Measuring Change in the Communication Skills of Children with ASD using the Communication Complexity Scale

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Abstract

Changes in minimal verbal communication by children with ASD were measured with the Communication Complexity Scale (CCS) and other communication assessments. The CCS measures complexity of preverbal and beginning verbal communication used to communicate behavior regulation and joint attention. The purpose was to investigate if the CCS was responsive to changes associated with a behavioral intervention aimed at improving communication skills. Changes were detected with CCS scores, rates of initiating joint attention and the MSEL Expressive Language subscale. Significant changes in CCS scores were also detected for a subgroup of participants who did not show significant changes on the MSEL expressive language scale, demonstrating that CCS scores are sensitive to changes associated with a behavioral intervention.

Key words: assessment, communication, ASD, intervention

Measuring Change in Minimal Verbal Communication with the Communication Complexity Scale

People communicate before they can speak, and for a significant number of individuals, non-speech communication remains their primary means of communication throughout their lives. For example, among individuals with an ASD spectrum disorder, nearly 25-30% remain minimally verbal at age 5 years, and nearly half do not have fluent speech through the early years of schooling (Anderson et al., 2007; Tager-Flusberg & Kasari, 2013). Despite this prevalence of minimally verbal individuals, few assessments of early, prelinguistic communication are available. This is a critical concern as the population of individuals who communicate with minimal verbal skills continues to grow (Bhismadev, 2017; Kasari, Brady, Lord, & Tager-Flusberg, 2013). Assessments are needed that can a) measure communication reliably and objectively, b) identify current levels of communication functioning to better inform interventions, and c) measure change over time, and in relation to intervention. The focus of the current study is this last purpose—investigating whether a new communication measure is sensitive to changes associated with intervention.

Measuring communication in individuals who communicate primarily with prelinguistic means can be difficult and time consuming. Many of these individuals may not follow instructions, making it difficult to determine if poor performance indicates a lack of skill, or lack of ability to demonstrate the skill due to testing parameters. In addition, many prelinguistic communicators have challenging behaviors that interfere with completing standardized testing. Assessing early communication requires a keen observer of behaviors such as changes in eye gaze and gestures and knowledge about how these behaviors combine to effect communication. Existing assessments are limited in their ability to measure subtle changes in communication and language for children who have minimal verbal abilities. Standard scores derived from normative assessments typically stay at floor levels even if the individuals make gains, because the amount of gain is not on pace with chronological aging or of sufficient magnitude to move the score. Subtle changes are important to track, however, because they may indicate progress associated with intervention targeting communication skills. Even subtle changes can inform intervention optimization, including decisions to continue on course, or to augment with additional strategies, change dosage, or adapt intervention approaches.

Although there are many assessments of expressive communication that encompass prelinguistic as well as linguistic behaviors, standardized measures such as the PLS-5 (Zimmerman, Steiner & Pond, 2011) or the McArthur Bates Communication Development Inventory (Fenson, 2007) contain only a few items about prelinguistic communication, and most of these items rely on caregiver report. Other existing assessments such as the Communication and Symbolic Behavior Scales (CSBS) (Wetherby & Prizant, 2003) focus on assessing prelinguistic and early linguistic communication in young children. The CSBS yields scores that can be compared to typically developing children or children at similar prelinguistic stages. The Communication Matrix (Rowland, 2004) is another well-known assessment of early communication. It relies on caregiver report to develop a profile of an individual’s current communication.

The Communication Complexity Scale (CCS) was developed by Brady and colleagues specifically to measure the complexities of prelinguistic and early linguistic communication with the aims of describing a person’s current communication abilities and measuring changes in communication over time (Brady et al., 2018; Brady et al., 2012; Fleming & Brady, in press). The CCS is a 12-point scale of expressive communication. Scores reflect how one communicates (quality of communication) in reference to a developmental continuum that spans from preintentional through beginning-symbolic communication (see Appendix A). Higher scores indicate that the individual communicates with more complex behaviors. For example, someone who communicates by combining gestures and vocalizations and eye gaze would have a higher score than someone who only uses vocalizations.

The primary goal of the CCS is to delineate subtle differences in pre-intentional and intentional pre-symbolic communication. The first 5 scores reflect preintentional behaviors such as gestures or vocalizations that are not clearly directed at a communication partner. For example, reaching toward an object without looking at someone would be described as preintentional because the person reaching may be trying to directly obtain the object rather than communicating to someone that they want the object.

Scores of 6-10 reflect intentional, pre-symbolic communication. They are viewed as intentional because the acts combine behaviors such as a gesture or a vocalization with attention to the communicative partner (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Crais, Douglas, & Campbell, 2004; Wetherby, Cain, Yonclas, & Walker, 1988). For example, if a child reaches toward an object while looking up at a communication partner, it could be described as intentional because the child appears to be trying to get the partner to help obtain the object. A score of 11 indicates that an individual said or signed a word or independently selected a symbol and a score of 12 indicates that an individual combined 2 or more words, signs or symbols into a meaningful phrase. As is apparent from this description and from reviewing Appendix A, most of the scale is devoted to presymbolic behaviors. Individuals who frequently communicate with spontaneous appropriate phrases would perform at the ceiling of this scale.

In the current study, we applied the CCS to a scripted interaction between an experimenter and student with minimal verbal skills- the ESCS. However, it should be noted that the CCS can be used in a variety of contexts. Past studies have applied the CCS to other social interactions constructed to provide opportunities for individuals to communicate with both symbolic and nonsymbolic means (Brady et al., 2018; Brady et al., 2012; Hahn, Brady, McCary, Rague, & Roberts, 2017). Thiemann-Bourque and colleagues recently demonstrated that the CCS can be used to code interactions between students with ASD and peers without ASD (Thiemann-Bourque, Brady, & Hoffman, 2018).

In studies with individuals with intellectual and developmental disabilities (IDD) between the ages of 3-60 years, Brady and colleagues demonstrated that scores from the CCS have high concurrent validity and inter-rater reliability (Brady et al., 2018; Brady et al., 2012). Acceptable levels of test-retest reliability were also reported (Brady et al., 2018). In addition to establishing the reliability and validity of a measure, it is also necessary to establish that measures designed for use in intervention are responsive (Aylward, 1997). Responsiveness refers to the ability of an instrument to detect clinically important differences over time (Guyatt, Walter & Norman, 1987). For prelinguistic and early linguistic communication, clinically important differences may include use of more complex behaviors and vocalizations along with coordinated attention to a communication partner (Fey et al., 2006; McCathren, 2000). It has not been previously demonstrated that the CCS is responsive to changes associated with intervention, however, because we only examined reliability and validity at a single point in time. Therefore, it is important to investigate how sensitive the CCS is to detecting changes associated with intervention.

This paper addresses the following research question: Is the CCS responsive to changes in communication complexity associated with intervention? In addition, we wanted to examine how changes in the CCS compare to changes in the MSEL Expressive Language subscale ((Mullen, 1995) and to rates of communication. Further, we wanted to Investigate if significant changes could be detected with the CCS in a subgroup who did not demonstrate significant changes on the Expressive Language subscale of the MSEL- a widely used measure of early learning. Demonstrating changes in this subgroup is important because doing so would suggest that the CCS is a measure that could be used to demonstrate more subtle changes in communication that may indicate that a participant is responding favorably to intervention.

Method

Participants.

The participants of this study were 60 children with ASD who were from 3 through 4.5 years of age (mean = 3.77 years). Fifty one were male and 9 were female. The participants were part of a larger study investigating behavioral interventions aimed at improving communication and spoken language. The inclusion criteria for the larger study were: diagnosis of ASD(ASD status was verified by ADOS scores from assessments administered by independent, blinded assessors); chronological age between 36-47 months; classification of minimally verbal (fewer than 30 different words recorded during pre-intervention language assessments). The current study represents a subsample of this larger study, including only children who had fewer than 20 functional words, consistent with more recent definitions of minimally verbal (NIH workgroup, 2010; Tager-Flusberg & Kasari, 2013). This resulted in 60 children with average severity scores on the ADOS of 6.8 and a standard deviation of 1.7. Exclusion criteria included major medical conditions other than autism, specifically (a) genetic disorders such as Fragile X, Down syndrome, or tuberous sclerosis, (b) sensory disabilities such as blindness or deafness, and (c) motor disabilities such as cerebral palsy; and nonverbal mental age < 12 months, based on nonverbal scores from the Mullen Scales of Early Learning (Mullen, 1995).Table 2 shows the mean and standard deviations for age equivalent scores on the MSEL for participants in this study, completed at the pre-intervention assessment. (The MSEL is described below.)

Children had diverse ethnic and racial backgrounds, as shown in Table 1. All participants were enrolled in special education preschool programs. In addition to their regular preschool services, they received one of two early childhood interventions, both aimed at improving communication and spoken language. Sessions were researcher-implemented and primarily delivered in the school setting. Therapists used a range of established behavioral strategies and developmentally based treatment techniques to teach social communication and spoken language including, but not limited to, preparing the environment, modeling and prompting communication. For the current study, we combined the two intervention groups because our aim was to examine the sensitivity of the CCS for detecting change and not to compare interventions.. On average, children received 87 hours (*SD* = 12 hours) of intervention over 6 months. Each participant was assessed before and after the 6-month intervention period.

Measures.

Pre-and post- intervention scores were compared from the following measures:

Mullen Scales of Early Learning (MSEL, 1995)--Expressive Language subscale. The MSEL is a standardized and norm-referenced test of early learning for children from birth through 68 months of age. It is comprised of several subscales. In this study we analyzed raw scores from the expressive language scale. The MSEL has been used to measure treatment outcomes in previous studies of children with ASD (Flanagan, Perry, & Freeman, 2012; Green et al., 2010; Kasari, Paparella, Freeman, & Jahromi, 2008).

Rates of Communication. The *Early Social Communication Scale (ESCS;* (Mundy et al., 2003) was administered to each child before and after intervention, by an experimenter who was not familiar to the child. In the ESCS, a series of activities are presented over approximately 20 minutes, and each activity provides opportunities for participants to request or comment. For example, a clear jar with an enticing toy is presented to the child. The experimenter waits to see if the child communicates about the toy or about wanting the toy. In addition, the experimenter asks open-ended questions such as "What should we do next?" Rates of communication recorded during the ESCS have reportedly changed in response to intervention (Anagnostou et al., 2015; Howlin, Gordon, Pasco, Wade, & Charman, 2007)

Communication acts observed during the videotaped ESCS interactions were coded by trained observers in the UCLA lab who were blind to the assessment timing (i.e., pre vs post intervention). Rates of initiating joint attention (IJA) and initiating behavior regulation (IBR) communication were coded. IJA behaviors include child eye contact, pointing, giving, showing, and spoken language used to initiate shared attention to the objects or event. IBR behaviors include eye contact, reaching, giving, pointing and spoken language used to elicit assistance in obtaining an object, or object-related event. Rates for IJA, and IBR were determined by dividing the frequencies by the total assessment duration. The rate measures (as opposed to frequency) were used in analyses in order to account for the varying length of assessments.

Inter-rater reliability for rates of IJA and IBR were determined using intraclass correlation coefficients (ICC). ICCs were used because they directly measures agreement between raters of continuous or discrete scales (such as rates). Prior to scoring the ESCS, coders were trained by a master coder using 10 to 20 practice videos. Each coder met established criteria of .75 interobserver agreement for IJA and IBR. The range of reliability scores for IJA was .77 to .97 with an average of .87. The range of ICCs for IBR was .76 to .97 with a mean of .90.

CCS scores. The CCS is a 12-point scale developed by Brady and colleagues (2012; 2018) to measure expressive communication that is primarily nonverbal. It is the primary outcome variable in this study because we wanted to demonstrate that CCS scores changed over time and in association with intervention. The scale spans from behaviors that indicate environmental awareness through word (or symbol) combinations. Higher scores reflect more complex behaviors (e.g., gesture-vocal combinations) and clear directionality in behaviors. A score of 0 indicates no response, while a score of 1 indicates alerting behavior. Scores of 2 through 5 indicate pre-intentional communication increasing in complexity. Scores of 6 or higher indicate intentional behavior, with a 6 indicating a triadic orientation, 7 and 8 indicating dual orientation with one or more gestures or vocalizations, and 9 and 10 indicating triadic orientation with one or more gestures or vocalizations. For example, vocalizing and pointing while looking back and forth at a communication partner would receive a score of 10. Scores of 11 or 12 reflect symbolic communication, with 11 indicating a single word spoken, signed, or selected on an AAC device, and 12 indicating a multiple word phrase. The complete scale is presented in Appendix A.

Following training by the first author, two research assistants at UCLA completed CCS coding. A total of 13 activities from the video-recorded ESCS were scored for each participant at each time point (pre and post intervention). The 13 tasks included 3 opportunities to request wind-up toys, 1 request for a pull toy, 1 request for balloon, 2 requests for help opening a plastic jar, request for ball, opportunities to comment about a car toy, hat and glasses worn by the experimenter, combing hair, and joint book reading . We did not score the following tasks from the ESCS because of low reliability in identifying initiated communication acts: gaze following task, songs and tickle.

The research assistants were blind to whether a video was from pre- or post- intervention. The first step in coding was to identify the most complex communication act during each activity and assign a score between 0-12 to that act. If that communication was intentional (scoring a 6 or above), a function was assigned. The coder determined whether the function of the communication was Behavior Regulation (BR), such as obtaining help opening a difficult container, or Joint Attention (JA), such as pointing out a picture on the wall. Thus, each activity had a numeric score between 0-12 and scores above 6 also had an indication of BR or JA.

An *overall* score was calculated using the average of the top three scores. For example, if the three highest scores were an 11 for activity one, a 12 for activity seven, and a 10 for activity eight, the participant's overall score would be an 11. The rationale for using overall scores in analyses was that interactions were relatively short (approximately 30 minutes) and there was substantial intra-subject variability in responses to different items based on individual preferences. Thus, cumulative or mean scores could reflect interest in activities rather than communication skills.

Additionally, the highest scores for BR (topBR) and JA (topJA) were used in analyses comparing change in complexity of BR and complexity of JA. For example, if a participant's highest score with a function of JA was a 10, this score of 10 was used in analyses. Thus, for most participants, there were 3 CCS scores (i.e., overall, topBR and topJA). However, some participants had fewer scores if they did not use intentional communication, or only used intentional communication for one function.

Inter-rater reliability for CCS scoring was determined before and during scoring. Two researchers were trained by the first author to a criterion of 80% agreement for scores and functions before coding the videos used in these analyses. Additionally, 36% of the videos were independently coded by both researchers. The overall weighted kappa score was .821. 72.4% scores were identical and 86.6% were within one point of each other. Kappa is an appropriate index of agreement for CCS scores because scores of 1-12 can be considered as categorical variables.

Results

We first analyzed changes in widely used measures—MSEL scores, and rates of communication. Results from these measures provide a basis for comparison to our new measure, the CCS. We examined main effects for change over time in all participants from pre to post-intervention. See Table 3 for descriptive information about each of these variables.

MSEL. MSEL Expressive Language subscale scores from pre to post intervention were compared using a paired samples t-test. Results indicated a significant effect for time ($t(59) = 11.932$, $p<.001$, Cohen's $d=1.5404$ (95% CI: 1.1621 to 1.9127)) with about a 7-point increase in raw scores. See Table 3 for means and standard deviations.

Rates of Communication. We examined changes in rates of communication from pre to post intervention using paired sample t tests. For the outcome of rate of IJA, significant effects are observed for time ($t(59)=3.483$, $p=.001$, Cohen's $d=0.4497$ (95% CI: 0.1823 to 0.7136)) with a .28 increase in rate of IJA. For the outcome rate of IBR, there were no significant effects for time ($t (59)= 1.719$, $p=.091$, Cohen's $d=0.2219$ (95% CI: -.0352 to 0.4772)) with a .17 increase in means-- see Table 3.

CCS scores. Changes in three CCS outcomes were examined: *Overall* (i.e., average of the top 3 scores), TopBR, and TopJA. For the outcome of Overall CCS score, significant effects are observed for time (t (59)=6.703, p<.001, Cohen's d=0.8654 (95% CI: 0.5656 to 1.1598)) with a 1.2 increase. See Table 3 for means and standard deviations. CCS function scores also changed significantly over time. While CCS scores can range from 0 to 12, only scores of 6 or higher are categorized as BR or JA. Thus, not everyone who participates has a TopBR or TopJA score. Some do not demonstrate behaviors that lead to scores of 6 or higher, or may only do so for one function. For the outcome of Top BR, 58 individuals had data. Significant effects are once again observed for time (t (57) = 4.711, p<.001, Cohen's d=0.6186 (95% CI: 0.3351 to 0.8975)), with about a 1-point increase overtime. For the outcome of Top JA, 39 individuals had data. Significant effects are observed for time (t (38) = 2.817, p=.008, Cohen's d=0.4511 (95% CI: 0.1187 to 0.7781), with about a 1-point increase over time.

We also conducted a separate analysis of CCS change in individuals who did not demonstrate significant change on the.MSEL Expressive Language subscale. The purpose of this analysis was to see if CCS scores might be particularly informative in cases where change was *not* detected with a standardized metric. We categorized participants according to whether they demonstrated change on the MSEL Expressive Language subscale, operationalized as an increase of at least one standard deviation over the course of the intervention. The standard deviation in MSEL Expressive Language raw scores at pretest was 5.95.

Of the 60 participants in the sample, 24 did not change according to this criterion, and 36 did change. As expected, those that demonstrated significant change on the MSEL Expressive Language subscale also showed significant changes in CCS scores (Overall: t(35)=5.842, p<.001, Cohen's d=0.9737 (95% CI: 0.5710 to 1.3668), Top BR: t(34)=3.892, p<.001, Cohen's d=0.6579 (95% CI: 0.2877 to 1.0200), Top JA: t(25)=3.275, p=.003, Cohen's d=0.6413 (95% CI: 0.2129 to 1.0591)). Pertinent to the goals of this study however, we also found that those who did *not* demonstrate change on the MSEL Expressive Language subscale showed significant changes on two of the three CCS scores—Overall and Top BR (Overall: t(23)=3.462, p=.002, Cohen's d=0.7067 (95% CI: 0.2519 to 1.1492), Top BR: t(22)=2.671, p=.014, Cohen's d=0.5569 (95% CI: 0.1112 to 0.9917). Changes in Top JA were not significant: t(12)=0.413, p=.687, Cohen's d=0.1154 (95% CI: -0.4327 to 0.6585).

Figures 1 -3 illustrate changes for these 3 CCS scores.

Summary of Results. Across all 60 participants, significant changes over time were detected for the MSEL Expressive Language subscale raw scores, rate of IJA, and all three CCS scores. A comparison of effect sizes shows that the largest effect was detected with the MSEL Expressive Language raw score, followed by the CCS overall score (avg top 3). Similar effect sizes were found for the rate of IJA and the CCS BR and CCS JA scores. For the subgroup who did not show a significant change on the MSEL Expressive Language subscale, we were able to detect a significant change from pre- to post-intervention on CCS scores (Overall and TopBR).

Discussion

Results indicate that CCS scores are sensitive to change in children participating in a behavioral intervention. In addition, we compared these changes to changes in other scores. It is not surprising that the largest effect sizes were found for the MSEL Expressive Language subscale results. This sub-test includes 28 items and several items have multiple scoring options. Thus, the range of possible scores – and the ability to detect changes– is greater with the MSEL Expressive Language subscale than the 12-point CCS scale. Plus, early items are typically scored through caregiver report and caregivers may report more changes than seen in a direct observation. However, as expected, the MSEL Expressive Language subscale score was not sensitive for everyone and the CCS was able to detect significant changes in a subgroup who did not show significant changes in expressive communication on the MSEL Expressive Language subscale. A close examination of the early occurring items on the MSEL Expressive Language subscale shows a focus on vocal behaviors related to speech development, e.g., “Coos, chuckles, or laughs” or “vocalizes two-syllable sounds such as dada or baba.” Only 1 of the first 12 items addresses gesture use (i.e., item 10, “Plays gesture/language game.”), and none of the items address development of coordinated joint attention. Changes in coordinated attention and gesture use could be detected with the CCS but not with the MSEL Expressive Language subscale. Thus, it may be that the CCS is sensitive specifically to changes in these important prelinguistic behaviors.

We observed significant changes in most rate variables as well as CCS scores. The differences we observed in changes of rates of communication (i.e., significant changes for IJA but not IBR) could reflect greater emphasis on JA during intervention. The observed changes in IJA were small (mean increase of .28 per minute) but statistically significant. A change of .28 indicates that on average children produced about 3 more JA acts during the 30 minute observation after intervention. Any increases in IJA should be viewed as positive given that IJA rates are consistently reported to be low in autism, and that increases in IJA are predictive of improved language outcomes (Poon, Watson, Baranek, Poe, 2012). It should also be noted, however, that the rates of IBR were much higher at pre-intervention than rates of IJA, providing less room to grow.

Changes across both rate and CCS scores provide important complementary assessment data. Changes in CCS scores indicate that an individual is using more (or less) complex communication across timepoints, whereas changes in rates indicate the sheer quantity of communication. Both of these measures may be useful for research and clinical practice. For research, it is important to know how intervention impacts both complexity and quantity of communication. It is plausible that some interventions may lead to relative gains in either complexity or rate, but not both. For clinical purposes, it is also important to gain more complete information about how an intervention relates to changes in these two aspects of communication. For example, clinical communication goals for individuals with minimal verbal skills often target acquisition of specific skills such as use of intentional communication or use of AAC. Use of the CCS at various points during intervention could indicate the degree of impact for a particular individual. Communication complexity scores and rate data can be used to reflect how much the student or client is changing in the quality and amount of communication behaviors.

<u>Future Directions.</u> The current study used the CCS to code communication observed in a video recorded interaction. Video recorded assessments are valuable because they allow repeated viewings and discussion of differences in scores. However, coding from video also requires extra time. Current efforts are underway to use the CCS to code naturally occurring communication with live observations in contexts such as classrooms, playgrounds, and lunchrooms. Data from these contexts would provide additional information about communication outside of a scripted assessment context. In addition, scoring live observations would increase the time-efficiency and flexibility, and hence the viability of the CCS as an outcome measure.

Developing additional methods to assess presymbolic and early symbolic communication is a critical need for research and practice. Results of this study indicate that the CCS is sensitive to changes associated with intervention, and that the changes parallel changes in MSEL Expressive Language subscale and rates of IJA. With the CCS, we were also able to show significant gains in communication in a subgroup that did not change significantly on the MSEL Expressive Language subscale. Hence, the CCS shows promise for detecting subtle but important changes in the communication of individuals with severe communication impairments. Further research with the CCS and other measures is needed to help fill the void of information about available tools for assessing communication in individuals who communicate with minimal verbal skills.

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Table 1

Ethnic and Racial Background of Participants

	Frequency	Percent
Asian	18	30.0
Black or African American	2	3.3
Hispanic	19	31.7
Native Hawaiian/other Pacific Islander	2	3.3
White	9	15.0
More than one race or ethnicity	9	15.0
Not disclosed	1	1.7
Total	60	100.0

Table 2. MSEL Subscale Age Equivalents in Months

Scale	Mean	*SD*
Visual Reception	26.32	7.92
Fine Motor	27.05	7.09
Receptive Language	18.68	8.13
Expressive Language	16.13	6.86

Table 3. Descriptive data obtained pre-and post-intervention.

	Pre-intervention		Post-Intervention	
Variable	Mean	SD	Mean	SD
MSEL ELC raw	15.93	5.934	23.12	7.495
Rate of IJA	0.34	0.370	0.62	0.629
Rate of IBR	1.05	0.716	1.22	0.690
CCS Overall (Avg. top 3)	9.02	1.713	10.36	1.749
CCS top JA	9.34	2.232	10.36	2.030
CCS top BR	9.69	1.764	10.71	1.619

Figure Captions

Figure 1. Changes in Overall CCS scores from pre- to post-intervention in individuals who changed or did not change by a standard deviation on the MSEL Expressive Language subscale Scales of Early Learning, Expressive Language subscale. Error bars indicate 95% confidence intervals.

Figure 2. Changes in TopBR scores from pre- to post-intervention in individuals who changed or did not change by a standard deviation on the MSEL Expressive Language subscale Scales of Early Learning, Expressive Language subscale. Error bars indicate 95% confidence intervals.

Figure 3. Changes in TopJA from pre- to post- intervention in individuals who changed or did not change by a standard deviation on the MSEL Expressive Language subscale Scales of Early Learning, Expressive Language subscale. Error bars indicate 95% confidence intervals.

Figure 1: Overall CCS Score Change by Group

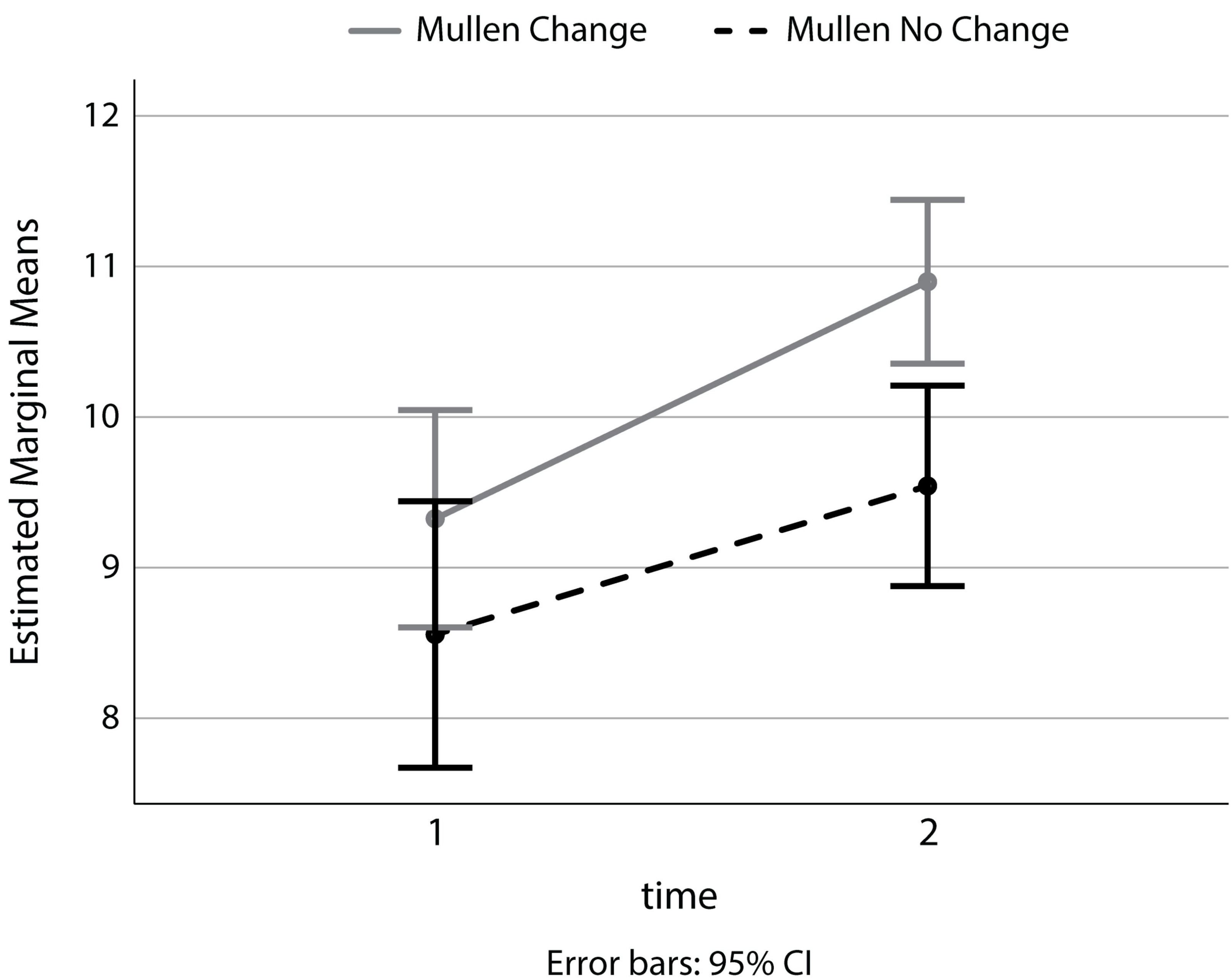

Figure 2: Behavioral Regulation Change by Group

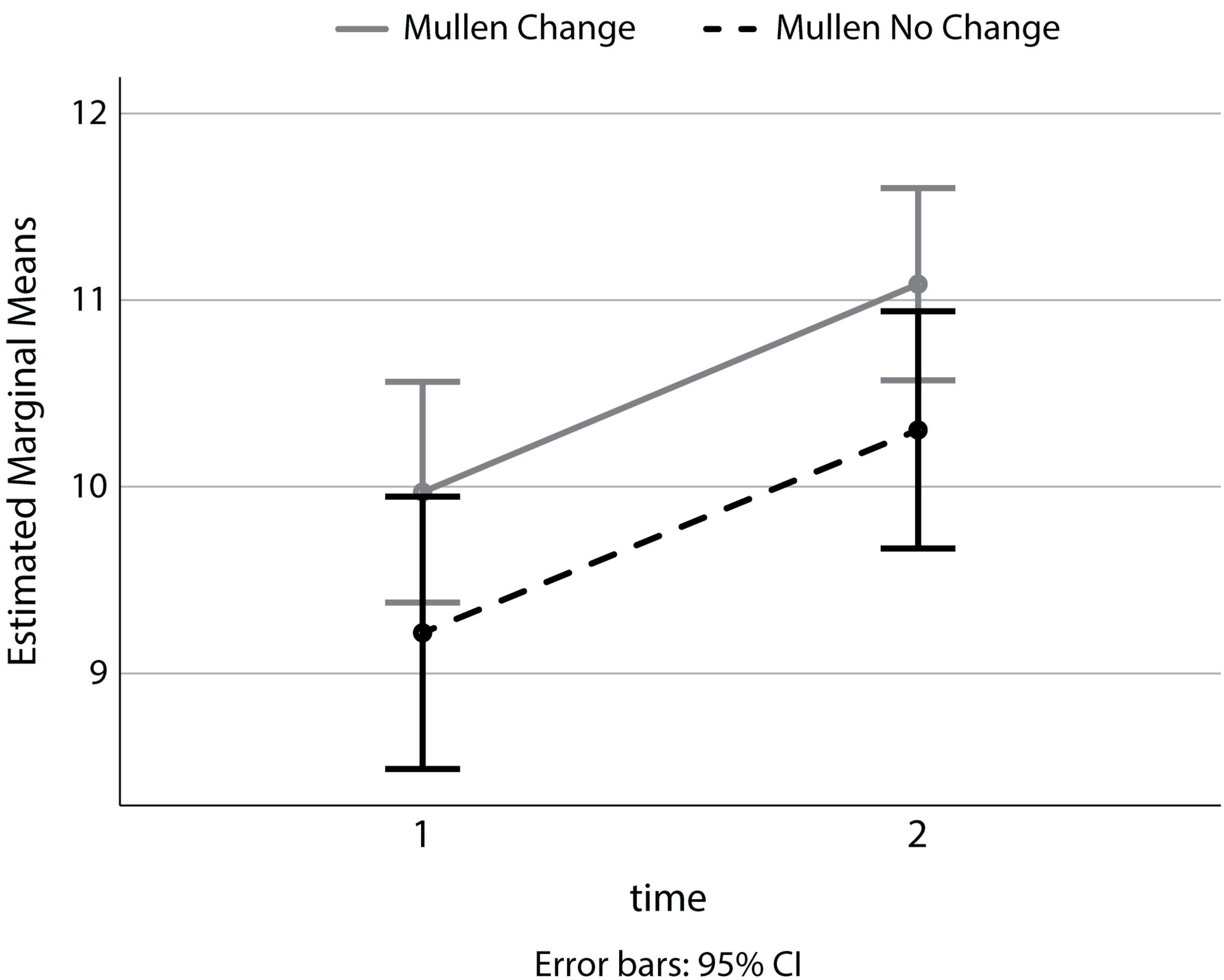

Figure 3: Joint Attention Change by Group