Clifford, S., Hudry, K., Brown, L., Pasco, G., **Charman, T.** & the PACT Consortium (2010). The Modified – Classroom Observation Schedule to Measure Intentional Communication (M-COSMIC): evidence for reliability and validity. *Research in Autism Spectrum Disorders, 4,* 509-525.

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The Modified – Classroom Observation Schedule to Measure Intentional Communication (M-COSMIC): Evaluation of Reliability and Validity

Sally Clifford

Institute of Psychiatry, King's College London

Kristelle Hudry

Department of Psychology and Human Development, Institute of Education

Laura Brown

UCL Institute of Child Health

Greg Pasco

Autism Research Centre, University of Cambridge

Tony Charman

Department of Psychology and Human Development, Institute of Education

and the PACT Consortium

Text word count: 7,207

Abstract

The Modified – Classroom Observation Schedule to Measure Intentional Communication (M-COSMIC) was developed as an ecologically valid measure of social-communication behaviour, delineating forms, functions, and intended partners of children's spontaneous communication acts. Forty one children with autism spectrum disorder (ASD) aged 48 to 73 months were filmed within small-group settings at school. Communication behaviours during a five-minute teacher-led activity and a 10-minute free play session were coded from video-tape. Inter-rater reliability was high. Many M-COSMIC codes were significantly associated as predicted with Social and Communication domain scores on the Autism Diagnostic Observation Schedule (ADOS) and with scores on standardised language assessments. Agreement was more variable, however, at the level of individual M-COSMIC codes and ADOS items. Higher rates of responding, compliance behaviours and following pointing gestures and gaze occurred during the more structured teacher-led activity, compared to the free play. Results demonstrate preliminary construct validity of the M-COSMIC, showing its potential to describe and evaluate spontaneous social-communication skills in young children with ASD for research and applied purposes.

[Word count = 167; Limit = 200]

Keywords: Autism spectrum disorders, Observation, Ecological validity, Social Communication, School, Measurement

Role of funding source: The sponsor of the study had no role in study design, data collection, data analysis, data interpretation or writing of the report.

Conflicts of interest: None.

1. Social and communication impairment in ASD

While social and communication impairments are core features of autism spectrum disorders (ASD; American Psychiatric Association, 2000; World Health Organisation, 1993), wide variation is present. Some individuals with ASD make their needs known only through non-specific vocalizations or the instrumental use of others' bodies, whereas others develop fluent and age-appropriate levels of speech. Along with variation in such *forms* of communication, the *functional* and *social* uses of communication – pragmatics – are also significantly impaired in ASD (Wetherby, 1986). While very low-functioning children may demonstrate little spontaneous verbal communication, frequently, these youngsters can communicate for the purpose of behaviour-regulation, making requests or responding through protest (Wetherby, Yonclas, & Bryan, 1989). Impairments are more readily apparent in the frequency and quality of communication bids for the purposes of sharing experiences and interests with others (e.g., signaling enjoyment and establishing joint attention; Leekam, Lopez, & Moore, 2000; Mundy, Sigman, & Kasari, 1990; Sigman, Mundy, Sherman, & Ungerer, 1986). Wetherby (1986) proposed a model for the ontogeny of communicative functions in children with ASD. The suggestion is that, unlike the synchronous development seen in typically developing children, children with ASD display an uneven pattern of communicative development, in the following predictable sequence: regulation of behaviour (e.g., protesting and requesting), followed by dyadic social interaction (attracting and maintaining attention to oneself; e.g., showing off, social routines), and finally directing another's attention to an object or event (joint attention; e.g., commenting and requesting information). Empirical research using both cross sectional and longitudinal designs has been found to support this model (e.g., Curcio,

1978; Stone & Caro-Martinez, 1990; Wetherby, Yonclas, & Bryan, 1989). Communication in ASD is therefore not only delayed but also deviant from the normal trajectory.

As core features of ASD, the forms and functions of social communication skills are a focus of many early intervention targets for young children. However, randomised-controlled trials in this area are relatively few (see, Lord et al., 2005; National Research Council, 2001; Rogers & Vismara, 2008; for reviews) and there is a shortage of appropriate measurement tools for outcome evaluation. The development and refinement of meaningful measures of social communication skills to test the effectiveness of such programmes is therefore essential.

2. Observational measures of social communication behaviours

While naturalistic observation is arguably the most representative form of assessment for evaluating social communication skills and conducting educational planning (Gerber, 2003; Spears, Tollefson & Simpson, 2001; Wetherby, Schuler, & Prizant, 1997), few such standardised instruments exist. Rather, current tools tend to evaluate the child's skills during a structured play setting, where an experienced examiner arranges specific activities, presses, and prompts, to provide opportunities for the child to demonstrate his or her abilities (or lack thereof, as for children with ASD). Such measures include the Early Social Communication Scales (ESCS; Mundy, Hogan & Doehring 1996); the Communication and Symbolic Behaviour Scales (CSBS; Wetherby & Prizant, 2002), or the Social Communication Assessment for Toddlers with Autism (SCATA; Drew et al., 2007). Originally designed as a diagnostic tool, the Autism Diagnostic Observation Schedule – Generic (ADOS-G, Lord et al., 2000) is one such structured assessment which has been incorporated as an outcome measure of social communication impairment in some psychosocial and biomedical treatment studies (e.g. Aldred et al., 2004; Unis et al., 2002).

Although providing valuable information on social communication skills, established instruments such as those listed above do not address children's functioning within real-world settings. As such, they have limited utility in informing the extent to which progress achieved in treatment might generalise outside of the specific intervention context (National Research Council, 2001). Moreover, at all levels of functioning, individuals with ASD have been found to show greater impairment during real-world social interactions than during assessment situations which provide structure and scaffolding (e.g., Wimpory, Hobson & Nash, 2007). Existing instruments therefore evaluate the skills of children with ASD in contexts that are more likely to be facilitative, rather than in contexts which might capture the true extent of functional impairment (e.g., during everyday interactions with peers). The need to develop such *direct* and ecologically valid measures is therefore clear.

A small number of such measures do exist, but are too limited to successfully capture the full range of skills pertinent to the evaluation of social communication in children with ASD. For example, Carr and Felce (2007) developed a naturalistic measure to assess effectiveness of a Picture Exchange Communication System (PECS) intervention. However, only interactions between child-adult dyads were evaluated, and the researchers did not delineate the functions of communication bids observed. Roos, McDuffie, Weismer and Gernbacher (2008) conducted a comparative study of child skills used across a structured clinic assessment and a naturalistic home play session. Again, only examiner-child interactions were observed, and this evaluation pertained only to non-verbal joint attention bids rather than a broader range of possible social communication behaviours. Using a more comprehensive measure designed to evaluate various *forms*, *targets*, and *functions* of communication bid (Watson, Lord, Schaffer, & Schopler, 1987), Stone and Caro-Martinez (1990) found children with autism to communicate only 3 to 4 times

per hour in unstructured environments. Furthermore, they found that three low-level communicative functions (i.e., attention seeking, engaging in social routines, and requesting) accounted for around 60% of the children's total communication bids, while four high-level functions (i.e., giving and seeking information, expressing feelings, and engaging in social interactions) accounted for only 10% of all bids. However, this measure was restricted to evaluating children's spontaneous *initiations* of communication, ignoring any response behaviours.

Very few studies have included any assessment of peer interaction. McGee, Almeida, Sulzer-Azaroff and Feldman (1992) evaluated three young children with ASD interacting with their teachers and peers. While two forms of communication (gestural and verbal) and two broad facets of communicative function (initiations vs. responses; and positive vs. negative interactions) were delineated, the researchers only reported on the initiation and responding behaviours of their participants. Another such instrument, the Social-Communication Assessment Tool (S-CAT; Murdock, Cost & Tieso, 2007), measures social communication in four distinct areas: verbal initiations, verbal responses, joint attention acts, and non-verbal communication attempts. While useful in its inclusion of evaluation of peer interaction in everyday settings, this instrument similarly lacks the detail required for comprehensive measurement of those aspects of social communication frequently affected in youngsters with ASD (i.e., delineation of both the forms and functions of acts, along with specification of identity of the interaction partner and the child's own role in the interaction).

Although a few naturalistic social-communication measures have been developed for use with language impaired pre-schoolers without ASD (e.g., Kliewer, 1995; Roberts, Burchinal &

Bailey, 1994), the lack of comprehensiveness in such tools is also apparent. Kliewer (1995) employed qualitative methodology but provided only descriptive data on the use of the children's pragmatic communication in inclusive school settings. Roberts et al. (1994) assessed communication in unstructured play settings but only considered communicative form in terms of the number of different words used by children and their mean length of utterance. The need for a comprehensive tool evaluating forms, functions, roles, and social partners across a range of everyday settings remains.

3. Development of the COSMIC and rationale for modification

Recognising this need, Pasco, Gordon, Howlin and Charman (2008) recently developed the Classroom Observation Schedule to Measure Intentional Communication (COSMIC) to assess effectiveness of a PECS intervention (Howlin, Gordon, Pasco, Wade, & Charman, 2007). COSMIC sampled the behaviour of (mainly) non-verbal, low-IQ children with autism in special education classrooms, across 15-minute periods of video-taped interactions. Codes included various forms and functions of communication, and delineated social interaction partners and the children's own roles within the communication acts. Unlike existing tools, COSMIC coding delineated each of these facets independently[1], considering both teacher and peer interaction. Pasco et al. (2008) assessed 91 children aged 4 to 11 during snack time and various other activities (including one-to-one and group teaching, free play, etc.). COSMIC codes were compared to ADOS-G item scores for the assessment of concurrent validity, with moderate to high correlations evident between some but not all corresponding items. COSMIC rates of *Initiation* acts and *Use of PECS* were found to be sensitive to change following implementation of the PECS intervention (Howlin et al., 2007). Predictive

validity of the new measure was demonstrated with a sub-sample of 28 children who were seen for ADOS-G assessment 15 months after their initial COSMIC evaluation (Pasco et al., 2008).

Although proving valid as a measure of social communication skills for children with ASD and useful for intervention outcome measurement (Howlin et al. 2007), the COSMIC (Pasco et al., 2008) was initially designed for use with low-functioning (mostly non-verbal) children in special educational settings. The current study undertook to revise the COSMIC to permit its use in evaluating the social-communication in children with ASD with more varied levels of functioning and language ability. Development of the Modified (M)-COSMIC is described, with evaluation of reliability and validity reported for the sample of verbally heterogeneous children with ASD.

4. Method

4.1 Development of the Modified – Classroom Observation Schedule to Measure Intentional Communication (M-COSMIC)

Revision of the COSMIC (approved by the Central Manchester Multicentre Research Ethics Committee 05/Q1407/311) was undertaken to increase its utility by providing a coding scheme and structure likely to elicit various types of form and function of social communication act. The original COSMIC sampled social communication across a variety of classroom activities (which were allowed to vary naturally across participants) as well as during the more structured setting of snack time. Coded data were then combined across available settings for the final analysis. Whilst standard across all participants, the snack setting arguably elicits lower-level instrumental/imperative communicative functions (i.e., requests and refusals), providing

only limited opportunity for higher-level functions of social interaction (i.e., joint attention and shared enjoyment). This setting was therefore omitted.

Standardisation was sought for the additional activities sampled. As group teaching and free play situations were considered likely to elicit different types of child communication behaviour (e.g., with responses more likely during a structured teaching period and initiations more likely during unstructured play), both a structured teacher-led activity and an unstructured free-play session were included within the modified behaviour sampling. A standard set of highly motivating toys was used so that each participant child with ASD would have similar opportunities and motivators for communication. Despite this standardisation, the group interaction remained naturalistic in that no specific instructions or presses were introduced by the teacher or researcher.

Event recording was retained as the method of coding behavior from session videotapes. Revisions of the original COSMIC coding structure were also undertaken. Modifications were made to the coding of the communication *forms* and *functions*, so as to reflect the potential abilities of higher-functioning and more verbally-able children. New codes evolved from those of the original COSMIC, review of the literature on social communication skills in ASD (e.g., Drew et al., 2007; Wetherby, 1986; Wetherby et al., 1989), and the results of pilot work. Communication functions were classified into three super-ordinate categories; *Behaviour Regulation, Dyadic Social Interaction,* and *Joint Attention* (Wetherby et al., 1989). *Forms* were extended to include non-verbal *Showing* and *Giving*. *Actions* directed toward an examiner (e.g., bringing and showing or 'dumping' an object, and proximal pointing) were considered forms of proto-joint attention (see Drew et al., 2007). Verbal *forms* were extended to include

Vocalisation/*Single Words* and *Phrase Speech*, so as to be more appropriate for children with broader-ranging abilities.

4.2 Participants

Participants were recruited upon completion of the Preschool Autism Communication Trial (PACT; http://www.medicine.manchester.ac.uk/pact/). PACT enrollment was based on referral by local UK service providers when children were aged between 2 and 5 years. Subsequent diagnostic confirmation was made using the ADOS-G and ADI-R (full cohort n = 152 preschoolers meeting instrument cutoffs for autism). Invitation to participate in the current study was extended to 45 families who completed their PACT involvement during the 10-month period of M-COSMIC data collection, and where the London-based research team could feasibly travel to conduct school visits[2]. One family and three schools declined consent to participate, resulting in a final sample of 41 children with ASD (38 males, 3 females) from diverse ethnic (n = 20 white, 15 black, 2 Asian, 1 Hispanic, and 3 mixed race) and family backgrounds (n = 32 dual-parent and 9 single-parent). Fourteen families had annual incomes less than £20,000; 13 earned between £20,000 and £40,000; 9 earned between £40,000 and £60,000; and 5 earned over £60,000.

4.3 Measures

At PACT intake, this subgroup were aged between 33 and 59 months (M = 45.2, SD = 7.6). Amongst a battery of measures, the non-verbal subscales of the Mullen Scales of Early Learning (MSEL, Mullen, 1995) were administered, yielding a non-verbal Developmental Quotient (DQ) for each child (the average of *visual reception* and *fine motor* age-equivalence scores/chronological age). Around 13 months later at PACT follow-up, the ADOS-G (Lord et al. 2000; Module 1 n = 30; Module 2 n = 11) and the

Preschool Language Scales-UK Edition (PLS-UK; Zimmerman, Steiner, & Pond, 1997) were administered. Parents were interviewed using the Vineland Adaptive Behavior Scales-II, Survey Form (VABS, Sparrow, Cicchetti, & Balla, 2005) and they also completed the MacArthur-Bates Communicative Development Inventory: Words and Gestures Form (MCDI; Fenson et al., 1993). Teachers completed the VABS-Teacher Rating Form (T-VABS, Sparrow, Cicchetti, & Balla, 2006). Administration and scoring of assessments was conducted by researchers independent of the M-COSMIC coding.

Table 1 summarizes the children's standardised scores from the PACT assessments, demonstrating heterogeneity in functional and language abilities within this sample. Whilst unbalanced in terms of the ADOS-G module administered, individual language abilities were varied and evenly distributed across categories of language ability. Specifically, examination of scores on ADOS-G item A1 (Overall level of non-echoed language) indicated that 12 children were non-verbal, eight used single-word speech, 11 used phrase speech, and 10 spoke in fluent sentences. Some children attended mainstream schools and nurseries while others attended facilities for children with special needs.

- Insert Table 1 –

M-COSMIC school-visits were completed as soon as practicable following PACT follow-up assessments (within 1 to 10 weeks thereof; $M = 5$, $SD = 2.5$), so as to permit evaluation of concurrent validity between M-COSMIC codes and the standardised assessment scores. Children were seen in their usual nursery/school settings when aged between 48 and 73 months ($M = 60$, $SD = 7.5$), with 31 attending mainstream settings and 10 at settings for children with special needs. Behaviour sampling was conducted in small groups which included the target child, one teacher or classroom assistant, and two familiar peers[3].

4.4 Procedures

Behaviour Sampling and Filming

Groups were filmed for around 15 minutes (M = 17.3, SD = 2.6), comprising a 5-minute teacher-led activity (ACT) followed by 10 minutes of free play (FP). Participating peers were classmates who had known the child with ASD for at least two months and whose parents had consented to filming. Participant teachers were either the regular classroom teacher or an assistant/support worker regularly involved with the child with ASD. Groups were filmed in a quiet location (e.g., an unused classroom, or whilst other classmates were outside) so that vocalizations could clearly be heard. The standardised set of highly motivating items provided by the research team comprised: (for use during the ACT) a colouring book with crayons and a large jigsaw puzzle; and (for use during the FP) a Jack-in-the-Box; two small cars; a slinky spring; two tubs of Play-Doh; a marble run; a plastic birthday cake with associated materials (candles, knife, etc.); a tea set (with cups, bowls, plates, etc.); a textured story book; a bubble gun with liquid; and two soft balls.

Minimal instruction was given to maintain naturalistic group interaction. Teachers were asked to first engage the children in the ACT before proceeding to FP[4]. For the ACT, teachers were asked to give instructions and feedback as they would in a typical focused classroom activity, whilst having the children complete the jigsaw or a page of colouring-in. For the FP, they were asked to allow the children to engage in relatively unstructured play, encouraging involvement of all the children but minimising direct instruction. Teachers understood that the aim was to observe the child with ASD in his/her natural setting. While any interruptions to the protocol were noted, filming was continued as normal, with the exception of two cases where the

child with ASD required a toilet break, at which time filming was paused and resumed upon the child's return.

Behaviour coding

Coding was conducted from videotapes using the modified coding scheme (presented in Table 2). (For orthogonal coding categories, the full record form, and operational definitions of behaviours, see Appendix). Prior to analysis, event recorded behaviours were transformed into rates-per-minute to allow for slight variations in the duration of filming for each child.

- Insert Table 2 –

4.5 Assessment of concurrent validity

Concurrent validity of the M-COSMIC was investigated by comparing scores on the broad M-COSMIC coding categories for *form*, *function*, and *role* with the Communication and Social Interaction algorithm scores on the ADOS-G. Positive associations were also predicted between the following *specific* codes and items (or item combinations):

1. M-COSMIC rates of *Initiated Vocalisation/Single words* and *Phrase Speech* and ADOS-G item Overall Level of Non-Echoed Language;
2. M-COSMIC rates of *Gesture/Point* and ADOS-G items Pointing and Gestures;
3. M-COSMIC rates of *Eye Contact* and ADOS-G item Eye Contact;
4. M-COSMIC rates of *Follows Gaze/Point* and ADOS-G item Response to Joint Attention;
5. M-COSMIC rates of *Show/Give* and ADOS-G item Showing[5];
6. M-COSMIC rates of *Initiating Joint Attention* and ADOS-G item Spontaneous Initiation of Joint Attention; and
7. M-COSMIC rates of *Request Object/Action* and ADOS-G item Requesting (for the subsample of children for whom Module 1 had been administered; $n = 30$).

To demonstrate specificity of the new measure, comparison was made between M-COSMIC broad codes and the ADOS-G Restricted Interests/Stereotyped Behaviour algorithm total, with the expectation that no significant associations would be apparent.

The following modifications to the ADOS and M-COSMIC scoring systems were also adopted:

1. ADOS-G item and algorithm scores were reversed to permit greater ease of comparison with the M-COSMIC rates of social communication, with higher scores thereby representing greater ability on both measures.

2. To further permit meaningful comparison, some ADOS-G item scores were simplified. For example, Overall Level of Non-Echoed Language was transformed into a 3-point ordinal scale, with resultant scores indicating no words (original score of 8, recoded to 0), single words (original scores of 3 and 2 combined and recoded to 1), and phrases (original scores of 1 and 0, combined and recoded to 2), thereby paralleling the coding options available on the M-COSMIC. ADOS-G Requesting, Showing, Spontaneous Initiation of Joint Attention, and Response to Joint Attention were all recoded into 2-point binary items so as to similarly facilitate comparison with the relevant M-COSMIC codes. For example, in examining ADOS-G Response to Joint Attention, we were interested in whether children responded to the examiner's gaze or point (original scores of 0 and 1 combined and recoded as 1) or did not do so (original scores of 2 and 3 combined and recoded as 0). The two ADOS-G items Pointing and Gestures were reversed scored and then combined to permit comparison with the M-COSMIC code which similarly combines these forms.

3. We also combined rates of the M-COSMIC function of *Initiation* within certain communicative forms (i.e., Language, Joint Attention), in order to permit more meaningful comparison with relevant ADOS-G items which combine these forms and functions together.
4. We also compared the broad category M-COSMIC codes with the standardised language/communication measures. MCDI receptive and expressive raw vocabulary counts, and communication domain Standard Scores (SS) from the VABS and T-VABS showed good spread within this sample, and as such, were employed as appropriate metrics for comparison. Receptive, expressive, and total SS from the PLS were not considered useful, however, due to lack of sensitivity for preschoolers with autism and very low verbal ability (i.e., with an artificial floor at SS = 50) of 22 children in the current sample. By contrast, age-equivalence (AE) scores showed good spread, and these were therefore employed for comparison of the M-COSMIC with this measure.

4.6 Assessment of cross-contextual agreement

As the spontaneous communication behaviours of children with ASD were considered likely to differ across activity settings, with different types of behaviour more or less easily promoted by a structured teacher-led ACT vs. FP, comparison of the various M-COSMIC form, function, role and partner codes across the ACT and FP settings was conducted. Arising differences would provide information about the sampling context on child social communication acts, validating the decision to sample more than one context systematically across all children in modification of the original COSMIC protocol.

5. Results

5.1 Assessment of inter-rater reliability

Coding was conducted by the primary M-COSMIC developer (SC) and a second researcher (LB) who received approximately 25 hours of training in use of the instrument. Footage collected for a child was allocated to one of the two raters for primary coding. In conducting a formal inter-rater reliability (IRR) check, the two raters also independently double-coded around 50% of all tapes (n = 20). While both were aware of the aims of the study, neither was aware of the children's scores on the standardised clinic measures. IRR was calculated using intra-class correlation coefficients (ICCs; see Table 3). Resultant ICCs were good, above 0.66 (p's < .001) and with the majority above 0.84. This was with the exception of some codes for *Compliance*, *Action*, and *Follow gaze/point*. However, given that high reliability was demonstrated in one of the two activity settings (*Compliance* FP, r = .54; *Action* FP, r = .68; and *Follow gaze/point* ACT, r = .89), these coding categories were retained.

- Insert Table 3 –

5.2 Association with non-verbal DQ

The majority of M-COSMIC codes were significantly associated with children's non-verbal DQ, with the exception of two *behaviour regulation* functions; *show off/attention seek* and *eye contact*. The significant correlations ranged from r = .37 (*Action*) to .73 (*Joint attention*), with a mean association of r = .52. As such, associations among M-COSMIC codes and other items were sought with the effects of DQ removed. While some item distributions were negatively skewed, results obtained through use of parametric and non-parametric statistics did not differ. Parametric analyses are therefore presented so as to permit the more straightforward control for DQ through the use of partial correlations.

5.3 Associations between M-COSMIC and ADOS-G

Table 4 presents correlation coefficients between the rates of broad M-COSMIC coding categories for form, function, and role and the children's scores on the ADOS-G. Bonferroni correction applied for multiple comparisons resulted in adoption of a significance level of $p \leq .002$. Higher rates of M-COSMIC verbal forms were associated with less severe ADOS-G Social Interaction algorithm scores. Rates of M-COSMIC non-verbal communication forms were similarly associated with better ADOS-G Communication and Social Interaction scores. Rates of M-COSMIC act for *Behaviour Regulation* function were also associated with better ADOS-G Communication and Social Interaction scores. There was no such association, however, for rates of M-COSMIC acts for either *Social Interaction* function or *Joint Attention* function. Similarly, while higher rates of M-COSMIC *Initiations* were associated with better ADOS-G Communication and Social Interaction scores, no such association was apparent for rates of M-COSMIC *Responses*. Specificity of the M-COSMIC codes was evidenced in the lack of any association among the aforementioned M-COSMIC codes for form, function, or role, with the ADOS-G Stereotyped Behaviours/Restricted Interests algorithm scores.

- Insert Table 4 -

Examination of associations between M-COSMIC code and the respective ADOS-G *item* (or item combinations) yielded less consistent results than for the algorithm totals. Due to the a priori specification of these comparisons, no correction was made for multiple comparisons, with $p < .05$ adopted as the criterion. M-COSMIC rates of *Initiated Vocalisation/Single words* were associated with ADOS-G item Overall Level of Non-Echoed Language, $r = .35$, $p = .027$. By contrast, M-COSMIC rates of *Initiated Phrase Speech* showed no such association with this ADOS-G item, $r = .28$, $p = .08$. M-COSMIC rates of *Gesture/Point* and the combined ADOS-G items of Pointing and Gestures were also correlated, $r = .42$, $p = .006$. It was not possible to

examine associations of M-COSMIC rates of *Eye Contact* with the ADOS-G item Eye Contact, nor the M-COSMIC rates of *Request Object/Action* with ADOS-G Requesting due to lack of variability in the ADOS-G scores for these items (with almost all children at floor on Eye Contact and at ceiling on Requesting). However, M-COSMIC rates of *Show/Give* were highly correlated with ADOS-G Showing[5], $r = .49$, $p = .001$. There was no association, however, between M-COSMIC rates of *Follows Gaze/Point* and ADOS-G item Response to Joint Attention, $r = -.05$, $p = .77$, nor between M-COSMIC rates of *Initiating Joint Attention* and ADOS-G item Spontaneous Initiation of Joint Attention, $r = .26$, $p = .11$. Thus at the specific M-COSMIC and ADOS-G item level, associations were mixed and were generally stronger for the non-verbal items than the verbal items.

5.4 *Associations between M-COSMIC and standardised language assessments*

Table 5 presents correlation coefficients between various rates of broad coding categories of M-COSMIC forms, functions, and roles and children's scores on the standardised language assessments. Bonferroni correction was applied for multiple comparisons, with resultant adoption of a significance level of $p \leq .001$. Higher rates of M-COSMIC *verbal* forms (i.e., *vocalisations*, *single words*, and *phrase speech*) were associated with better parent- and teacher-reports of adaptive communication, higher expressive vocabulary counts, and better performance on the PLS for both comprehension and expression. Rates of M-COSMIC non-verbal communication forms (i.e., *gestures/pointing*, *actions*, *eye contact* and *gaze switching*, *following another's gaze/point*, and *showing/giving* acts) were only significantly associated with expressive vocabulary counts.

Rates of M-COSMIC act for *Behaviour Regulation* function were not associated with any of the standardised language measure scores. Higher bids for *Social Interaction* function were

associated with higher expressive vocabulary counts and greater parent-reported adaptive communication. Higher rates of M-COSMIC act for the function of *Joint Attention* were associated with better scores on both the comprehension and expression subscales of the PLS, as well as with expressive vocabulary count. Rates of M-COSMIC *Initiations* were positively associated with almost all standardised language measures, such that more frequent initiators tended to achieve higher language and communication scores (with the exception of teacher-rated functional communication). Finally, associations regarding M-COSMIC *Responses* were less robust, but present for parent- and teacher- reports of adaptive communication and parent report of expressive vocabulary.

– Insert Table 5 –

5.5 Assessment of cross-contextual agreement

Paired samples *t*-tests were used to compare rates of different M-COSMIC codes across the ACT and FP settings. Bonferroni correction applied to correct for multiple comparisons resulted in the adoption of $p \leq .002$ significance level. Figure 1 presents the mean rate-per-minute of child communication acts toward the different possible partners; teacher, other adult, peer, and the whole group. Across both sampled contexts, significantly more communication acts were directed toward teachers ($M = 3.58$, $SD = 1.72$) than toward peers ($M = 0.71$, $SD = .82$), $t(40) = 10.10$, $p < .001$. While significantly more communication acts were directed toward the teacher during the ACT ($M = 4.31$, $SD = 2.04$) than during the FP ($M = 3.23$, $SD = 1.79$), $t(40) = 5.22$, $p < .001$, no such discrepancy was apparent for any of the other partners.

Figure 2 shows the mean rate-per-minute of the three M-COSMIC coded *Roles* (i.e., *Initiations*, *Responses*, and *Non-Interactive behaviours*) across the ACT and FP sessions. Initiations occurred with similar frequency in the ACT and FP settings, $t(40) = -1.63$, $p = .11$ (*M*

= 1.96, *SD* = 1.71 vs. *M* = 2.30, *SD* = 2.21, respectively), as did *Non-Interactive* acts, *t* (40) = 2.66, *p* = .011 (*M* = .90, *SD* = .81 vs. *M* = .65, *SD* = .66, respectively). *Responses*, however, occurred significantly more frequently during the ACT (*M* = 2.46, *SD* = 1.43) than during the FP (*M* = 1.56, *SD* = 1.09), *t* (40) = 6.26, *p* < .001.

- Insert Figures 1 and 2 -

Figure 3 presents the mean rate-per-minute of various communication functions coded in the M-COSMIC (i.e., requests, protests, etc.) across the ACT and FP sessions. Rates of specific coding categories were relatively low (most means < 1 per minute). Paired comparisons indicated that most communicative functions did not differ across the two sampled contexts. This was with the exception of *Compliance*, with children showing higher rates of *Compliance* and in the ACT (*M* = .42, *SD* = .38) than during the FP (*M* = .22, *SD* = .25) setting; *t* (40) = 3.71, *p* = .001.

Figure 4 presents the mean rates-per-minute of the various communication *Forms* coded in the M-COSMIC (i.e., vocalization, use of speech, gestures, etc.), across the ACT and FP sessions. Again, paired comparisons indicated most forms occurred equally often across the two sampling contexts. This was with the exception of the M-COSMIC code *Following another's gaze/point*, which was more common during the ACT (*M* = .46, *SD* = .50) than in the FP (*M* = .12, *SD* = .17), *t* (40) = 5.03, *p* < .001 (see Figure 4), and M-COSMIC rates of *Shows/gives*, which were seen more frequently in FP (*M* = .25, *SD* = .28) than in the ACT (*M* = .12, *SD* = .18), *t* (40) = -3.75, *p* < .01.

- Insert Figures 3 and 4 -

6. Discussion

This study reports on the modification of a naturalistic observation measure of social communication in young children with ASD. Data were collected during social interactions with a teacher and peers at school, and included two contexts: a teacher-led activity and an unstructured free play session. Concurrent validity of the M-COSMIC codes was evaluated through comparison of rates of behaviour at school with scores on an autism diagnostic measure and standardised language assessments. Additionally, evaluation of child behaviour across the two contexts of group activity and free-play informed the extent to which the specific behaviour sampling context might influence the results obtained by such a naturalistic observational measure.

6.1 M-COSMIC and ADOS-G

A number of strong associations were apparent between the M-COSMIC and ADOS-G algorithm total scores for communication and social interaction ability. Both *verbal* and *non-verbal* forms of communication were associated with the ADOS-G algorithm total scores for communication and/or social impairments. Inspection at the item level yielded a more modest pattern of associations, with some non-verbal forms such as gesturing, pointing, showing and giving being related to relevant ADOS-G items. Additionally, the ADOS-G item Overall Level of Non-Echoed Language was associated with M-COSMIC rates of *initiated vocalization/single words*. However, there was no such association between the former and M-COSMIC rates of *initiated phrase speech*.

With respect to functions and roles of communication, associations with ADOS-G were less clear. M-COSMIC rates of act for the function of *behaviour regulation* were highly associated with ADOS-G algorithm scores, as were rates of initiated communication. However, rates of act for the function of *social interaction* and *joint attention*, as well as rates of overall

response, showed no such association with ADOS-G overall scores. Furthermore, at the specific item level, there was no association between similar pairs of M-COSMIC and ADOS-G items evaluating neither the initiation of joint attention nor response to joint attention.

An 'imperfect' pattern of associations between the M-COSMIC and standardised diagnostic assessment could be due to at least two factors. Firstly, different definitions of joint attention are employed by the two instruments, with the ADOS-G requiring child direction to code *initiating joint attention* whereas the M-COSMIC also accepts *sharing of joint attention* here. Secondly, it should be remembered that behaviours of interest to each instrument are measured across different settings, involving different social partners and different levels of scaffolding provided for the child. The lack of association between items assessing response to joint attention may have been due to the provision of a hierarchical sequence of presses for this behaviour in the ADOS-G compared to the observation of naturally occurring (i.e., unprompted/pressed) behaviours in the M-COSMIC. However, clear specificity was shown in the complete lack of association of any broad M-COSMIC code with the ADOS-G *Stereotyped Behaviour and Restricted Interests* algorithm score.

6.2 M-COSMIC codes and standardised language measures

While *verbal* forms of communication measured by the M-COSMIC were shown to be highly associated with scores on most standardised language measures, rates of *non-verbal* communication use showed little association with language ability. Among the M-COSMIC communication function codes, an overall pattern emerged such that 'higher level' functions appeared to be more strongly associated with the standardised language scores than was the case for 'lower level' communication functions. Specifically, while no significant association was found between language scores and M-COSMIC rates of communication for *behavioural*

regulation, children with better language showed greater rates of communication for the purposes of *social interaction* and *joint attention*. This latter finding is consistent with literature suggesting concurrent association between joint attention skills and language development (e.g., Loveland & Landry, 1986; Mundy, Sigman, Ungerer, & Sherman, 1987; Mundy, Sigman, & Kasari, 1994), and suggests that such an association holds even when evaluating social communication behaviours across different settings (e.g., the school and the clinic).

M-COSMIC rates of *initiation* were strongly associated with scores on the standardised language measures. In contrast, associations between language ability and M-COSMIC rates of *response* were significant only with respect to parent and teacher reports of ability, but not the direct clinician assessment. Such a pattern may be explained by the fact that the M-COSMIC and parent and teacher reports of language evaluate functional and naturally-occurring communication behaviours, while a direct assessment by a clinician evaluates the language generated by specific presses in a contrived setting.

This broad pattern of results therefore indicates aspects of communication form, function and role that show robust associations with language ability, along with other aspects of communication that show more limited language association. This suggests a degree of independence of *verbal* and *non-verbal* communication forms, of functions *behaviour regulation, social interaction* and *joint attention*, and of roles of *initiation* and *response*, from one another (Drew et al., 2007; Wetherby et al., 1989). In this way, results yielded by the M-COSMIC are consistent with the literature on social communication in these children, thereby evidencing validity of this naturalistic observational tool. Furthermore, specificity of the new measure is also demonstrated, with a predictable pattern of associations evident among the

different rates of behaviour coded in the M-COSMIC and standardised measures of language taken elsewhere.

6.3 Cross-contextual differences in social and communication behaviours

Paired comparisons of M-COSMIC codes indicated largely similar rates of behaviour across the two contexts of teacher-led group activity and free-play, yet some important differences emerged. Communication bouts with teachers were more frequent during the structured activity session (greater than 4 times per minute) than during the free-play (around 3 times per minute). Children showed greater responding to others during the structured activity than during free play, complying more often with instructions in this former situation. This pattern of findings is likely to be explained by the fact that teachers were taking the lead in the structured activity and, as such, providing more direct instruction to the children. This would have resulted in greater number of child responses and acts of compliance to the teachers during this activity than during the free-play time. Thus, a more highly structured environment may be conducive of increased rates of responsive communication acts for children with ASD The rate of initiations per minute (approximately 2) was higher in the present sample than in the older but more impaired children involved in the original COSMIC study (approximately one initiation every 5 minutes; Pasco et al., 2008) and that seen using the observational schedule of Stone and Caro-Martinez (1990; approximately one every 15 minutes).

The joint attention response behaviour of following another's gaze/pointing gesture was also more commonly observed during the activity than the free-play setting. This further suggests that the structure promoted through high teacher involvement may facilitate increased response behaviour in children with ASD. As an example, teachers were regularly heard to ask direct questions of the children whilst leading the structured activity (e.g., asking "What's that?" whilst

pointing to pictures in the colouring book). This thereby provided many opportunities for children both to follow their pointing gestures and to provide a communicated response.

Interestingly, the acts of showing and giving were seen more frequently in the context of free-play than during the structured activity. This finding may have been due to the materials available and the reduced level of structure imposed by the teacher during this context. The toys available during free play were more varied and probably more exciting for the children than those used for the teacher-led activity, thereby affording greater number of opportunities for children to initiate joint attention with another person about a toy of interest. This differentiation of coded behaviours across the activity and free play settings therefore demonstrates sensitivity of the M-COSMIC to variation of types of social activity in the naturalistic settings for which it was designed; further supporting validity and usefulness of the measure.

6.4 Limitations of the study and measure

Despite the promising results from this initial evaluation of the Modified-COSMIC, the measure will require additional evaluation to establish its readiness for research or clinical use. In aiming to increase utility of the original COSMIC we investigated skills in children attending both mainstream and special needs school settings. Current sub-group sample sizes were insufficient to permit sub-analysis of communication behaviours by type of school setting or by child language level. However, given that communication behaviours in children with ASD are influenced by the characteristics of the involved partners, future consideration of such effects along with the effect of type of school setting (including teaching styles and specializations, or the ability level of participant peers) is important. Similarly, duration of the behaviour sampling may affect results. In the current study, sampling occurred over a 5-minute structured activity and 10-minutes of free play. Equivalence of sampling time across contexts may have changed

the pattern of results seen. Furthermore, increases in sampling time may have led to alterations in patterns of behaviour as children warmed up to the filming situation (or equally, became exhausted with the demand to stay in the filming space) and communication behaviours may have differed as a result.

Effects of teacher-directed structure and communication toward the child with ASD have been commented upon here but not directly evaluated through experimental modification of behaviour or through more focused evaluation and statistical control of effects on the child behaviour. Such evaluation was not the primary focus of the current study but may be of interest in the future. Similarly, evaluation of the M-COSMIC may benefit from the future inclusion of a control group of typically developing children or children with other (non-autism) developmental concerns (e.g. developmental language delay), so as to assess specificity of the current findings to ASD.

A limitation with the current M-COSMIC measure is its reliance upon frequency counts alone. Kazdin (1982) argues that much information can be lost when only quantitative measures of social communication are considered, and future development could benefit from the addition of qualitative measures. This would be particularly important in making the M-COSMIC applicable to even more verbally-able and high-functioning children with ASD whose difficulties may centre around the quality and appropriateness, rather than frequency, of their interactions with others. In order to provide more subtle evaluation of change over time in the skills of very low-functioning and non-verbal children, measures tapping duration of engagement of shared attention (e.g., see Aldred, Green & Adams, 2004) might be a valuable addition, as changes in these very early skills might be important starting points for intervention, before intentional communication can even meaningfully begin to be targeted.

Finally, motivation for the development of measures such as the COSMIC (Pasco et al., 2008) and its currently modified form has come largely from the need for sensitive tools to evaluate the change brought about by interventions, and further, the extent to which targeted change might generalize to real world settings. The COSMIC yielded promise in its original form, and while the current modifications suggest utility of this instrument to measure intentional communication in groups of children with ASD of wider-ranging abilities, the current study has not attempted to use the M-COSMIC as a measure of change in behaviour over time or following intervention. Furthermore, use of the M-COSMIC in a longitudinal study may enable observation and interpretation of developmental links between different functions of communicative act, along with comprehension of associations between such functions across measures, serving to clarify certain unexpected results from the current study. For example, weak associations between the M-COSMIC and ADOS joint attention behaviours might be shown to be stronger over time (or within higher-functioning subgroups of children).

Summary

The M-COSMIC showspromiseasanecologically valid measure of a child's early skills within a naturalistic classroom setting with a teacher and small group of peers. The current modification means that the measure is now more suitable for use in measuring social communication in children with ASD with a much broader range of verbal ability than was feasible with the original COSMIC (Pasco et al., 2008).The measure could be useful in providing additional information about a child's communication skills within the real world setting of the classroom, supplementing information collected in a clinical setting or via parent report. Such an instrument would have important uses both in research and applied practices. With further development, the M-COSMIC may be demonstrated to be a useful measure of treatment

outcome, particularly with respect to the evaluation of generalization to real world settings of skills which might be taught in a clinic or other one-to-one setting. Such a tool could also be useful to educationalists and school psychologists for use in evaluating progress and as the basis for future planning or teacher-mediated and peer-based interventions.

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Appendix – M-COSMIC Record Form and Definitions

M-COSMIC

Classroom Observation Record Form

Child study number: **Observation/visit:**

Observer: **Date:**

Communicative function		Role		Form	
	Behaviour regulation				**Speech**
Q	request object, action	**I**	initiation	**V**	vocalisation
T	refusal/protest			**S**	single words
C	compliance	**R**	response	**SS**	two word phrases
				SSS	three word+ phrases
	Dyadic social interaction	**N**	non-interactive/ no response		**Non-verbal**
RS	request social routine			**P**	picture/symbol/ sign/Makaton
SO	showing off/ attention			**X**	gesture/pointing
AK	acknowledge			**A**	action
	Joint attention			**E**	eye contact
J	comment, shared attention			**G**	gaze switch
RI	request information, clarification			**L**	looks to target
				SG	show/give

Context N.B. record onset/offset times		Communication partner	
		1	teacher/teaching assistant
T	group teaching/table activity	**2**	other adult/researcher
		3	other child
F	free play/unstructured	**4**	group

Definitions of M-COSMIC codes

Form	
Picture/Symbol/ Sign/Makaton	▫ The form of an interaction should be coded as picture/symbol if it involves the child giving or pointing to a symbol, picture, photograph, object of reference or other symbolic representation of an object, food item or activity
Speech	▫ Single words, short phrases and whole sentences should be coded as a single bout of speech. Ascribe relevant codes for single words; two-word phrases; and three word + phrases. ▫ Repetition of a sentence in short succession (for emphasis) should be coded as ONE bout of speech. E.g., 'It's a big red caterpillar, a *big* caterpillar'. ▫ Speech must be used with some apparent communicative intent ▫ Speech may include word approximations and speech of poor intelligibility as long as there is sufficient contextual information to identify what the child is saying (e.g. 'ba' while holding a ball)
Vocalisation	▫ Sounds that do not appear to have a speech-like quality, but that are being produced for apparently communicative purposes, should be coded as vocalisation. This may include crying, moaning or wailing, or laughing, <u>if</u> used with some apparent <u>communicative intent</u>
Gesture/Pointing	▫ This code includes head nodding and shaking, pointing, descriptive, demonstrative or instrumental gestures
Action	▫ This code covers a range of behaviours, including sitting down, reaching, walking, putting a toy in a box, etc ▫ Only code an action if it is part of communication (must always involve a partner). ▫ Actions can involve a response to a partner also (e.g., walking away, hitting out). Any manipulation of symbols, pictures or photographs should be coded as picture/symbol
Eye contact	▫ Child makes eye contact with another ▫ May be in response to another saying/ doing something
Gaze switch	▫ Child alternates gaze between object and person to establish social attention coordination. This must be a 3-point shift (in quick succession): object-person-object; or person-object-person.
Looks to target (follows point or gaze by shifting attention)	▫ The child looks to where another is pointing/ looking. ▫ This form is always coded as a response behaviour
Show or Give	▫ The child deliberately <u>hands</u> an object to a person or <u>orients</u> the object where it can be seen (for the purposes of sharing interest OR getting help, coded as a function)
Function	
Behaviour regulation	

Request for object/ action/ help	▫ Use this code for any communicative act where an object, toy, help with a toy etc., is requested, whether this is spontaneously initiated by the child or prompted by an adult ▫ In cases where a request has been made, and the communication partner asks for a repeat or rehearsal of the request, do not assign this code for subsequent requests
Refusal/Protest	▫ This code may be used to classify a range of behaviours from appropriate refusal to inappropriate screaming as a protest/ non-compliance. Acts used to refuse an undesired object or request, or a command for another to stop an undesired action should receive this code. ▫ E.g., crying, shouting, throwing, pulling away, pushing away.
Compliance	Acts of cooperation with communicator. Code when the child is following instructions/ firm suggestions (also within play**)** to carry out an action (e.g., pass me the pizza; child passes; sit down; child sits down)
Social interaction (dyadic)	
Request for social routine	▫ This code is used when the child makes a request for a game or activity that is clearly social or interpersonal in nature – such as tickling, hugging or other informal social routines ▫ Also use this code when the child is attempting to have the interaction continue (e.g., requests to be tickled a second and third time) ▫ This code may be used when the request is for a formal game or activity, for a game of chess, for example, but not where the child is simply requesting that the adult facilitates an activity that will not involve them, such as switching the computer on, or reaching a toy that is on a high shelf
Showing off/ Directing attention to self	▫ Acts used to attract another's attention to oneself ▫ Seeking attention or calling someone for play, love attention (Dore, 1977) e.g., 'Hey'; 'watch' to direct adult's attention; 'can I___?'
Acknowledgement	▫ Acts/verbal acts used to indicate notice of another person's previous statement or action; involves the child's focusing attention on or shifting attention to the interactant ▫ Yes/ Yep/ No/OK/mmmhhmm/ thanks responses to questions or utterances (e.g., 'Is this yours; Do you want to?') ▫ 'Done it'; 'Excuse me'; (if trying to get attention drawn to self and not object); sing song for attention to self
Joint attention (triadic)	
Comment	▫ Comment is coded when a child verbally or nonverbally refers to an event, object or action in order to share attention with a partner. ▫ This may include pointing out, or a verbal description of, a picture, object or event in order to direct another's attention to that object, event or topic.
Request information	▫ *Acts* used to seek information, explanations or clarifications about an entity, event or previous utterance; includes wh-questions and other utterances with a rising intonation contour ▫ It may also include requesting information or clarification. However, if a child is clearly making a request for the object in question, albeit indirectly, code as a request for object
Role	
Initiation	▫ Code initiation when the child spontaneously initiates an interaction. Initiation

	should not be coded when the communication partner clearly prompts the interaction verbally, physically, or otherwise ▫ Also code initiation when the child's response is a clear elaboration, contradiction or correction to the communication partner – e.g. The adult says, "There's your coat" and the child responds, "That's not my coat: *this* is my coat" (pointing to a different coat)
Response	▫ Code response when a child responds to an instruction, prompt, question, suggestion, or action (e.g. the child sits after being told to "sit down") of another. ▫ This code should be used even if the content of the child's response is incorrect (e.g., during a puzzle the teacher instructs the child to find the blue piece, but the child picks the red piece); or non-complaint (e.g., child says 'No' and slumps in chair)
Non-interactive/ No response	▫ Non-interactive is used when the child responds to an approach by withdrawing, avoiding further interaction, or responding in a non-meaningful or stereotyped manner ▫ This code may also be used to classify an *approach* by the child that is clearly not *interpersonal*, where for example they are attempting to take something from another person without looking at them or otherwise interacting with them; or where the child uses another's body as a tool to request something (code: Q,N,A) ▫ Non-interactive speech/vocalization is also used to classify examples of immediate echolalia, and should be paired with a code of speech. ▫ No response**.** This is used when the child does not respond in any way to a request, approach or prompt

A more detailed coding manual is available from the authors

Author Note

Sally Clifford, Institute of Psychiatry, King's College London, UK; Kristelle Hudry, Department of Psychology and Human Development, Institute of Education, London, UK; Laura Brown, UCL Institute of Child Health, London, UK; Greg Pasco, Autism Research Centre, University of Cambridge, Cambridge, UK; Tony Charman, Department of Psychology and Human Development, Institute of Education, London, UK; the PACT Consortium.

PACT consortium members: Jonathan Green[10] (Chief Investigator), Catherine Aldred[9, 10], Sam Barron[7], Barbara Barrett[3], Karen Beggs[8], Katy Bourne[10], Sarah Byford[3], Tony Charman[2], Julia Collino[4], Ruth Colmer[7], Anna Cutress[6], Tori Houghton[9], Patricia Howlin[3], Kristelle Hudry[2], Ann Le Couteur[6], Sue Leach[5], Dharmi Kapadia[10], Kathy Leadbitter[10], Helen McConachie[6], Wendy MacDonald[10], Andrew Pickles[10], Sarah Randles[7], Vicky Slonims[1, 3], Carol Taylor[9], Kathryn Temple[6], Lydia White[10].

[1]Guy's & St Thomas' NHS Trust; [2]Institute of Education London; [3]King's College London; [4]Lewisham PCT; [5]Mental Health Research Network; [6]Newcastle University; [7]North Tyneside PCT; [8]Southwark PCT; [9]Stockport PCT; [10]University of Manchester.

Acknowledgements: We are grateful to all the children, parents and teachers who took part in the study. We thank Kate Gordon for her advice on scoring the original COSMIC, along with Mary-Jo Doyle, Rebecca Rowles, and Rachel Whalley for their help with data collection. The M-COSMIC study was funded by Autism Speaks. The PACT study is funded by a UK Medical Research Council Grant to the Principal Investigators of the PACT Consortium (www.medicine.manchester.ac.uk/pact/).

Correspondenceto:Prof. Tony Charman, Centre for Research in Autism and Education, Department of Psychology and Human Development, Institute of Education, 25 Woburn Square, London, WC1H 0AA, UK.

t.charman@ioe.ac.uk

Footnotes

1 The ESCS and CSBS, for example, rate *combinations* of forms, functions and roles of social communicative behaviours (e.g., initiation of a joint attention bid through the form of showing).

2 All London-based families were approached. Some families based around Manchester and Newcastle-upon-Tyne were also approached, when it would be possible for researchers to conduct school visits in blocks of appointments in close succession.

3 In four instances, there was only one peer present, while in three cases, three peers were present for the M-COSMIC filming.

4 It was not possible to counterbalance presentation order of the ACT and FP as the latter was more motivating for children, and piloting revealed that children had difficulty relinquishing the FP toys for the ACT materials if presented in this order.

5 The M-COSMIC *Giving* code could not be included in this comparison since it is not measured in ADOS-G Module 2

Table 1. *Summary of child scores on standardised assessment measures taken at different PACT and M-COSMIC appointments.*

	M	***SD***	**Range**
Chronological age at PACT Intake[1]	45.2	7.6	33 – 59
MSEL non-verbal mental age	27.5	10.6	13 – 54
Developmental quotient	60.4	19.0	32 – 111
Chronological age at PACT Follow up	60.0	7.5	48 – 73
PLS-III-UK comprehension age equivalent	29.9	21.2	6 – 81
PLS-III-UK expressive age equivalent	29.2	16.5	11 – 82
PLS-III-UK total age equivalent	29.6	17.9	9 – 81
ADOS-G communication algorithm	5.0	1.8	1 – 8
ADOS-G social interaction algorithm	9.7	2.6	5 – 14
ADOS-G Total algorithm	14.8	4.2	6 – 22
ADI-R communication algorithm	12.8	3.1	4 – 20
ADI-R social interaction algorithm	18.4	3.5	12 – 26
ADI-R repetitive/stereotyped algorithm	5.8	2.4	0 – 10
ADI-R onset algorithm	4.1	0.9	1 – 5
Chronological age at M-COSMIC visit	60.0	7.5	48 – 73

[1] All ages are given in months

Table 2. *M-COSMIC Social Communicative Behaviour Codes*

Communication Partner	***Role***
Teacher /teaching assistant	Initiation
Other adult	Response
Other child	Non-interactive/no response
Whole group	
Communicative Function	***Form***
Behaviour regulation	Vocalisation (voc)/ Single words
Request object/action	Phrase speech (2 words+)
Refusal/protest	Gesture/pointing
Compliance	Action
Social Interaction	Eye contact
Showing off/attention	Gaze switch
Acknowledge	Follow gaze/point
Joint Attention	Show/Give
Comment, shared attention	
Request information	

Adapted from Pasco et al. (2008); Watson et al., (1987); Wetherby et al. (1988); Wetherby & Prutting (1984).

Table 3. *Intra-class correlations for each COSMIC item*

M-COSMIC code	*Activity ICC*	*Free Play ICC*	*Combined Settings ICC*
Form			
Voc/ Single words	.86	.96	.99
Phrase speech	.99	.99	.99
Gesture/pointing	.90	.98	.97
Action	.55	.68	.66
Eye contact	.95	.82	.89
Gaze switch	.89	.72	.79
Follow gaze/point	.89	.52	.90
Show/Give	.92	.93	.94
Communicative Function			
Request object/action	.93	.99	.96
Refusal/protest	.91	.76	.89
Compliance	.34	.54	.47
Showing off/attention	.96	1.00	.99
Acknowledge	.78	.76	.80
Comment, shared attention	.90	.90	.91
Request information	.71	.67	.69
Child's Role			
Initiation	.95	.99	.98
Response	.91	.87	.91
Non-interactive	.76	.85	.82

All correlations were significant at the level of $p < .001$ level with the exception of: *Compliance* (p's = .069; .006 and .015 respectively), and Follows point/gaze (free play $p = .007$)

Table 4. *Pearson product moment correlations (controlling for DQ) between M-COSMIC codes and ADOS-G algorithm total scores*

M-COSMIC	ADOS Algorithm Total Scores		
	Communication	Social Interaction	Restricted Interests/ Stereotyped Behaviours
Forms			
Verbal	.44	**.58***	.43
Non-Verbal	**.70***	**.59***	.26
Functions			
Behaviour Regulation	**.52***	**.64***	.16
Social Interaction	.20	.17	.28
Joint Attention	.39	.45	.35
Roles			
Initiations	**.57***	**.64***	.46
Responses	.27	.15	.18

N.B. All ADOS items and algorithm scores have been reversed (i.e., higher scores indicate lesser abnormality).

*$p \leq .002$

Table 5. *Pearson product moment correlations (controlling for DQ) between M-COSMIC codes and Standardised Language Assessment Scores*

	PLS Age Equivalence		MCDI Raw Vocabulary Count		VABS Communication Domain Standard Score	
M-COSMIC	Comp.	Expr.	Comp.	Expr.	Parent Report	Teacher Report
Forms						
Verbal	**.57***	**.53***	.48	**.65***	**.59***	**.51***
Non-Verbal	.45	.35	.49	**.62***	.44	.33
Functions						
Behaviour Regulation	.12	.22	.25	.37	.36	.25
Social Interaction	.42	.25	.38	**.52***	**.61***	.44
Joint Attention	**.63***	**.55***	.46	**.60***	.38	.41
Roles						
Initiations	**.64***	**.57***	**.51***	**.63***	**.53***	.39
Responses	.29	.21	.45	**.57***	**.52***	**.55***

*$p \leq .001$

Figure 1. Rates (per minute; mean (SE)) of child communication behaviours toward different *Partners* across the Activity and Free-Play settings

Figure 1. Rates (per minute; mean (SE)) of child communication behaviours for different *Roles* across the Activity and Free-Play settings

Figure 3. Rates (per minute; mean (SE)) of various communication *functions* across the Activity and Free-Play settings

Figure 4. Rates (per minute; mean (SE)) of various communication *forms* across the Activity and Free-Play settings

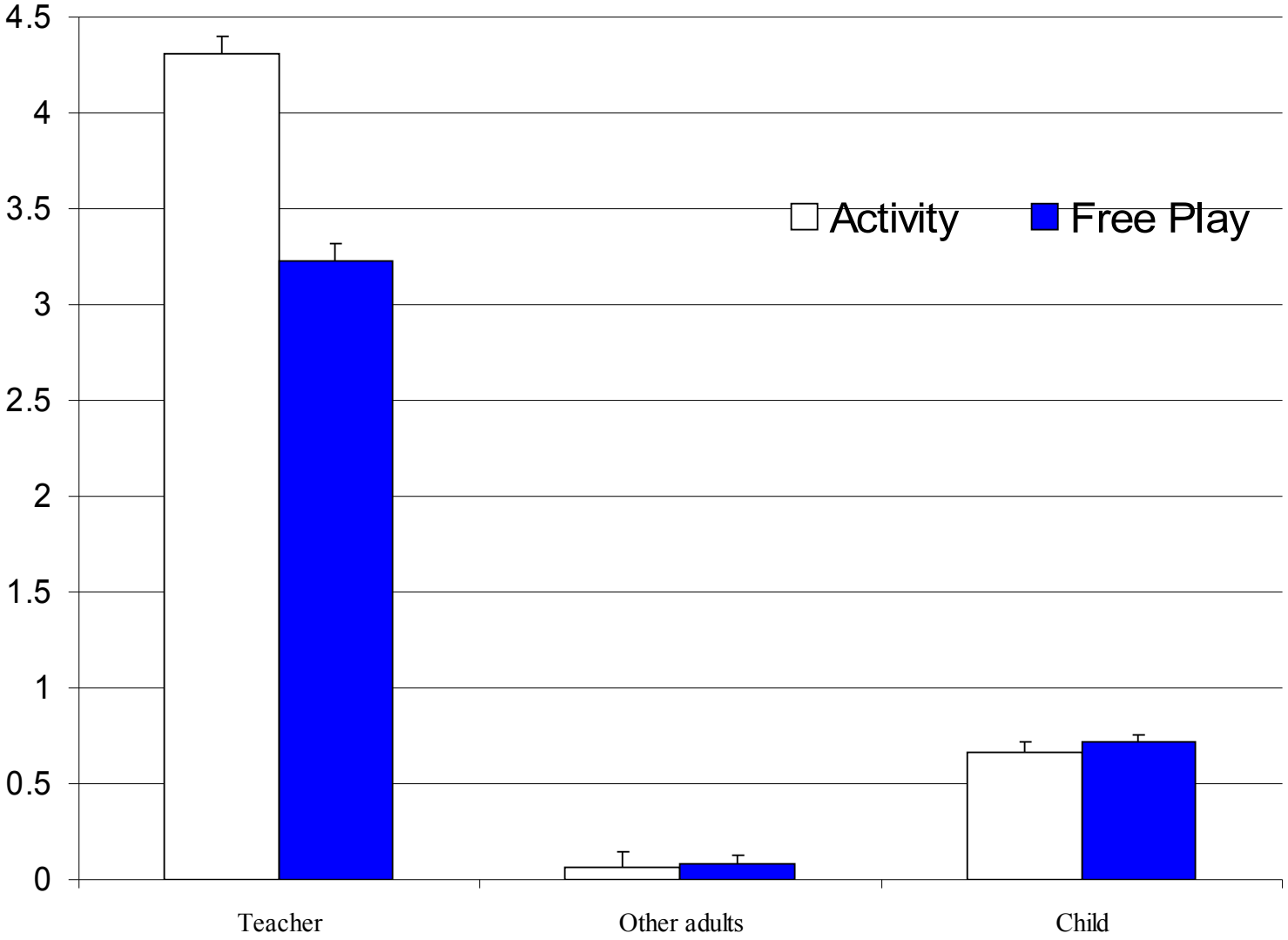
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Activity
Free Play
Teacher
Other adults
Child

Figure 1

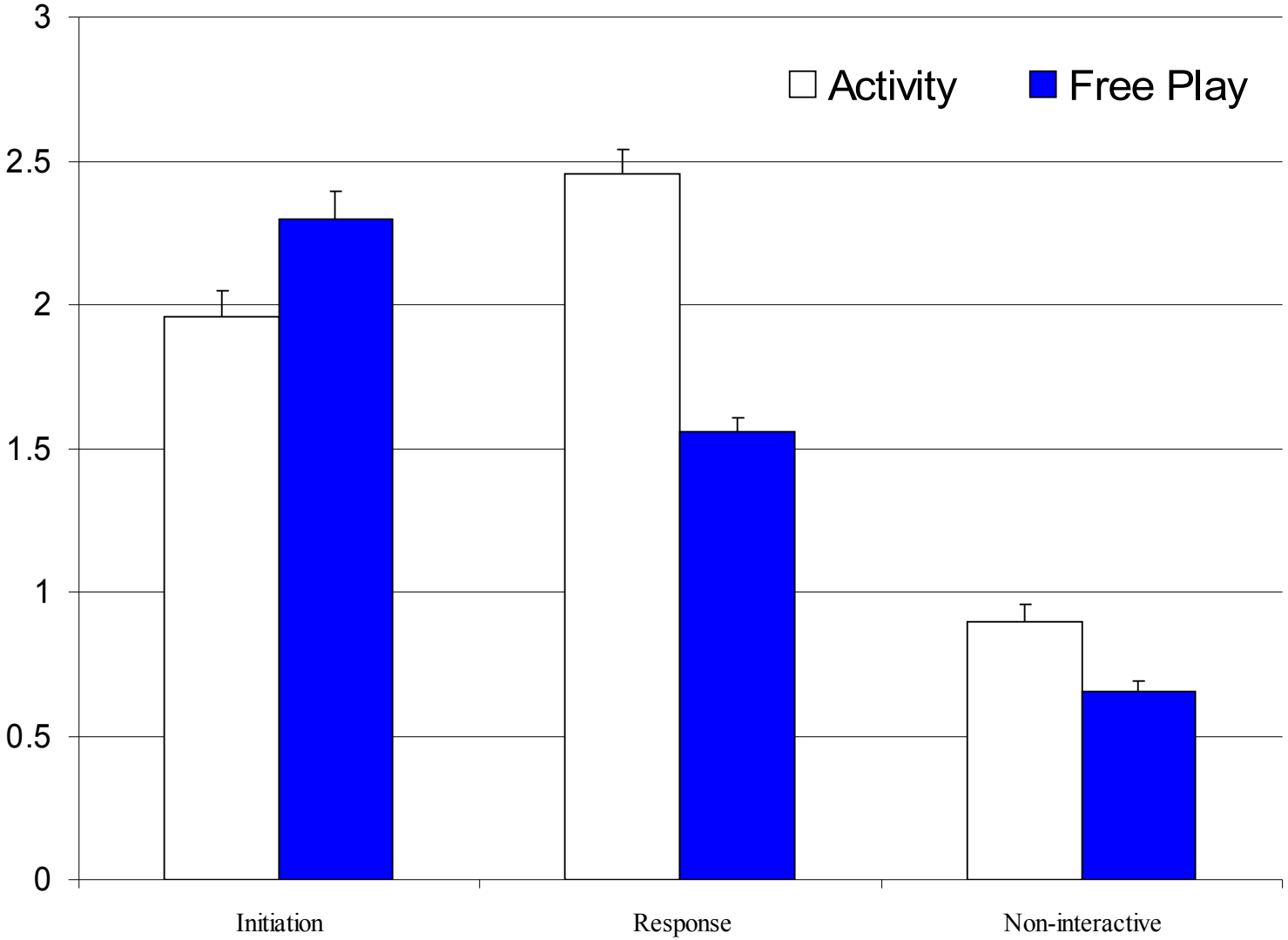
3
2.5
2
1.5
1
0.5
0
Activity
Free Play
Initiation
Response
Non-interactive

Figure 2

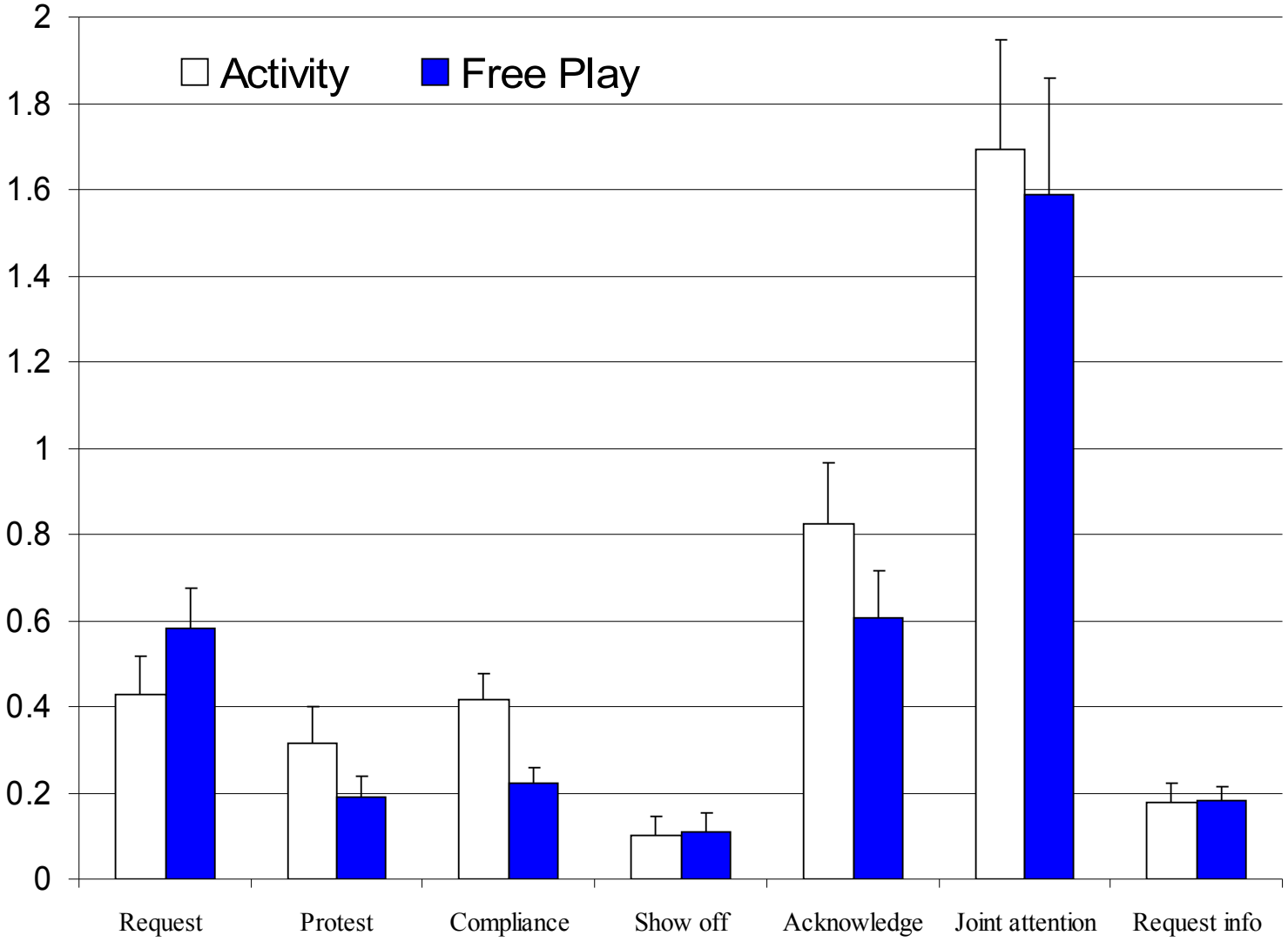
Activity
Free Play
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Request
Protest
Compliance
Show off
Acknowledge
Joint attention
Request info

Figure 3

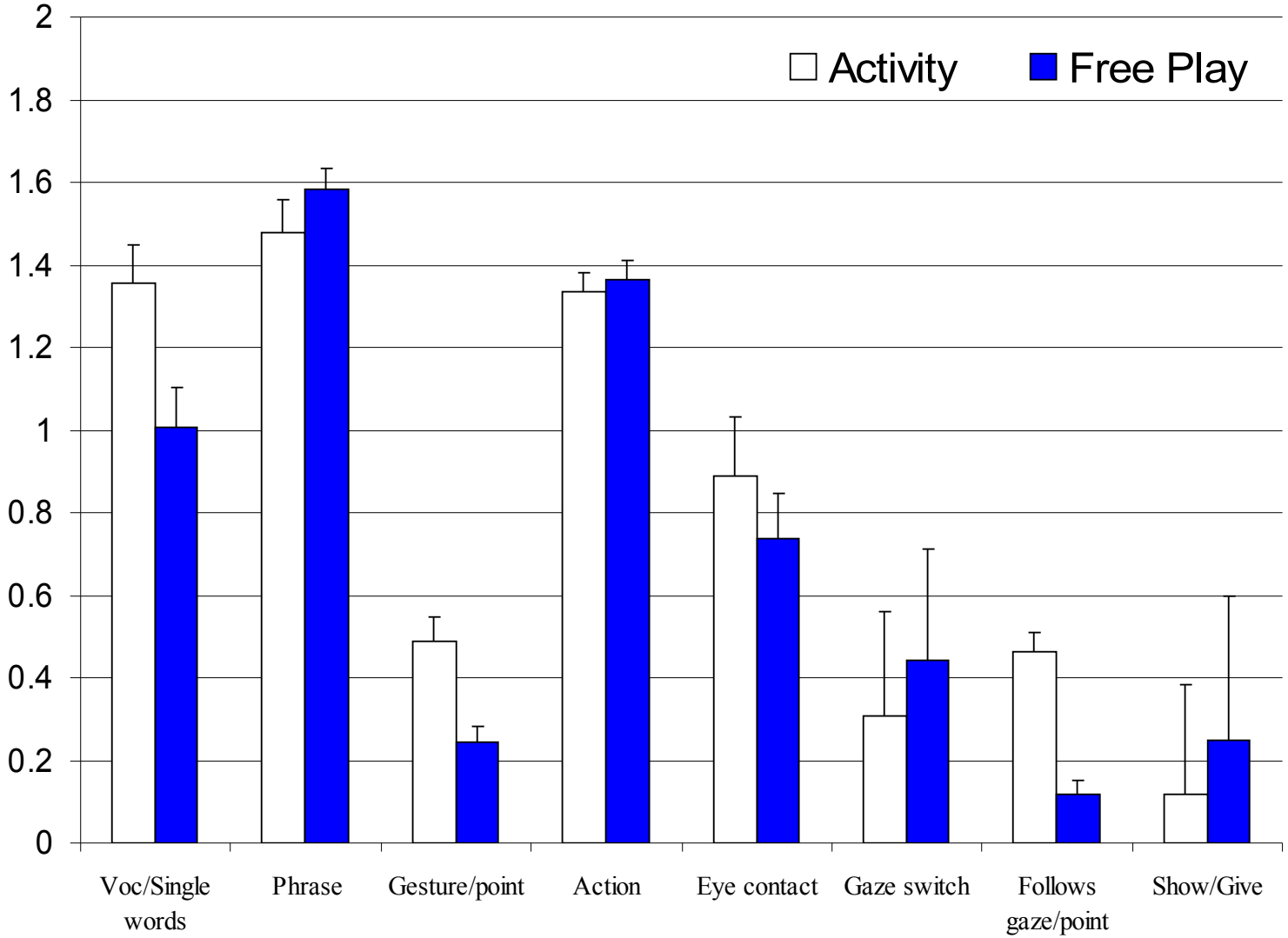
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Activity
Free Play
Voc/Single words
Phrase
Gesture/point
Action
Eye contact
Gaze switch
Follows gaze/point
Show/Give

Figure 4