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# Task and Participant Variables Predict Communication Complexity Scores (CCS): Closer Examination of the CCS

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## Abstract

Communication Complexity Scale (CCS) scores for 269 minimally verbal participants were examined to determine if communicator behavior and task and communicator characteristics were related to scores in a manner consistent with theoretical and research evidence expectations. Each participant completed an interactive assessment with 6 joint attention tasks and 6 behavior regulation tasks. Caregivers completed the Vineland Adaptive Behavior Scales. Results indicated (a) joint attention tasks yielded lower scores than behavior regulation tasks, (b) older participants had lower scores, (c) individuals with autism spectrum disorder scored more similarly than those without, (d) the difference between joint attention and behavior regulation scores was greater for the autism spectrum disorder group, and (e) adaptive behavior was significantly positively related to complexity scores.

### Keywords

Assessment; communication; severe disabilities; autism; joint attention

In response to a recognized need for better outcome measures for individuals with intellectual and developmental disabilities (IDD; Kasari, Brady, Lord, & Tager-Flusberg, 2013; Plesa Skwerer, Jordan, Brukilacchio, & Tager-Flusberg, 2016), we developed a new measure of communication to be used with individuals who communicate primarily without speech, sign, or symbolic forms. The measure is called the Communication Complexity Scale (CCS) and two previous publications reported on the validity and reliability of the scale (Brady et al., 2018; Brady et al., 2012). The purpose of the present study is to further analyze sources of variability in communication complexity measured with the CCS. Specifically, we examine how diagnosis, communication function, and age affect complexity of communication acts.

The CCS was developed as an outcome measure for individuals who communicate primarily without speech, using gestures, body movements, eye gaze, or forms of augmentative or

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alternative communication (AAC) such as signs or speech generating devices. Existing measures primarily rely on caregiver report (e.g., Rowland & Fried-Oken, 2010) or were developed specifically for young children (e.g., Wetherby & Prizant, 2002). The CCS is based on directly observed communication behaviors, and psychometric evaluation has indicated that it is appropriate to use with individuals with IDD and/or autism spectrum disorder (ASD) between the ages of 3 to 70 years who communicate primarily without speech. It is intended to fill a gap in existing communication measures by describing subtle differences in expressive communication. It is designed to avoid floor effects because it encompasses prelinguistic behaviors such as change in arousal state and attending to an object or person. A zero is only recorded if someone does not attend in any way to the task presented and this rarely happens.

The current version of the CCS has 12 scores that range from basic awareness of the environment (score 1) through early word combinations (score 12). Scores of 1 to 5 are preintentional communication acts such as vocalizing while looking at an object. Scores 6 to 10 reflect an important milestone in early communication—intentional communication with others. For example, a score of 7 could reflect giving an object to someone to request help. By including multiple scores at the prelinguistic stage, the CCS is able to reflect changes in individuals' communication that may occur with development or intervention. For example, communication that adds vocalizations to gestures would be scored as more complex than a gesture without a vocalization. A score of 11 indicates communicating with a word, sign, or symbol, and a score of 12 is used when the individual combines two or more words, signs or symbols into a meaningful phrase. The entire scale is presented in Table 1.

To date, the CCS has been applied to communication observed during a scripted communication protocol carried out with a trained examiner. Twelve different communication opportunities, or tasks, are presented and the most complex communication act for each task is given a score according to the CCS 12-point scale.

Previous research (Brady et al., 2018; Brady et al., 2012) demonstrated that the summary scores from the CCS were significantly correlated with other measures of early communication, demonstrating concurrent validity. Specifically, moderate correlations were found between Optimal CCS scores (i.e., the average of the three highest task scores) and the Communication Matrix (Rowland & Fried-Oken, 2010), and between Optimal CCS scores and the Vineland Adaptive Behavior Scales-Expressive communication subscale (Sparrow, Cicchetti, & Balla, 2005). In addition, Brady and colleagues (2018) reported that CCS scores were significantly correlated with rates of joint attention and behavior regulation communication measured by the Early Social Communication Scales (Mundy et al., 2003). *Behavior regulation* (BR) refers to communication used to request something or protest. *Joint attention* (JA) refers to communication acts used to point out something of interest, such as a novel event, or share positive social affect. For example, if someone's favorite song came on and they indicated they liked it by looking at their communication partner, smiling, and vocalizing, this would be scored as joint attention communication.

The CCS has been administered to over 400 participants and we have detected considerable variability within and across participants. Within participants, we note that participants are likely to respond differently across the 12 different scripted tasks. Our protocol includes six tasks designed to promote BR communication and six tasks designed to promote JA communication precisely because we do not expect everyone to be motivated by the same materials. For example, most children are motivated to open the closed container of bubbles, but some are not interested in—or even afraid of— the bubbles. Although researchers working on our team have noted that some tasks are more likely to be responded to than others, we have not previously determined how responsiveness to different tasks affects overall scores. This is important for validating the protocol because it may be that some items are infrequently responded to and therefore do not contribute to overall scores. Conversely, other items may be responded to almost always with a communicative act that represents the participants' best communication skills.

Although we have not previously considered the intended function of a task as a factor in CCS scores, previous research has found that individuals with severe IDD and/or ASD are less likely to communicate intentionally for purposes of JA than for BR (Bopp & Mirenda, 2011; Brady, Marquis, Fleming, & McLean, 2004; McLean, McLean, Brady, & Etter, 1991; Wetherby & Prutting, 1984). Because CCS scores differentiate intentional from nonintentional communication acts, and over half of our sample has a diagnosis of ASD, we also expect to find differences in CCS scores across these two communication functions, with lower scores associated with JA communication.

Differences in participant characteristics may also account for CCS score variability. Although all participants in our samples had IDD, there were different diagnoses and etiologies associated with IDD. Nearly half of our participants have had a diagnosis of ASD. Individuals with ASD show a characteristic pattern of differential responding to BR and JA tasks, with much less frequent responding to JA (McArthur & Adamson, 1996; Mundy & Crowson, 1997). Thus, a likely source of variability across individuals is whether the individual has ASD.

In addition to diagnosis, our participants varied in chronological age. Although all participants have been at similar stages of communication and language development (e.g., vocabularies of less than 20 words), it is likely that an individual who is 50 and still communicates primarily with nonverbal means, responds differently from a 3-year old child with similar communication skills. Hence it is important to analyze differences in scores that may be attributable to age differences.

Participants' behavior is another variable that could affect the complexity of communication responses. *Adaptive behavior* describes behaviors needed to live independently and function well in daily life. Individuals with higher adaptive behavior composite scores as measured with the Vineland Adaptive Behavior Scales (VABS-II) tend to also have higher communication and language scores (Kjellmer, Hedvall, Fernell, Gillberg, & Norrelgen, 2012; Stone, Ousley, Hepburn, Hogan & Brown, 1999). This association is partly because receptive and expressive language items are included in the Adaptive Behavior composite scores. In addition, individuals with more skills in social and daily living are likely to also have better communication scores including rate of communication and number of different words (Brady, Warren, Fleming, Keller, & Sterling, 2014).

Problem behaviors may also impact scores on communication assessments either positively or negatively because they may interfere with communication and hence lower communication scores; or they may be used as a form of communication and show a positive relationship with communication scores (Paul et al., 2004). For these reasons, we considered how adaptive behavior, measured with the VABS-II composite, and problem behaviors, measured with the Maladaptive Behavior scale from the VABS II, impacted CCS scores in our sample.

Given these observations in our own and others' previous research, our purpose in the current investigation was to further examine the psychometric properties of the CCS by investigating how differences in individual characteristics and task requirements affect scores. The extent to which scores from the CCS are consistent with theoretical and research-based expectations lends support to the construct validity of the CCS. Our specific research questions were:

1. How did the intended communication function of tasks affect communication complexity scores? We hypothesized that participants would respond with less complex forms (and hence lower scores) on tasks designed to provide opportunities for JA communication.

2. How did ASD and age impact communication complexity scores? We hypothesized lower complexity scores in JA tasks for participants with ASD and higher complexity scores in both JA and BR for younger compared to older participants.

3. What effect did adaptive and problem behaviors have on communication complexity scores? We hypothesized that participants with lower adaptive behavior and greater problem behavior scores would have lower complexity scores.

The answers to these questions will allow us to determine if task and participant characteristics account for significant variance in communication complexity assessed using the CCS. In addition to providing additional evidence for the construct validity of the CCS, these findings have the potential to facilitate interpretation of future research that examines communication differences in response to treatment or change over time for individuals in different subgroups.

## Methods

### Participants

The participants, part of whom were described previously (Brady et.al. 2018), included 269 individuals in the Midwest recruited by directly contacting school districts and adult facilities that provide services to individuals with minimal verbal skills defined as less than 20 functional words and/or signs. A few participants self-recruited on the project website or in response to posts on local websites for families of children with Down syndrome or ASD. All participants had normal or corrected hearing and vision, were able to hold their head upright, and physically interacted with the toys provided during the assessment.

The age range of the participants was 3- to 66 years with a mean of 22 years and a standard deviation of 18 years, and 38% of participants were female. When we grouped participants into age categories, 25% were less than 6 years, 19% were 6 to 12.99 years, 14% were 13 to 18.99 years, 11% were 19 to 29.99 years, 19% were 30 to 49.99 years, and 12% were 50 years plus. Most of the participants (51%, $n = 137$) had received a diagnosis of ASD. Table 2 provides a summary of age and other participant characteristics by ASD status. Most commonly, the ASD diagnosis was made by a physician (45%), a psychologist (25%), or a psychiatrist (8%). Most of the caregivers (64%) did not know how ASD was diagnosed, although 10% noted use of the Autism Diagnostic Observation Schedule (ADOS), and 10% said The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) was used. One participant was Hawaiian/Pacific Islander, four (1%) were American Indian/Alaska natives, eight (3%) were Asian, nine (3%) did not report their race, 21 (8%) reported more than one race, 32 (12%) were African American, and the remaining 72% of participants were White. Half of the 26 participants identifying as Hispanic were White and half were more than one race. English was the primary language spoken by all participants.

Nearly all of the 3- to 16 year-old participants lived at home with their parents, whereas many of the adults lived in homes with other caregivers. Overall, 65% of the participants lived with family, 14% lived in a residential facility, 18% lived in a group home, and 3% lived in some other arrangement.

## Procedures

The CCS Assessment Protocol was administered to each participant following procedures described in the next and previous sections (Brady et al., 2018; Brady et al., 2012). Assessments were completed at participants' school or home depending on what was most convenient for families. Each CCS protocol lasted approximately 30 min. The assessment was videotaped for later scoring, which required on average an additional 60 min. Within 2 weeks of administration of the CCS protocol, the VABS-II was obtained from parents or caregivers who lived with or frequently interacted with the participant.

## Measures

**Communication Complexity Scale (CCS)—**A communication protocol consisting of a series of 12 play-based tasks designed to elicit communication for BR or JA were administered by project staff. One of two versions of the protocol was used—one with materials we thought were more appropriate for adults and another with materials selected for children (under 16 years of age). For example, version A included a child's book and version B included a magazine. In both tasks, the reading material was altered to see if the participant would communicate about the altered pages (e.g., some were upside down, scribbled on, or torn).

Communication responses were coded from videotaped recordings. Research assistants, who were trained to a criterion of 80% agreement across three videos prior to coding project videos, assigned a code for the highest communicative act observed within each task. Twenty-four percent of project videos were randomly selected and coded by a second research assistant. The overall kappa score across all the scripted opportunities presented was .83. As shown in Table 1, scores of 0 and 1 describe no response and alerting behavior, scores of 2–5 describe preintentional communication, scores of 6 to 10 describe intentional nonsymbolic communication, and scores of 11 and 12 describe intentional symbolic communication. Coders also assigned a communicative function to communicative acts scoring 6 or higher which convey intentional communication. Three possible functions, behavior regulation (BR), joint attention (JA), or response to question (RQ), were scored based on past research (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Brady et al., 2004). BR was operationalized as requests and protests. An example of BR is handing a wind-up toy that is not working to a communication partner and waiting for the partner to fix it. JA was operationalized as social commenting. An example of JA was pointing at the bubbles coming from the bubble toy. RQ refers to responses to questions issued by the examiner, such as “Do you need help?” Such questions were discouraged during administration, occurred rarely, and were dropped from analyses. In following with the intent of the CCS, we only analyzed participant communication that was *initiated*, that is, acts that did not follow questions or prompts by the examiner.

Our analyses (described next) compared communication complexity scores for six tasks designed to provide opportunities for BR to six tasks designed to provide opportunities for JA. However, on 16% of the total tasks designed to encourage BR communication, a participant responded with a JA function, and for 25% of the total tasks designed for JA communication, a participant responded with a BR function. We analyzed results according to the intended (rather than realized) function for two reasons. First, we wanted to see if scores for tasks that were intended to provide opportunities for BR differed from those intended to provide opportunities for JA. Second, this allowed us to use all of the data because function of communication was only assigned when a communication act was intentional (score 6 and above). By focusing on intended function, we could look at the entire ranges of scores for a given task.

**Vineland Adaptive Behavior Scales II (VABS-II)—**Project staff administered the VABS-II (Sparrow et al., 2005) survey interview to a parent or caregiver of each participant. The VABS-II measures the personal and social skills of individuals from birth through adulthood and because of this wide age range, is useful for describing the skills of individuals of varying ages with different types of intellectual disability. Parents rated each item as 2 = *yes usually,* 1 = *sometimes or partially,* 0 = *no never,* N = *no opportunity,* and DK = *don’t know*, until a ceiling of seven consecutive items were scored a 0 within each domain. The Communication domain with 67 items assesses receptive, expressive, and written communication skills and includes items like “Follows instructions or directions heard 5 minutes before.” The Daily Living domain with 92 items assesses personal, domestic, and community skills and includes items such as “Tells time using a digital clock or watch.” The Socialization domain with 66 items assesses interpersonal relationship, play and leisure, and coping skills and includes items such as “Meets with friends regularly.” Reported interrater reliability for the VABS-II across domains/subdomains is high with correlations ranging from .71 to .81. Reported correlations with other measures provide evidence for the concurrent and discriminant validity of the VABS-II. A sum of the VABS-II raw scores for the Communication, Socialization, and Daily Living subscales was used as an indicator of adaptive behavior. The Maladaptive Behavior raw score which includes items such as "Is too impulsive" and "Has poor eye contact" was used as an indicator of problem behavior.

### Analysis Approach

Data from the CCS and VABS-II were used in our analyses. Crossed random effects models were used to examine variability in complexity of communication scores across participants and tasks. Initial analyses were conducted to determine if there was sufficient variability in scores across participants and tasks to enable us to answer our research questions. Next, to address research questions one and two, characteristics of task (BR vs. JA) and subject (ASD, age) were added to the model to examine their influence on complexity scores. Finally, adaptive and problem behavior were added to the model to determine if there were significant relationships between participant behavior and communication complexity. Restricted maximum likelihood was used to estimate the models. Random effects were evaluated using likelihood ratio tests and fixed effects were evaluated using Wald tests of whether the parameters were significantly different from zero.

## Results

Each of 269 individuals with minimal verbal skills was presented with 12 tasks. Scores on all 12 tasks were obtained for 248 individuals (92%). Nineteen individuals were missing one score, one individual completed 10 of 12 tasks, and one individual completed 9 of 12. Thus, a total of 3,204 scores were available for analyses.

To determine if tasks and subjects were a significant source of variance in complexity scores, a series of empty means models (i.e., model without predictors) were estimated. First, a model specifying only a single residual variance was estimated as a baseline model for comparison. This baseline model that specified that all complexity score deviations from the grand mean were due to residual or error variance was compared to a model allowing for subject random intercepts, (i.e., different complexity scores across subjects). The subject random intercept model significantly improved model fit, $-2\Delta LL\ (\sim 1) = 1239.5$. $p < .001$, which indicated that there was significant subject variability in scores. A third model allowing for random task intercepts in addition to the random subject intercepts resulted in improved model fit compared to the subject random intercepts only model, $-2\Delta LL(\sim 1) = 70.5$. $p < .001$, so an additional significant variance term for tasks was added to the model indicating that there are significant differences in mean complexity scores across tasks. In other words, the tasks are not interchangeable. They differ in the average complexity of participant responses. Thus, the final model, needed to partition the variance into its significant sources, included both random subject intercepts and random task intercepts. Having established this, we could proceed to the second step in our analysis approach—adding task and subject characteristics that could potentially account for significant task and subject variance.

The parameter estimates from the final empty means model, Model 1, which partitioned the variance into subject and task sources are presented in Table 3. This model is the base model which we used as a comparison for subsequent models with added predictors. The average communication complexity score across all trials (tasks and persons) was 6.54. Table 4 provides the random item intercepts and their corresponding Wald tests indicating whether the communication complexity mean for each task was significantly different from the average communication complexity across all tasks and communicators. Eight tasks had intercepts that were significantly different than the overall intercept. The *bubbles* and *snack* tasks were especially effective at eliciting complex communication for children, with scores averaging around a point higher than the average score. *Magnatiles* and *bubble machine* tasks were especially ineffective at eliciting complex communication for adults with average scores around .75 points less than the 6.54 average complexity.

The task random intercept variance was .31, the subject random intercept variance was 4.79, and the level-1 residual variance was 6.09, yielding a total complexity score variance of 11.19. Thus, 43% of the complexity score variation was due to mean differences across subjects, 3% was due to mean differences across tasks, and the remaining 54% was due to subject by task interaction or residual variance. To describe the size of the random intercept variation across subjects and tasks, 95% random effect confidence intervals were computed using the formula, fixed intercept ± 1.96*SQRT (random intercept variance) as recommended by Hoffman (2015). 95% of the task score means were expected to fall between 5.45 and 7.63, and 95% of the subject score means were expected to fall between 2.25 and 10.83. Although there is much greater variation between subjects than between tasks, both sources of variance were significant and thus their random effects were retained in the model.

## Analysis of Research Questions

Once we established that there was significant subject and task variance in communication complexity scores, our research questions examining predictors of these variances could be addressed.

**How does the intended communication function of tasks affect communication complexity?—**Recall that our hypothesis based on earlier research with individuals with IDD was that scores would be lower (less complex) for JA tasks, compared to BR tasks. In Model 2, which added a predictor of task variance to the model for the means, we examined the effects of task function (JA vs. BR). For this predictor of task variance, there was a marginally significant main effect, $F(1,15.5) = 4.49$, $p = .05$, such that **tasks with a communication function of JA resulted in complexity scores that were about half a point (.5) *lower* than were tasks with a communication function of BR.** Intended task communication function accounted for 16% of the item variation (i.e., item random intercept variance decreased from .31 to .26), although significant item intercept variation remained, as indicated in Table 3, Model 2.

**How do ASD and age impact communication complexity?—**The literature noting a decrease in frequency of communication response by individuals with ASD to JA opportunities led us to hypothesize that a diagnosis of ASD could influence both average communication complexity scores and variability of complexity scores across communicators. Therefore, we examined the effect of ASD status and age centered at 15 years (the age associated with a change in protocol materials) on the model for the means, and we also examined the effect of ASD status on the variance of complexity scores across communicators (see Model 3 which added predictors of subject variance and Model 4 which allowed for different subject random intercept variance for ASD groups in Table 3).

Although there were no significant effects for ASD on the subject means in the predictors of subject variance model, (i.e., there were not significant mean differences in complexity across all items between ASD and No ASD participants), there was a significant effect for age on the means, $F(1,231) = 14.91$, $p < .0001$. Furthermore, the effect for task function which had a marginally significant *p*-value when there were no subject predictors in the model, was statistically significant after adding these subject predictors to the model, $F(1, 21.4) = 5.22$, $p = .033$. Communication complexity scores decreased for all participants by .03 for every year of age and decreased by .45 if the task was JA as can be seen in the parameters for Model 3, the subject variance predictor model.

To more fully understand the age effect, we exported the subject intercepts, average complexity across all available tasks for each person, from the model. First, we examined average complexity across the age groups. Participants less than 6 years of age had an average communication complexity of 7.22, participants aged 6 to 12 years of age had an average communication complexity of 7.18, participants aged 13 to 18 had an average communication complexity of 7.09, participants aged 19 to 29 had an average communication complexity of 6.25, participants aged 30 to 49 had an average communication complexity of 5.23, and participants aged 50 or more had an average communication complexity of 5.94.

Additionally as can be seen in the model allowing for separate subject random intercept variances for ASD and no ASD subgroups, (Model 4, Table 3) there was significant improvement in model fit when separate variance terms were estimated for participants with ASD and without ASD, $-2\Delta LL(\sim1) = 13.6$. $p = .0002$. Participants with a diagnosis of ASD were less variable in the complexity of their communication, (subject random intercept variance of 3.10) than were participants with no ASD diagnosis, (subject random intercept variance of 6.30). In other words, the participants with ASD who met our criteria for minimally verbal had CCS scores that were more similar than did the participants with IDD not associated with ASD after accounting for differences in age across groups. Figure 1 presents the distribution of complexity scores for ASD and No ASD groups for each age category and demonstrates that complexity scores for the ASD group were less variable for all age categories.

As a next step in our modeling process, to examine whether lower complexity scores were observed in JA tasks for participants with ASD, we added two-way and three-way interactions between ASD status, task function, and age to the model. Only one interaction was significant—there was a significant difference in the task function slope for participants with and without ASD. The interaction model presented in Table 3 under Model 5, provides the parameter estimates for the best fitting model. Although tasks with a JA communication function were generally responded to with lower communication complexity scores than tasks with an intended behavior regulation function, this difference is significantly *less* for participants *without* ASD. **For individuals with ASD, complexity scores are .62 points lower when the function is JA rather than BR, supporting our hypothesis.** For individuals without an ASD diagnosis, complexity scores are still significantly different across functions, but they are only .27 points lower when the function is JA rather than BR.

**Are there differences in residuals across participants with and without ASD?—**Given the differences in variability in complexity scores across tasks between participants with and without an ASD diagnosis and the lower scores for JA tasks for participants with ASD, it seemed likely that there would be group differences in residual variance estimates (variance unexplained by the model) between ASD and non-ASD groups. Model 6 in Table 3 which allows for separate residual variance estimates for ASD and no ASD communicators, had significantly improved model fit, $-2\Delta LL(\sim 1) = 31.2$. $p < .0001$ over the model that estimated a single residual for all communicators, indicating that the residual variances are significantly different. Fifty-four percent of the variance in the No ASD group is attributable to differences between persons in the group (6.27/11.62) and only 30% of the variance in the ASD group is attributable to differences between persons in the group. Thus, although the communication complexity scores of communicators with ASD are less variable than those of the communicators in the No ASD group as reported previously, the ASD group has more variability that is not explained by task and communicator characteristics in our model than do the communication scores of communicators with no ASD. The complexity of communication for individuals with ASD may be more sensitive to the materials within the task or some other environmental factor.

**What effect does communicator adaptive and problem behavior have on communication complexity scores?—**We hypothesized that the adaptive behavior of participants and the amount of problem behavior reported for a participant could account for additional variance in communication complexity scores. Therefore, *adaptive behavior raw score* centered near the mean at 41 and *maladaptive behavior raw score* centered near the mean at 32 were added in Model 7 (Table 3) to test this hypothesis.

Adaptive behavior had a significant effect on communication complexity scores, $F(1271) = 24.39$, $p < .0001$, such that complexity scores increased by .04 for every point increase in adaptive behavior score. However, maladaptive behavior was *not* significantly related to communication complexity scores in our sample. The addition of these predictors to the model reduced the subject random intercept variance in participants not diagnosed with ASD by 13% to 5.53 and reduced the subject random variance of participants with ASD by 5% as compared to the previous model without these predictors included.

## Results Summary

Our analyses have demonstrated that there was significant variability in mean complexity scores across tasks and across participants. Eight of the tasks had mean complexity scores that were significantly different from the grand mean complexity score of 6.54. Tasks intended to produce a JA function had significantly lower means than tasks intended to produce a BR function. Participant age significantly impacted mean complexity scores with means decreasing as participants aged. Although ASD status did not affect mean complexity scores, there were variance differences in both subject random intercepts and residuals based on ASD subgroups. An additional ASD effect was the significant interaction between task function and ASD status which indicated that although participants in both the ASD and No-ASD groups had more complex communication in BR than in JA, the difference between complexity in JA and BR functions was less for individuals without an ASD diagnosis than for individuals with an ASD diagnosis. Finally, adaptive behavior was significantly positively related to complexity scores.

## Discussion

Variability in CCS scores was associated with task function and participant characteristics in our sample of participants with IDD who all had minimal verbal skills (less than 20 functional words and signs). The pattern of variability matched predictions based on findings derived from other assessments, and thus bolsters confidence in the construct validity of the CCS.

Our analyses of task variability indicated that participants responded with higher complexity to tasks designed to evoke BR communication, even though equally complex communication acts can be used across contexts. For example, one could indicate that help is needed in initiating a push-button activated toy by shifting eye gaze between the toy and experimenter while vocalizing (a score of 9). This same shifting of gaze between an object and experimenter could be used to communicate a JA function if an unusual object appeared during play.

Differences in complexity of BR and JA tasks may be attributable to motivation. BR tasks tend to be more intrinsically motivating. For example, many individuals with IDD may be more motivated to ask for help to access a preferred item than to comment on an unexpected event. Another reason people with minimal verbal skills associated with IDD may be less likely to respond to JA tasks is that responding to such tasks requires a level of intersubjectivity—a realization that something unusual is happening, that the communication partner is not aware of the unusual event, and an interest in sharing this event with the communication partner. The development of intersubjectivity is often stilted in individuals with severe IDD (Brady et al., 2004; Trevarthen & Aitken, 2001).

Our comparison of participants with and without ASD also confirmed previous findings of differential responsiveness to BR versus JA tasks. Individuals with ASD respond with less complex communicative acts to JA tasks, and this difference has been considered a “red flag” associated with the diagnosis of ASD (Wetherby et al., 2004). Our results of lower complexity scores for individuals with an ASD diagnosis is consistent with these findings and indicative of a life-long difference in expressing communication functions for individuals with minimal verbal skills. It was also not surprising that individuals with ASD, as a group tended to respond more similarly to each other than those without an ASD diagnosis. The group without ASD were truly heterogeneous in terms of etiologies.

Findings of lower complexity scores in older individuals may be related to several variables. Age-related declines have been reported in some individuals with IDD (Krinsky-McHale &

Silverman, 2013) and particularly in individuals with Down syndrome (Couzens, Cuskelly, & Haynes, 2011) and fragile X syndrome (Hahn et al. 2015). Although these effects have been observed for cognition in general, similar effects for communication would be consistent with these findings. In addition, we may have observed "learned helplessness" that developed cumulatively over years of interacting in a nonresponsive environment (Wehmeyer & Bolding, 2001). Learned helplessness describes passivity that results from little opportunity to actively communicate choices or preferences. Older individuals in our study may have been "conditioned" to no longer attempt to communicate in nonverbal ways due to consistent failure on the part of their partners to pick up nonverbal communication cues. We also observed that older participants were less likely to receive ongoing communication interventions than younger participants—a trend reported in other studies (Shattuck, Wagner, Narendorf, Sterzing, & Hensley, 2011).

Participants in our study who had greater adaptive behavior scores also had more complex communication. We suspected that this finding may have been partially attributable to communication items contained within the VABS-II, used in this study. The composite score of the VABS-II includes items from expressive and receptive communication subscales. However, there are only a few items that would directly map on to communication complexity as described by the CCS such as "makes sounds or gestures to get caregiver attention" and "points to wanted objects out of reach." It seemed more likely that these two constructs, adaptive behavior and communication complexity, have parallel developmental trajectories. To confirm this hypothesis, we removed the communication items from the adaptive behavior score and re-ran the analyses. The association between adaptive behavior and communication complexity actually increased slightly and remained highly significant.

The finding that problem behavior was unrelated to communication complexity scores on the CCS assessment may be explained by our use of the Maladaptive raw score of the VABS-II. Many of the items address behaviors such as eating difficulties, sleeping difficulties, or taunts, teases, or bullies that would not affect a short-duration assessment such as the CCS. Similarly, problem behaviors that likely *would* impact scores in our assessment protocol such as the inability to sit and complete simple tasks are not assessed by the Vineland maladaptive subscale.

### Limitations of the Present Study

We reported significant differences in communication complexity based on a diagnosis of ASD. However, we relied on parent/caregiver report for ASD. Although we queried family members about the source of participants' diagnoses, we did not have resources to complete an independent confirmation of the ASD diagnosis using gold standard procedures. Hence, our results should be interpreted with limitations associated with parent report and current diagnostic criteria/procedures.

It is possible that presentation order influences task random intercepts (i.e., mean differences in complexity across tasks). Because the tasks are presented in the same order to all participants, we have no way to assess for order effects. The order of tasks on the CCS was chosen for somewhat practical reasons. For example, we like to start with a task that most participants find to be engaging, but not so engaging as to cause a disruption when the task is put away. The especially engaging ball toy task is presented last and participants can interact with that task for a while once the assessment has been completed. In addition, administration across participants is more consistent when a consistent order is followed.

### Future Directions

Variability in CCS scores could have important consequences in terms of monitoring changes over time and in response to interventions selected for subgroups of individuals with IDD. For example, small changes in JA scores for individuals with ASD may be viewed as important given the overall lower scores in response to tasks aimed at evoking this function. A shrinking gap in BR and JA scores over time, particularly in association with an intervention, could be interpreted as positive outcomes for individuals with ASD. Similarly, stability over later adult years would be viewed more positively in light of lower overall scores for older adults. However, further research with greater numbers of participants per subgroups and longitudinal analyses are needed to make such interpretations.

It may also be worthwhile to further investigate scores for groups such as individuals with Down syndrome or other etiologies/diagnoses. For example, Hahn, Brady, McCary, Rague, and Roberts (2017) specifically looked at communication complexity scores for infants with fragile X syndrome. With sufficient sample sizes, it would be possible to generate “normative data” within subgroups of interest and allow researchers and interventionists to make comparisons within and across subgroups of individuals with IDD who all have minimal verbal skills. Although one goal for the CCS is to use it to measure *individual* differences in scores for descriptive purposes and to measure change, it may also be useful to compare CCS scores within and across subgroups of individuals with IDD.

In conclusion, the current findings identified task and participant variables that were associated with variability in communication complexity as measured with the CCS. Our findings substantiate the construct validity of CCS scores for measuring early communication complexity by demonstrating that the variability was commensurate with theory and past research findings. In addition, although this study is not an attempt to obtain normative data, our results provide useful reference points for interpreting results from individuals in research and clinical practice.

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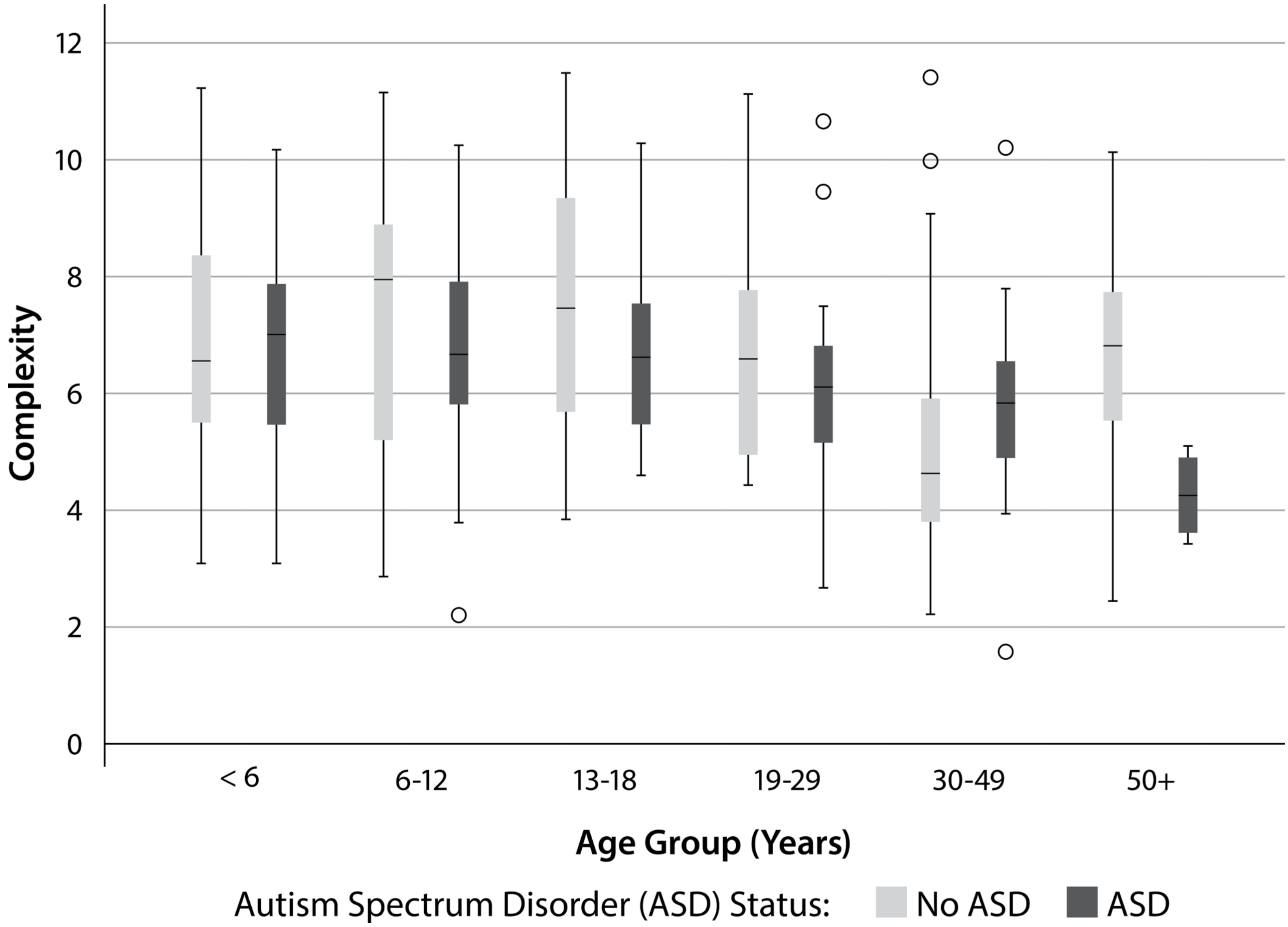


**Figure 1.**
Complexity score distributions for No ASD and ASD groups by age category

**Table 1**

Summary of Communication Complexity Scale

| Scores | | |
|---|---|---|
| **Number** | **Definition** | **Communication level** |
| 0 | No response | |
| 1 | Alerting–a change in behavior, or stops doing a behavior | Preintentional |
| 2 | Single orientation only–on an object, event, or person; can be communicated through vision, body orientation, or other means. | Preintentional |
| 3 | Single orientation only + 1 other PCB (potentially communicative behavior) | Preintentional |
| 4 | Single orientation only + more than 1 PCB | Preintentional |
| 5 | Dual orientation–shift in focus between a person and an object, between a person and an event using vision, body orientation, etc. (without PCB) | Preintentional |
| 6 | Triadic orientation (e.g., eye gaze or touch from object to person and back) | Intentional Non-Symbolic |
| 7 | Dual orientation + 1 PCB (e.g., dual focus + gesture) | Intentional Non-Symbolic |
| 8 | Dual orientation + 2 or more PCB (e.g., dual focus + gesture + vocalization, switch closure) | Intentional Non-Symbolic |
| 9 | Triadic orientation + 1 PCB (e.g., triadic + vocalization) | Intentional Non-Symbolic |
| 10 | Triadic orientation plus more than 1 PCB (e.g., triadic plus vocalization and differential switch closure) | Intentional Non-Symbolic |
| 11 | One-word verbalization, sign, or AAC symbol selection | Intentional Symbolic |
| 12 | Multi-word verbalization, sign or AAC symbol selection | Intentional Symbolic |

*Note*. PCB = Potentially Communicative Behavior; AAC = Augmentative and Alternative Communication.

## Table 2

Participant Characteristics by ASD Status

| | No ASD (*N* = 132) | | ASD (*N* = 137) | |
|---|---|---|---|---|
| | ***M*** | ***SD*** | ***M*** | ***SD*** |
| Chronological Age | 27.06 | 20.44 | 16.80 | 13.53 |
| Adaptive[a] | 38.57 | 34.05 | 43.67 | 26.23 |
| Malaaptive[b] | 30.22 | 11.27 | 34.58 | 8.81 |

Note. ASD = Autism Spectrum Disorder.

[a]Adaptive is the raw summary of the communication, socialization, and daily living domains on the Vineland Adaptive Behavior Scales.

[b]Maladaptive is the raw domain score for maladaptive behavior on the Vineland Adaptive Behavior Scale.

**Table 3**

Summary of Crossed Random Effects Models.

| Model Effects | Model 1 | | | Model 2 | | | Model 3 | | | Model 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Est | *SE* | *p*< | Est | *SE* | *p*< | Est | *SE* | *p*< | Est | *SE* | *p*< |
| **Model for Means** | | | | | | | | | | | | |
| Intercept | **6.54** | .18 | .0001 | **6.79** | .21 | .0001 | **6.82** | .24 | .0001 | **6.83** | .21 | .0001 |
| Task Function is JA | | | | **−.47** | .22 | .050 | **−.45** | .20 | .033 | **−.45** | .20 | .032 |
| Participant is No ASD | | | | | | | .39 | .29 | .18 | .43 | .29 | .14 |
| Age: Years over 15 | | | | | | | **−.03** | .01 | .0001 | **−.04** | .01 | .0001 |
| **Model for the Variance** | | | | | | | | | | | | |
| Residual Variance | **6.09** | .16 | .0001 | **6.09** | .16 | .0001 | **6.09** | .16 | .0001 | 6.09 | .16 | .0001 |
| Task RI Variance | **.31** | .13 | .008 | **.26** | .11 | .010 | **.19** | .07 | .005 | .19 | .07 | .005 |
| Subject RI Variance | **4.79** | .47 | .0001 | **4.80** | .47 | .0001 | **4.66** | .45 | .0001 | | | |
| Subj. RI Var NoASD | | | | | | | | | | **6.30** | .85 | .0001 |
| Subj. RI Var ASD | | | | | | | | | | **3.10** | .44 | .0001 |
| −2LL | 15557.1 | | | 15553.9 | | | 15548.0 | | | 15534.4 | | |

| Model Effects | Model 5 | | | Model 6 | | | Model 7 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Est | *SE* | *p*< | Est | *SE* | *p*< | Est | *SE* | *p*< |
| **Model for Means** | | | | | | | | | |
| Intercept | **6.92** | .21 | .0001 | **6.92** | .21 | .0001 | **6.71** | .22 | .0001 |
| Task Function is JA | **−.62** | .21 | .007 | **−.62** | .21 | .006 | **−.61** | .21 | .006 |
| Participant is No ASD vs ASD | .25 | .31 | .41 | .25 | .31 | .41 | −.06 | .31 | .84 |
| Participant Age: Years over 15 | **−.04** | .01 | .0001 | −.04 | .01 | .0001 | .01 | .01 | .38 |
| Task Function by ASD | **.35** | .18 | .044 | **.36** | .18 | .041 | **.37** | .18 | .039 |
| Adaptive Behavior (0=41) | | | | | | | **.04** | .01 | .0001 |
| Maladaptive Behavior (0=32) | | | | | | | .01 | .01 | .46 |
| **Model for the Variance** | | | | | | | | | |
| Residual Variance | **6.08** | .16 | .0001 | | | | | | |
| Residual No ASD | | | | **5.18** | .19 | .0001 | **5.21** | .20 | .0001 |
| Residual ASD | | | | **6.97** | .26 | .0001 | **6.97** | .26 | .0001 |
| Task Random Intercept Variance | **.19** | .07 | .005 | **.17** | .07 | .005 | **.17** | .07 | .005 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Subject Random Intercept Variance | | | | | | | | | |
| Subject RI Variance No ASD | **6.30** | .85 | .0001 | **6.38** | .85 | .0001 | **5.53** | .76 | .0001 |
| Subject RI Variance ASD | **3.10** | .44 | .0001 | **3.03** | .44 | .0001 | **2.88** | .43 | .0001 |
| −2LL | 15532.6 | | | 15501.4 | | | 15328.5 | | |

Note: Bold values are $p < .05$.

*Note.* JA = Joint Attention; ASD = Autism Spectrum Disorder; RI = Random Intercept;LL = Log Likelihood.

## Table 4

Random Task Intercepts—Change From Overall Mean Across Tasks of 6.54

| Script | Estimate[a] | *SE* | *df* | *t* Value | p |
|---|---|---|---|---|---|
| Ball Toy Adult | −0.31 | 0.23 | 83.6 | −1.32 | 0.19 |
| Ball Toy Child | 0.46 | 0.24 | 80 | 1.93 | 0.06 |
| Blocks Child | −0.07 | 0.24 | 80 | −0.30 | 0.77 |
| Book Adult | −0.36 | 0.25 | 86.8 | −1.44 | 0.15 |
| Books Child | −0.09 | 0.24 | 80.2 | −0.36 | 0.72 |
| Bubbles Child | **1.37** | **0.24** | **80.2** | **5.70** | **<.0001** |
| Bubbles1 Adult | **−0.72** | **0.23** | **83.6** | **−3.09** | **0.003** |
| Bubbles2 Adult | −0.58 | 0.44 | 30.1 | −1.33 | 0.19 |
| Bumble Child | 0.21 | 0.24 | 80.2 | 0.87 | 0.39 |
| Cars Adult | **−0.48** | **0.23** | **83.6** | **−2.07** | **0.04** |
| Dots Child | 0.34 | 0.24 | 80 | 1.40 | 0.17 |
| Fan Adult | −0.09 | 0.24 | 85.8 | −0.38 | 0.71 |
| Fan Child | 0.04 | 0.24 | 80.6 | 0.15 | 0.88 |
| Hammer Child | 0.21 | 0.24 | 80.2 | 0.86 | 0.39 |
| Light Globe Adult | 0.18 | 0.24 | 85.5 | 0.76 | 0.45 |
| M Tab Adult | −0.31 | 0.23 | 83.8 | −1.33 | 0.19 |
| Mag Tiles Adult | **−0.81** | **0.23** | **83.8** | **−3.45** | **0.0009** |
| Mag Tiles Child | **0.48** | **0.24** | **80.4** | **2.00** | **0.049** |
| Music Child | −0.04 | 0.24 | 80 | −0.16 | 0.87 |
| Remote Car Adult | −0.12 | 0.23 | 83.8 | −0.50 | 0.62 |
| Sand Adult | −0.59 | 0.39 | 44.5 | −1.51 | 0.14 |
| Sealed Bag Adult | **0.53** | **0.23** | **83.6** | **2.27** | **0.026** |
| Simon Adult | 0.13 | 0.23 | 83.6 | 0.57 | 0.57 |
| Snack Adult | 0.22 | 0.23 | 83.6 | 0.92 | 0.36 |
| Snack Child | **0.87** | **0.24** | **80** | **3.62** | **0.0005** |
| Wind-Up Child | **−0.48** | **0.24** | **80** | **−1.99** | **0.049** |

Note.

[a]To obtain the mean for each task add the estimate to the overall mean of 6.54.