18. However, the direction of the associations between maternal education and adult outcomes in this sample varied. Chi-squares indicated that in the age 9 dataset, lower maternal education (i.e., having less than a four- year college degree) was significantly associated with a higher likelihood of having meaningful social relationships ($X^2(1, n = 152) = 5.82, p = .016$); in contrast, higher maternal education (i.e., having a four-year college degree or more) was associated with a higher likelihood of living independently in the age 18 dataset ($X^2(1, n = 143) = 5.69, p = .017$). Lower maternal education was associated with higher happiness factor scores in the age 18 dataset, though an independent t-test indicated that this association was not statistically significant ($t(141) = .785, p = . 217$). Clearly, there is meaningful and complex interplay between the development of adaptive function in autistic individuals, family characteristics, and adult outcomes. Expectations regarding adaptive behavior competency and opportunities to practice adaptive behaviors are two pathways through which such interplay may manifest—these are important areas for future inquiry.

Clinical Implications

Frequently, behavioral interventions for autistic individuals are limited to a specific context, such as the home, classroom, or clinic. Each of these contexts may be more conducive to learning some daily living skills than others (for example, it is likely easier to learn how to brush your teeth at home than in a classroom). However, none of these contexts may be especially conducive to learning community daily living skills, such how to order a meal in restaurant or how to obey traffic lights. Given that item sets and individual items from the community subdomain emerged as predictors of adult outcomes in Aim 1 and Aim 2 analyses, respectively, providing opportunities for autistic individuals to learn and practice daily living skills in public settings may be a meaningful way for interventionists to promote positive adult outcomes.

Conducting a therapy session in a grocery store or at a café, for example, may provide far more opportunity for an autistic client to learn and practice community daily living skills than conducting a similar session in clinic.

In addition to targeting community daily living skills, the results of Aim 1 suggest that ensuring individuals with autism are proficient in skills related to personal hygiene and cooking may improve some adult outcomes. Notably, at multiple timepoints, the bathing and kitchen chores item sets significantly predicted employment and well-being outcomes for autistic individuals both with and without co-occurring intellectual disability in the current sample. Given that these daily living skills can be taught and practiced at home with relative ease, clinicians could also encourage caregivers to assist their autistic family member in practicing kitchen and bathing skills, perhaps by building such practice into preexisting daily routines (i.e., mealtimes, bedtime).

Just like measures of cognitive function and autism symptomology, measures of adaptive behavior are an important component of clinical autism assessments that should be collected each time a client is evaluated. Even if adaptive behavior development is delayed, progress in this domain is still meaningful and should be monitored over time. Further, clinicians should make a point of discussing adaptive behavior goals with clients and their families when providing feedback. Deficits in adaptive function may not be at the forefront of a client or family's mind, particularly if there are other ongoing challenges. In such cases, clinicians can play an important role in reminding clients and their families of the importance of supporting adaptive behavior development, alongside other important developmental domains.

Measuring Adult Outcomes

The current study examined four indicators of adult outcome, three of which (employment, living status, friendships) align closely with expectations for success in adult life in the general population. Though some members of the autism community might contest the validity of these outcome measures, employment, living status, and social connection are sensible benchmarks of success for most adults—both with and without an autism diagnosis. Additionally, examining these indicators increases the replicability of this dissertation with existing literature on autism in adulthood, which has historically focused on adult outcomes common in the general population. That said, it is still an open question as to how best to conceptualize and measure adult outcomes in autism. There is growing consensus that only considering traditional markers is not sufficient (McCauley, Pickles, et al., 2020; Orsmond et al., 2024; Pellicano et al., 2022), but a suitable alternative or set of alternatives for effectively quantifying positive outcomes for autistic adults has yet to be established.

The happiness factor used here to measure subjective well-being has been previously used in studies of the LSA sample (Clarke, Sterrett, et al., 2021; McCauley, Pickles, et al., 2020), and appears to be consistent across caregiver and participant self-report (McCauley, Pickles, et al., 2020). The use of both caregiver and participant self-report makes the happiness factor a more inclusive measure of subjective well-being, as it captures this construct both in autistic adults who can express their own feelings and experiences, as well as autistic adults who cannot, but whose caregivers are able to report as proxies. However, the happiness factor has not been replicated in independent samples—additional work is needed to assess the validity of this measure in larger samples of autistic adults. Further, the happiness factor is a composite of scores from several existing measures which have not been validated for use in this population.

To better understand and support autistic adults' subjective well-being, validated measures that effectively quantify this construct and can capture change over time are essential. Efforts are underway to develop and validate the Relationships, Employment, Autonomy, and Life Satisfaction (REALS; MacKenzie et al., 2024) which would be one of the first adult outcome survey measures designed specifically for adults with autism and related developmental conditions. The REALS will consist of three domains, social relationships, employment, and autonomy, and would include an assessment of life satisfaction for each of these three domains. Psychometric analyses of self- and caregiver-report data are in progress (MacKenzie et al., 2024). Ideally, future work in this area should also strive to develop measures that are observational in nature, to minimize reliance on caregiver-report while still reflecting the full range of adult experiences encompassed by the autism spectrum.

Developing sound measures and identifying additional indicators of adult outcome that are meaningful to *all* adults with autism is an important area of future inquiry. Regardless of ability, fundamental questions of how to live a fulfilling adult life are universal. Ultimately, measures of both objective *and* subjective outcomes are necessary to capture the complexities of adult life.

Limitations

This sample, initially evaluated in the early 1990's and followed longitudinally ever since, comprises a unique and relatively small group of adults with autism. These participants' families sought help very early in childhood during an era in which autism services were much less available than they are today. Thus, the participants in this sample may be meaningfully different from individuals diagnosed later in development. Attrition has reduced the number of African American participants and participants with lower caregiver education in the LSA

cohort. Additionally, we have relatively few female participants in this sample. The limited number of female participants constrained the ability to test for gender differences in analyses for the proposed dissertation.

Analyses of younger cohorts of adults with autism suggest that the achievement of outcomes associated with adult life in the general population, though still exceptional, may be becoming increasingly common for this population (Orsmond et al., 2024). This is likely due to increased services availability and access (as well as identification of autism in more cognitively able people). Given the considerable changes to the autism landscape in recent decades, both in terms of who is receiving autism diagnoses and the availability of services, the possibility of cohort effects must be considered in future studies of adult outcomes in autism (Lord et al., 2022).

Overfitting is always a concern when building and interpreting machine learning models and may limit the generalizability of these findings. Given the unique characteristics of the LSA sample and the strong possibility of cohort effects, future work should attempt to replicate the results of the XG Boost models described here using larger samples of autistic individuals; ideally such samples would include both children recently identified as autistic, as well as adults who received autism diagnoses later in development.

The Vineland Adaptive Behavior Scales, though widely used, is not a perfect measure. Notably, the domains of the Vineland were theoretically, rather than empirically, derived (Price et al., 2018; Tassé et al., 2012). Though recent evidence in the general population suggests female children score significantly higher on the VABS than similarly-aged male children (Nishimura et al., 2022), the Vineland is not gender-normed. There is also evidence of considerable cross-cultural differences in Vineland scores even amongst high-income, Western

nations. Two studies have found that typically developing French children score lower on the Daily Living Skills domain of the VABS than their American peers (Fombonne & Achard, 1993; Touil et al., 2021). More research is needed to improve the utility and sensitivity of the Vineland in diverse populations.

There is some evidence that autistic individuals' degree of impairment in adaptive functioning may be driven by the presence of difficulties not associated with core autism deficits, such as executive functioning (Pugliese et al., 2015) as well as externalizing (Kraper et al., 2017) and attention symptoms (Wallace et al., 2016). This dissertation did not control for these aspects of participants' phenotypic profiles. It is unclear how executive functioning impairments and symptoms of psychopathology may influence adult outcome attainment, both independent of and in conjunction with the development of adaptive behaviors. Additional work is needed to understand associations between these factors, and how their development relates to adult outcomes for autistic individuals.

Future Directions

This dissertation only analyzed data from the daily living skills domain of the Vineland Adaptive Behavior scales, but it is possible that item sets and items from the socialization and/or communication domains of the VABS also have strong predictive utility for adult outcomes. This possibility should be explored in future work. Additionally, the current analyses only considered items from the first and second editions of the VABS that completely overlapped and did not include any data from the third and most recent edition of the VABS. It would be interesting to examine how the results of this dissertation might differ if all items from the first and second editions of the VABS were included, as well as whether the present findings would remain consistent if data from the most recent edition of the VABS was also included.

There is some evidence that the Adaptive Behavior Assessment Scale (ABAS; Harrison & Oakland, 2015) is a more valid and reliable measure of adaptive behavior for autistic adults than the VABS. However, little work to date has explored how ABAS scores relate to concurrent or later outcomes for autistic adults. There are also only a handful of studies directly comparing the convergent reliability and relative utility of the VABS and the ABAS (Tamm et al., 2022) and there is almost no published work detailing item-level analyses of the ABAS. All these gaps represent important areas of future inquiry.

For all autistic individuals, increasing opportunities to learn and practice specific daily living skills is likely to result in improved adaptive functioning (Teh et al., 2023). As mentioned above, autistic people with average or better cognitive abilities and fluent speech may be afforded more opportunities to learn and practice many DLS because those around them may place higher expectations on these individuals than their peers who have cooccurring ID and/or are minimally verbal. Recent evidence suggests that for autistic adults of all abilities, lack of opportunity to practice adaptive behaviors is a common barrier to improving adaptive functioning (Teh et al., 2023). In addition to identifying effective intervention targets for autistic individuals of various ages, additional research is needed to identify scalable strategies that caregivers, teachers, and service providers can use to increase opportunities for learning and practicing adaptive behaviors across a range of contexts.

This dissertation is one of the first studies to apply a machine learning approach to understanding adaptive behavior development in autistic individuals. Investigations leveraging a machine learning approach to understanding autism have greatly increased in the last ten years, however, most of these studies have only considered the utility of machine learning models for enhancing autism identification and diagnosis. Though improving early identification of autism

is an important area of investigation, few studies to date have considered clinically meaningful applications of machine learning for already diagnosed autistic individuals and their families. This dissertation attempted to identify aspects of adaptive behavior that strongly predict adult outcomes, and by extension, may be particularly effective intervention targets for individuals with autism. Future studies leveraging machine learning approaches to understanding autism should strive to answer other clinically meaningful questions for the large number of individuals with autism that have already been diagnosed and could benefit from more personalized services and supports.

Conclusions

Distilling an individual's adaptive functioning into a single number or small set of numbers, though parsimonious, has limited utility if it is difficult to leverage this information towards real world improvements. This dissertation provided important insight into which specific daily living skills are most critical to adult success amongst autistic individuals through fine-grained, item set and item-level analyses of longitudinal data from a cohort of autistic individuals first identified in early childhood and carefully followed for three decades. Future research should attempt to replicate the findings described here in larger and more recently identified samples of autistic individuals and should continue to refine adaptive behavior interventions for autistic individuals of all ages.

Table 1. Vineland Domains, Subdomains, and Sample Item Sets.

Domains	**Communication**			**Socialization**			**Daily Living Skills**		
Subdomains	**Receptive**	**Expressive**	**Written**	**Interpersonal Relationships**	**Play & Leisure**	**Coping Skills**	**Personal**	**Domestic**	**Community**
Sample Item Sets	Understanding Words	Using Gestures	Identifying Signs & Letters	Imitating Others	Make-Believe	Handling Transitions	Using Spoon & Fork	Food Preparation Basics	Basic Money Skills
	Following Basic Instructions	Using Complex Grammatical Forms	Reading Level	Friendships	Sharing	Controlling Anger	Toilet Training	Basic Household Chores	Using Technology
	Attending to Informational Material	Giving Directions	Advanced Writing	Conversational Skills	Doing Things with Peers	Making Decisions	Using Knives When Eating	Cleaning Up After Meals	Earning Money

Table 2. Descriptive Characteristics of the LSA Sample.

Longitudinal Study of Autism (LSA) Sample (n = 253)			
		Autism	**DD**[a]
		***n* = 196**	***n* =57**
Gender	Male	170	33
	Female	26	24
Race	White/Caucasian	135	40
	Black/African American	55	12
	Asian	3	1
	Biracial	2	1
Recruitment Site	North Carolina	105	27
	Illinois	74	7
	Michigan	17	23
Urbanicity	Urban	108	36
	Rural	87	21
Caregiver Education	Graduate or professional degree	41	8
	Four-year college degree	48	7
	Associate degree/some college	52	11
	High school diploma/GED	31	14
	Less than high school diploma	6	2
Ability Level	More Able (MA)	67	27
	Less Able (LA)	115	19

[a]Non-autism developmental delay

Table 3. Daily Living Skills Item Sets Comprised of Overlapping Items from the First and Second Editions of the Vineland Adaptive Behavior Scales by Subdomain.

DLS Subdomain	Item Set	VABS Items
Personal	Eating & Drinking	1. Opens mouth when food is offered. 2. Eats solid foods (for example, cooked vegetables, chopped meats, etc.). 3. Sucks or chews on finger foods (for example, crackers, cookies, toast, etc.). 4. Drinks from a cup or glass; may spill. 5. Feeds self with spoon; may spill. 6. Sucks from straw. 7. Feeds self with fork; may spill. 8. Feeds self with spoon without spilling. 9. Holds spoon, fork, and knife correctly.
	Toileting	1. Lets someone know when he or she has wet or soiled diaper or pants (for example, points, vocalizes, pulls at diaper, etc.). 2. Urinates in toilet or potty chair. 3. Asks to use toilet. 4. Defecates in toilet or potty chair. 5. Is toilet-trained during the night.
	Dressing	1. Takes off clothing that opens in the front (for example, a coat or sweater); does not have to unbutton or unzip the clothing. 2. Pulls up clothing with elastic waistbands (for example, underwear or sweatpants). 3. Puts shoes on correct feet; does not need to tie laces. 4. Wears appropriate clothing during wet or cold weather (for example, raincoat, boots, sweater, etc.).
	Bathing	1. Washes and dries face using soap and water. 2. Bathes or showers and dries self.
	Grooming	1. Brushes teeth. 2. Washes and dries hair (with towel or hair dryer).
	Healthcare	1. Wipes or blows nose using tissue or handkerchief. 2. Covers mouth and nose when coughing and sneezing.
Domestic	Safety at Home	1. Is careful around hot objects (for example, the stove or oven, an open fire, etc.).
	Kitchen Chores	1. Clears breakable items from own place at table. 2. Helps prepare foods that require mixing and cooking (for example, cake or cookie mixes, macaroni and cheese, etc.). 3. Uses stove or oven for heating, baking, or cooking (that is, turns burners on and off, sets oven temperature, etc.). 4. Prepares food from ingredients that require measuring, mixing, and cooking. 5. Plans and prepares main meal of the day.
	Housekeeping	1. Helps with simple household chores (for example, dusts, picks up clothes or toys, feeds pet, etc.). 2. Puts away personal possessions (for example, toys, books, magazines, etc.). 3. Puts clean clothes away in proper place (for example, in drawers or closet, on hooks, etc.). 4. Uses tools (for example, a hammer to drive nails, a screwdriver to screw and unscrew screws, etc.). 5. Sweeps mops or vacuums floors thoroughly. 6. Uses household products correctly (for example, laundry detergent, furniture polish, glass cleaner, etc.). 7. Cleans one or more rooms other than own bedroom. 8. Washes clothing as needed. 9. Performs maintenance tasks as needed (for example, replaces light bulbs, changes vacuum cleaner bag, etc.).
Community	Telephone Skills	1. Talks to familiar person on telephone. 2. Summons to the telephone the person receiving a call or indicates that the person is not available. 3. Makes telephone calls to others, using standard or cell phone.
	Rules, Rights, & Safety	1. Is aware of and demonstrates appropriate behavior while riding in car (for example, keeps seat belt on, refrains from distracting driver, etc.). 2. Looks both ways when crossing streets or roads. 3. Obeys traffic lights and "Walk" and "Don't Walk" signs. 4. Demonstrates knowledge of what phone number to call in an emergency when asked.

Table 3, Cont. Daily Living Skills Item Sets Comprised of Overlapping Items from the First and Second Editions of the Vineland Adaptive Behavior Scales by Subdomain.

	Time & Dates	1. Demonstrates understanding of function of clock (for example, says, "Clocks tell time"; "What time can we go?"; etc.). 2. Says current day of the week when asked. 3. Points to current or other date on calendar when asked. 4. Tells time by 5-minute segments on analog clock (for example, 1:05, 1:10, etc.).
	Money Skills	1. Demonstrates understanding of the function of money (for example, says, "Money is what you need to buy things at the store"; etc.). 2. States value of penny (1 cent), nickel (5 cents), dime (10 cents), and quarter (25 cents). 3. Counts change from a purchase. 4. Uses savings or checking account responsibly (for example, keeps some money in account, tracks balance carefully, etc.). 5. Manages own money (for example, pays most or all own expenses, uses checks or money orders for purchases as needed, etc.). 6. Budgets for monthly expenses (for example, utilities, rent, etc.).
	Restaurant Skills	1. Orders a complete meal in a fast-food restaurant.
	Job Skills	1. Obeys time limits for breaks (for example, lunch or coffee breaks, etc.). 2. Notifies school or supervisor when he or she will be late or absent. 3. Holds full-time job responsibly.

Table 4. Adult Outcome Attainment by Ability Level and Diagnostic Status

		MA		LA	
		ASD	**DD[a]**	**ASD**	**DD[a]**
Employment m(SD)		8.50(2.69)	8.41(2.85)	1.99(1.78)	2.83(0.69)
Living Status	**Living with Support**	29	8	74	12
	Living Independently	27	11	1	0
Social Relationships[b]	**At least one social relationship**	41	14	13	5
	No social relationships	12	4	59	5
Subjective Well-Being m(SD)		0.01(0.81)	0.76(0.60)	-0.20(0.76)	0.64(0.69)

[a]Non-ASD developmental delay

[b]For MA participants, a social relationship was defined as a mutual peer friendship. For LA participants, a social relationship was defined as a regular social contact who was not an immediate family member or paid staff person.

Table 5. Missingness Percentages by and Correlations between Adult Outcome and Behavioral Phenotype Measures in the LSA Sample.

Measure	n	Percent Missing	1	2	3	4	5	6	7	8	9	10	11	12
1. Diagnostic Status	253	0%	—											
2. Gender	253	0%	.090	—										
3. Race	253	0%	**-.138***	-.075	—									
4. Urbanicity	245	3%	-.030	-.105	-.058	—								
5. Maternal Education	247	2%	.114	-.074	-.024	-.102	—							
6. Recruitment Site	246	2%	-.067	-.078	.113	-.007	-.003	—						
7. CSS at 9	161	36%	.048	.085	-.082	.003	.061	-.050	—					
8. Verbal IQ at 9	192	24%	**-.150***	.049	.037	.046	.027	.082	-.073	—				
9. Happiness Factor	111	56%	**-.362*****	-.126	**.227***	.098	.037	-.083	-.014	**.218***	—			
10. Social Relationships	159	37%	**-.233****	.004	.002	-.078	-.068	-.010	-.148	**.611*****	**.252****	—		
11. Living Status	170	32%	-.145	.122	.063	.050	.101	.142	-.085	**.615*****	**.344*****	**.396****	—	
12. Employment	152	40%	**-.204***	-.033	**.160***	-.047	.050	.048	.048	**.777*****	**.233***	**.551****	**.646*****	—

***$p < .001$
**$p < .01$
*$p < .05$

Table 6. Model Performances on the Test Set For Social Relationships, Employment, Living Status, and Subjective Well-Being Outcomes.

	Employment				Living Status				Social Relationships				Subjective Well-Being			
Age	**5**	**9**	**14**	**18**	**5**	**9**	**14**	**18**	**5**	**9**	**14**	**18**	**5**	**9**	**14**	**18**
ROC AUC	.866	.912	.850	.811	.500	.500	.500	.912	.639	.799	.772	.672	.581	.500	.689	.971
Sensitivity	.826	.963	.791	.833	1.000	1.000	1.000	.939	.619	.769	.666	.826	.428	1.000	.650	.888
Specificity	.769	.705	.904	.555	.000	.000	.000	.444	.666	.777	.714	.473	.681	.000	.576	.937
PPV	.863	.838	.904	.714	.861	.822	.778	.861	.722	.833	.727	.655	.461	.444	.541	.918
NPV	.714	.923	.791	.714	—	—	—	.666	.556	.700	.652	.692	.652	—	.681	.914
Accuracy	.805	.863	.844	.714	.861	.822	.500	.833	.638	.773	.688	.666	.583	.500	.608	.916

Note. ROC AUC, receiver operating characteristic area under the curve; PPV, positive predictive value; NPV, negative predictive value.

Table 7. Top Five Predictors for Employment and Living Status Outcomes.

	Employment				**Living Status**			
Age	5	9	14	18	5	9	14	18
Top 5 Predictors	**Community 6** "Demonstrates understanding of the function of money"	**Community 18** "States value of penny, nickel, dime, and quarter"	**Community 24** "Makes telephone calls to others, using standard or cell phone"	**Community 30** "Counts change from a purchase"	—	—	—	**Community 36** "Notifies school or supervisor when he or she will be late or absent."
	Community 8 "Demonstrates understanding of function of clock"	**Community 16** "Demonstrates knowledge of what phone number to call in an emergency"	**Personal 27** "Covers mouth and nose when coughing and sneezing"	**Community 33** "Obeys time limits for breaks (for example, lunch or coffee breaks)"	—	—	—	**Community 30** "Counts change from a purchase"
	Personal 15 "Asks to use toilet"	**Community 5** "Is aware of and demonstrates appropriate behavior while riding in a car"	**Community 16** "Demonstrates knowledge of what phone number to call in an emergency"	**Domestic 20** "Uses stove or oven for heating, baking, or cooking"	—	—	—	**Domestic 22** "Washes clothing as needed"
	ADOS CSS at age 2	**Personal 32** "Bathes or showers and dries self"	**Community 11** "Summons to the telephone the person receiving a call"	**Community 24** "Makes telephone calls to others, using standard or cell phone"	—	—	—	**Maternal Education**
	Personal 21 "Puts shoes on correct feet; does not need to tie laces"	**Community 24** "Makes telephone calls to others, using standard or cell phone"	**ADOS CSS at age 9**	**Domestic 23** "Performs maintenance tasks (for example, replaces light bulbs)"	—	—	—	**Community 37** "Uses savings or checking account responsibly"

Note. Models without predictors listed performed at chance.

Table 8. Top Five Predictors for Subjective Well-Being and Social Relationship Outcomes.

	Subjective Well-Being				Social Relationships			
Age	**5**	**9**	**14**	**18**	**5**	**9**	**14**	**18**
Top 5 Predictors	**Domestic 2** "Helps with simple household chores"	—	**Community 2** "Talks to familiar person on telephone	**ADOS CSS at age 9**	**Community 6** "Demonstrates understanding of the function of money"	**Community 11** "Summons to the telephone the person receiving a call."	**Community 20** "Obeys traffic lights and "Walk" and "Don't Walk" signs."	**Community 36** "Notifies school or supervisor when he or she will be late or absent."
	Personal 20 "Is toilet trained during the night"	—	**Community 30** "Counts change from a purchase"	**Domestic 22** "Washes clothing as needed"	**Personal 20** "Is toilet trained during the night"	**Community 2** "Talks to familiar person on telephone."	**Community 24** "Makes telephone calls to others, using standard or cell phone."	**ADOS CSS at age 9**
	Domestic 11 "Puts clean clothes away in proper place"	—	**Domestic 16** "Uses household products correctly"	**Community 30** "Counts change from a purchase"	**Community 8** "Demonstrates understanding of function of clock"	**Maternal Education**	**Community 16** "Demonstrates knowledge of what phone number to call in an emergency when asked."	**Domestic 21** "Prepares food from ingredients that require measuring, mixing, and cooking."
	Personal 9 "Pulls up clothing with elastic waistbands"	—	**Personal 32** "Bathes or showers and dries self"	**Domestic 12** "Uses tools (for example, a hammer to drive nails)"	**Domestic 2** "Helps with simple household chores"	**Community 24** "Makes telephone calls to others, using standard or cell phone."	**Community 11** "Summons to the telephone the person receiving a call."	**Domestic 18** "Cleans one or more rooms"
	Domestic 5 "Puts away personal possessions"	—	**Community 25** "Orders a complete meal in a fast-food restaurant"	**Maternal Education**	**Personal 13** "Urinates in toilet or potty chair"	**Community 20** "Obeys traffic lights and "Walk" and "Don't Walk" signs."	**Personal 27** "Covers mouth and nose when coughing and sneezing."	**Domestic 14** "Sweeps, mops, or vacuums floors thoroughly"

Note. Models without predictors listed performed at chance.

Figure 1. Developmental cascades of adaptive functioning from childhood to adulthood in autism.

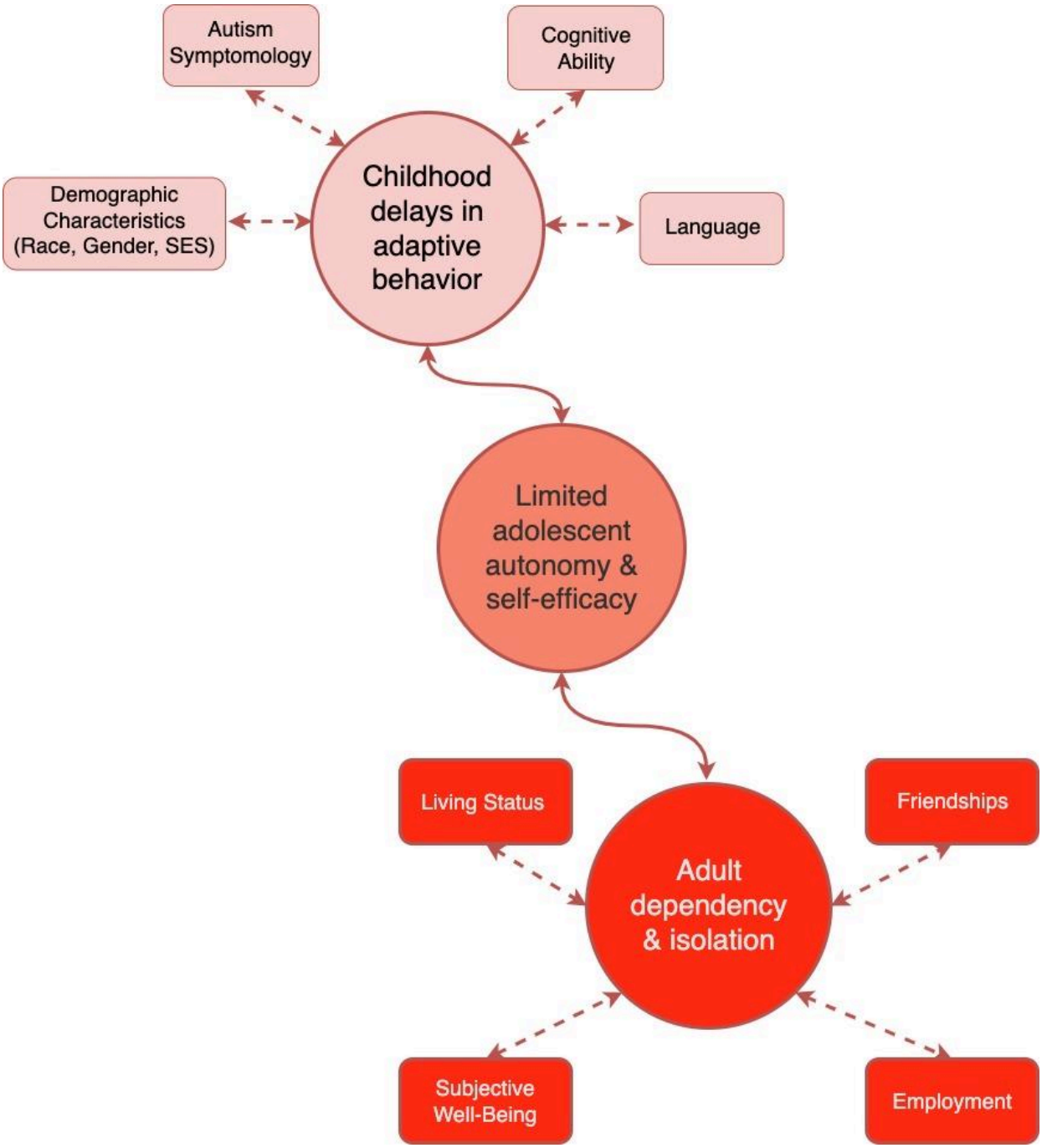
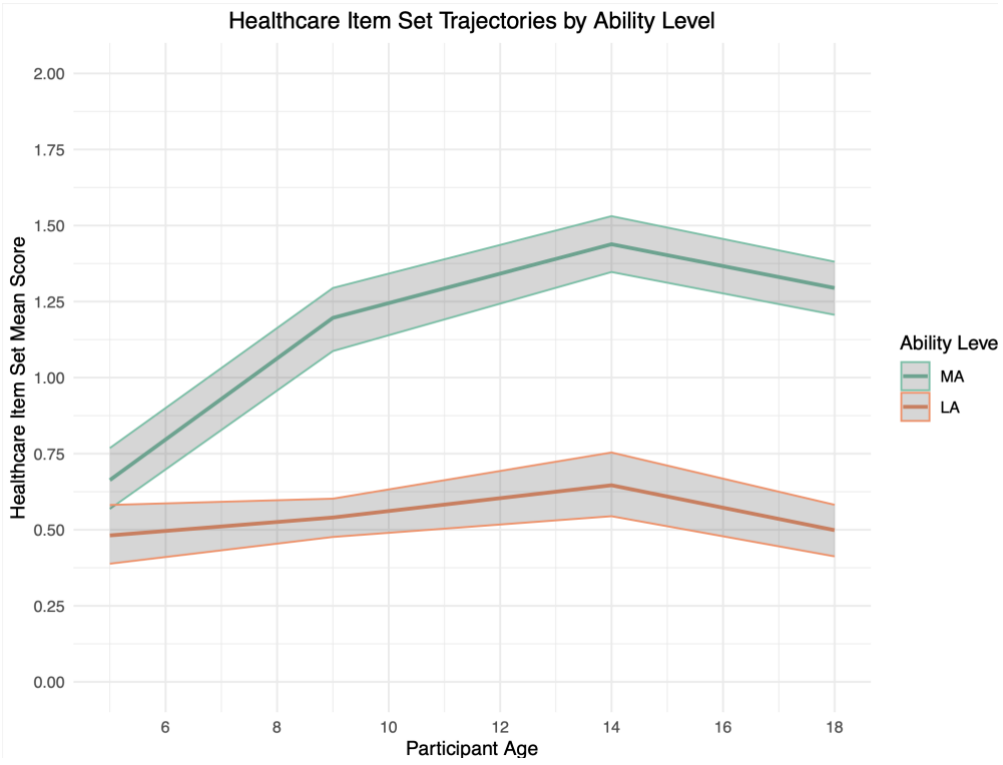


Figure 2. Trajectories of Select Personal Subdomain Item Sets Predictive of Adult Outcomes.



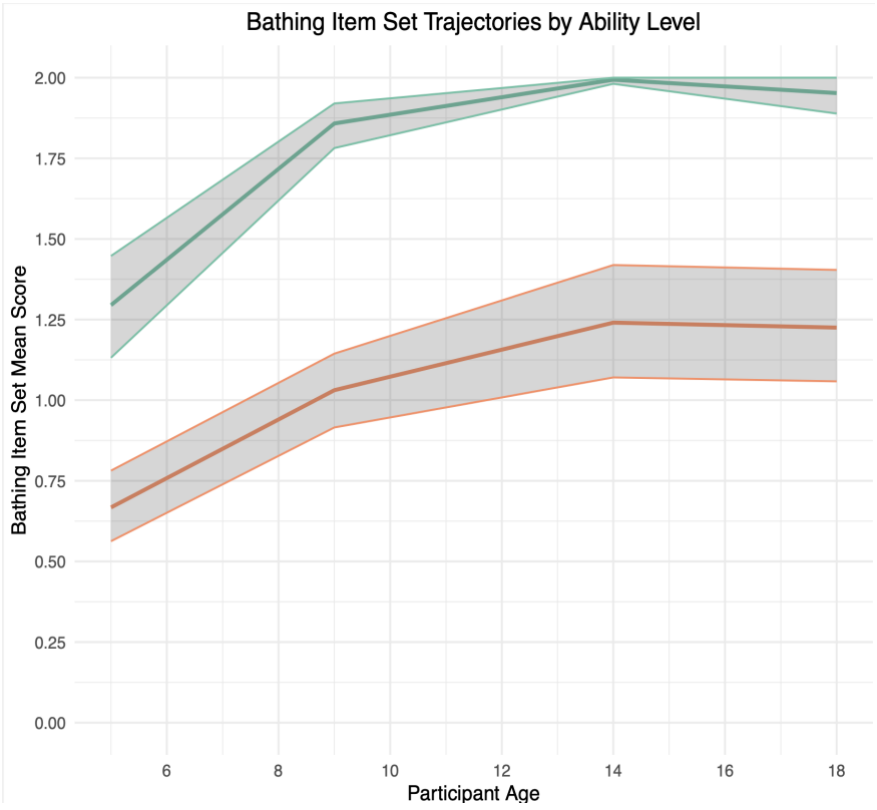


Figure 3. Trajectories of Select Domestic Subdomain Item Sets Predictive of Adult Outcomes.

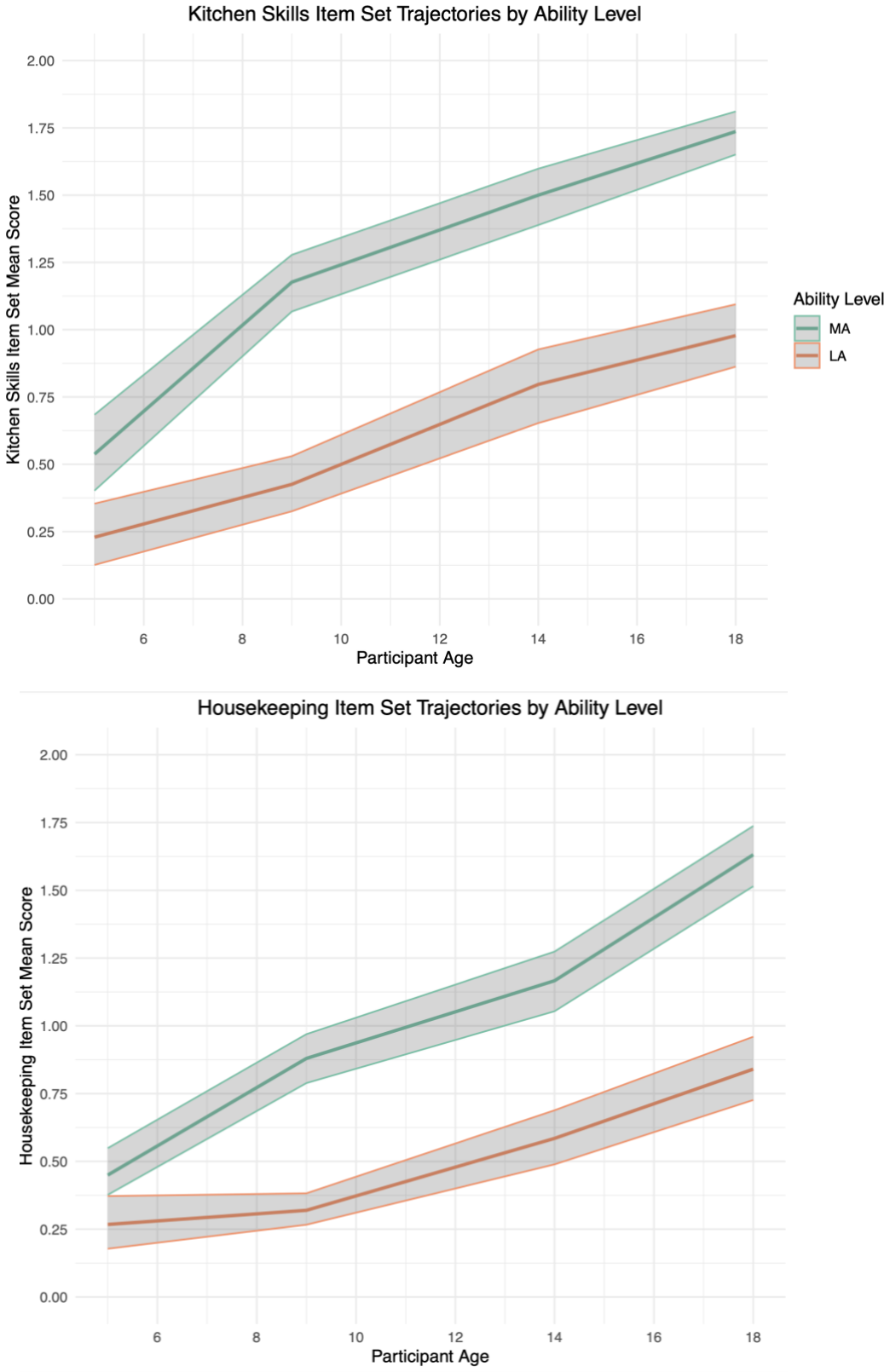
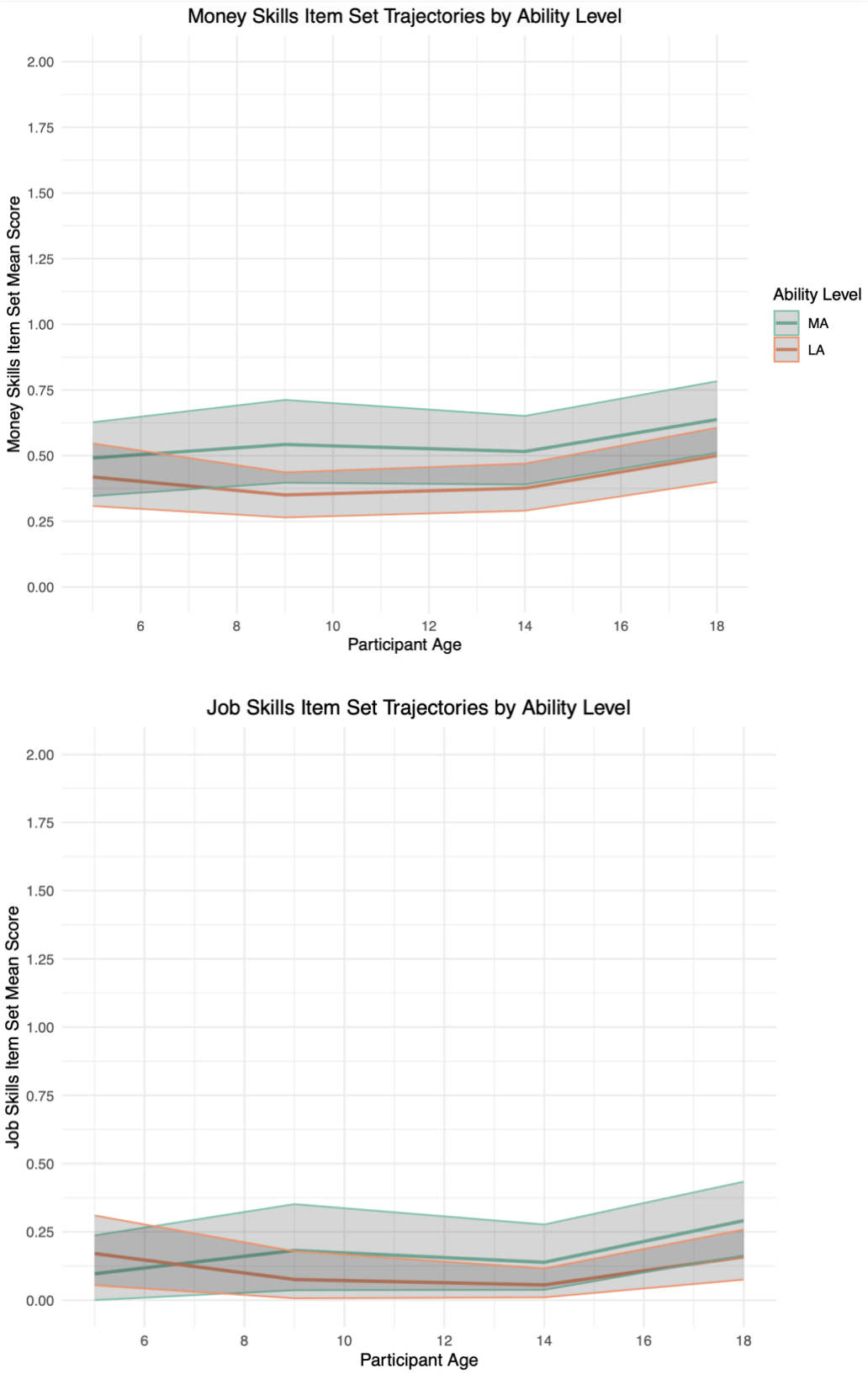


Figure 4. Trajectories of Select Community Subdomain Item Sets Predictive of Adult Outcomes.



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