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A communication-based intervention for non-verbal children with autism: What changes? Who benefits?

Final submission date: 20th April 2011

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ABSTRACT

Objective: This paper examines the form and function of spontaneous communication and outcome predictors in non-verbal children with autism following classroom-based intervention (Picture Exchange Communication System (PECS) training).

Method: 84 children from 15 schools participated in a randomised controlled trial (RCT) of PECS (Howlin et al., 2007). They were aged 4-10 years (73 boys). Primary outcome measure was naturalistic observation of communication in the classroom. Multilevel Poisson regression was used to test for intervention effects and outcome predictors.

Results: Spontaneous communication using picture cards, speech or both increased significantly following training (rate ratio (RR)=1.90, 95% confidence interval 1.46-2.48, *p*<0.001; RR=1.77, 95% CI 1.35-2.32, *p*<0.001; RR=3.74, 95% CI 2.19-6.37, *p*<0.001, respectively). Spontaneous communication to request objects significantly increased (RR=2.17, 95% CI 1.75-2.68, p<0.001) but spontaneous requesting for social purposes did not (RR=1.34, 95% CI 0.83-2.18, p=0.237). Only the effect on spontaneous speech persisted by follow-up (9 months later). Less severe baseline autism symptomatology (lower ADOS score) was associated with greater increase in spontaneous speech (RR=0.90, 95% CI 0.83-0.98), *p*=0.011) and less severe baseline expressive language impairment (lower ADOS item A1 score) with larger increases in spontaneous use of speech and pictures together (RR=0.62, CI 0.44-0.88, p=0.008).

Conclusion: Overall, PECS appeared to enhance children's spontaneous communication for instrumental requesting using pictures, speech or a combination of both. Some effects of training were moderated by baseline factors. For example, PECS appears to have increased spontaneous speech in children who could talk a little at baseline.

Keywords: autism; psychosocial intervention; communicative form; communicative function; intervention response predictors.

A communication-based intervention for non-verbal children with autism: What changes? Who benefits?

Over the past two decades, there has been accumulating evidence for the effectiveness of psychosocial programmes for young children with autism. These tend to incorporate a mix of behavioural, developmental and educational approaches, and although methods may vary, their general goals are to enhance cognitive, communication and social skills, whilst minimising rigid and repetitive and other problem behaviours (see Lord & McGee, 2001; Rogers & Vismara, 2008 for reviews). In part due to the design of studies, however, there have been few opportunities to examine the detail of exactly *what* changes and *who* benefits as a result of these interventions.

In terms of measuring *what changes*, many early autism intervention studies, in particular within the applied behaviour analysis (ABA) field, used global measures of outcome such as IQ scores and school placement (Dawson & Osterling, 1997; Howlin, Magiati & Charman, 2009). More recent studies have used a wider range of measures including standardised tests of adaptive behaviour, expressive and receptive language and measures of autism severity (Howard, Sparkman, Cohen, Green & Stanislaw, 2005; Remington, et al., 2007). Some studies have attempted to include measures of change in skills or behaviours specifically targeted by the intervention, for example parents' or carers' knowledge about autism (Jocelyn, Casiro, Beattie, Bow & Kneisz, 1998). Furthermore, a small number of studies include naturalistic or quasi-naturalistic measures of communication, e.g. observing spontaneous communication and language in parent-child interactions (Aldred, Green & Adams, 2004); observing parents' use of facilitative strategies during social interaction with their child (McConachie, Randle, Hammal & Le Couteur, 2005); recording the frequency and rate of children's turn-taking, joint attention and requesting behaviours (Yoder & Stone, 2006a, 2006b); and observing structured play and joint attention acts within parent- and experimenter-child interactions (Kasari, Freeman & Paparella, 2006; Kasari, Paparella, Freeman & Jahromi, 2008). In addition to increasing the face validity of the research, demonstration of change in specific behaviours is likely to be helpful in elucidating exactly how an intervention is working (Kazdin & Nock, 2003).

To examine *who benefits* from intervention, attempts have been made to study the effects of pre-intervention child characteristics on outcome, most notably IQ and age. For IQ, this usually involves examining correlations between pre-intervention IQ and post-intervention outcome (Eldevik, Eikeseth, Jahr & Smith, 2006; Harris & Handleman, 2000; Remington, et al., 2007) or the comparison of outcomes for high IQ versus low IQ subgroups (Aldred, et al., 2004; Ben Itzchak, Lahat, Burgin & Zachor, 2008; Ben-Itzchak & Zachor, 2007). Significant positive associations have been found between pre-intervention IQ and outcome. However, Yoder and Compton (2004) highlight the flaws of testing for moderators by exploring correlations or comparison of subgroups' effect sizes. They emphasise the importance of using statistical methods that enable differentiation of predictors of growth or progress from predictors of intervention response. Where participants have been randomly assigned to intervention or control conditions, the appropriate method for identifying predictors of intervention response is to test for statistical interactions between child characteristics and group assignment in relation to the outcome variables. Although such statistical tests of moderator effects are well established in medical trial literature and used increasingly in the psychiatry field (Kraemer, Wilson, Fairburn & Agras, 2002) to date, they have only been employed in two studies of autism intervention (Kasari, et al., 2006; 2008; Yoder & Stone, 2006a, 2006b).

Kasari et al. (2006) randomised 58 preschool children with autism (aged 3-4) to either joint attention training, symbolic play training or a control condition, demonstrating that both active interventions were effective at enhancing social communication skills. In a later paper, they presented further analysis revealing that growth in expressive language was positively predicted by a number of joint attention and symbolic play variables (Kasari, et al., 2008). Yoder and Stone (2006a, 2006b) used multiple regression to demonstrate the moderating effects of baseline joint attention abilities. Their randomised trial (N=36) compared Picture Exchange Communication Training (PECS, Bondy & Frost, 1998) with Responsive Education and Prelinguistic Milieu Training (RPMT, Yoder & Warren, 1999). Children who initiated joint attention relatively more frequently at baseline benefited more from RPMT in terms of their post-intervention frequency of joint attention initiations, whilst children who initiated joint attention less frequently at baseline benefited more from PECS (Yoder & Stone, 2006a). In a later analysis, using mixed-level modelling they found object exploration also moderated intervention response(Yoder & Stone, 2006b). Thus, children who displayed object exploration behaviours more frequently at baseline benefited most from PECS, showing greater increases in production of non-imitative words at outcome. The children who showed lower object exploration at baseline benefited more with respect to word production if they had received RPMT.

These studies notwithstanding, to date relatively few studies of psychosocial intervention for children with autism have effectively investigated what changes in response to treatment and who benefits. Common use of standardised IQ and language assessments to measure outcome has meant there has been relatively little naturalistic analysis of change in the form and function of children's communication as a result of intervention. Insufficiently sized samples and lack of randomisation have impeded investigation into treatment moderators.

The present study

Enhancing spontaneity in everyday communication has been highlighted as one of the most important goals of intervention for children with autism (Lord & McGee, 2001). The aim of the Picture Exchange Communication System is to teach spontaneous and functional communication to children with autism in a social context (Bondy & Frost, 1998). PECS is widely used in home and educational settings (Preston & Carter, 2009; Sulzer-Azaroff, Hoffman, Horton, Bondy & Frost, 2009) and there is evidence from a number of single case and case-series studies (Charlop-Christy, Carpenter, Le, LeBlanc & Kellet, 2002; Ganz & Simpson, 2004; Kravits, Kamps, Kemmerer & Potucek, 2002; Magiati & Howlin, 2003; Schwartz, Garfinkle & Bauer, 1998), a school-based controlled study (Carr & Felce, 2007) and two randomised controlled trials (Howlin, Gordon, Pasco, Wade & Charman, 2007; Yoder & Stone, 2006a, 2006b) that PECS can lead to improved communication skills in this group.

Howlin et al. (2007) conducted a pragmatic RCT of the Picture Exchange Communication System. The study was designed to test the "real world" effectiveness of PECS. Initial training was delivered to teachers and classroom assistants by PECS consultants at workshops. PECS was subsequently applied by school staff in the classroom under regular supervision by the PECS consultants. Naturalistic observations of rates of children's communication were used as the primary outcomes to measure intervention effects. Immediately after training had ended (approximately 5 months) the rate at which children spontaneously initiated communication (*IC*) had significantly increased. Overall rates of children's use of picture cards (*P*) to communicate (i.e. spontaneous or prompted) had also significantly increased. By the 9-month follow-up, however, these effects had disappeared. Overall rates of children's speech/vocalisation (*S*) (including spontaneous and prompted) did not increase.

In the present paper, using the sample from Howlin et al. (2007), we explore exactly which communication forms were used by children more spontaneously as a result of PECS training, which communicative functions increased and which children benefited most from the intervention. We aimed to build on previous studies by applying appropriate analysis to this relatively large sample to address the following questions:

Did PECS training act specifically to increase children's spontaneous communication using the picture cards or did its effect generalise to support greater spontaneity using speech as well? Previous studies have demonstrated that PECS supports children to communicate spontaneously using picture cards (e.g. Bondy & Frost, 1994; Charlop-Christy, et al., 2002; Ganz & Simpson, 2004; Kravits, et al., 2002) and sometimes speech (e.g. Bondy & Frost, 1994; Charlop-Christy, et al., 2002; Ganz & Simpson, 2004). Two studies using more naturalistic measures of outcome also suggest that PECS can increase spontaneous communication using picture cards and speech together (Carr & Felce, 2007; Yoder & Stone, 2006a).

Did PECS increase children's spontaneous communication purely for instrumental requesting or did the training also lead to increased spontaneous communication for more social purposes? PECS training initially focuses on teaching children to make requests for objects. Later training phases aim to broaden the range of communicative functions, such as sharing attention through commenting (Bondy, Tincani & Frost, 2004). Studies have shown that PECS training can be used successfully to teach children spontaneous requesting for objects (Carr & Felce, 2007; Ganz & Simpson, 2004; Kravits, et al., 2002) and some have demonstrated effects on other forms of non-instrumental, more social communication (Schwartz, et al., 1998; Yoder & Stone, 2006b).

Which children benefited most from the PECS training? PECS was specifically developed for children with autism in order to obviate the need for prerequisite communication skills and so it might be hypothesised that response to training would not be predicted by such factors as language comprehension skills or autistic symptomatology. Within the autism intervention literature more generally, however, higher IQ has been associated with better outcome (e.g. Harris & Handleman, 2000; Schwartz, et al., 1998). Yoder and Stone's study (2006a, 2006b) has been the only systematic investigation of PECS response predictors to date, finding that children who were *most impaired* in terms of baseline language and joint attention skills were those who gained most from PECS training. Given the lack of research in this area, this study will take an exploratory approach, investigating the potential moderating effect on PECS training of four factors measured at baseline: chronological age, expressive language, autistic symptomatology and cognitive ability.

Method

Participants of the RCT

Eighty-four children (73 boys, 11 girls) from 17 classes in special needs elementary schools participated in the study. Classes were broadly similar, with a child–adult ratio of approximately 2:1. Class teaching programmes varied but most classes adopted an eclectic approach incorporating a range of visual systems and structured teaching, often based on the TEACCH methodology (Mesibov, Shea & Schopler, 2004). Picture cards were present in most classrooms in the treatment and non-treatment groups even at baseline, though these were not necessarily used according to the Picture Exchange Communication System principles. All schools were situated in Greater London or the South East of England. Children were aged between 4 and 10 years (mean age at baseline = 6.8 years, SD = 1.26) and all had an intellectual disability. Ethnicity, socio-economic status and comorbidity data were not formally collected. This was a community-based study that included all suitable children whose parents consented. To be eligible, children had to: have a formal clinical diagnosis of autism, use little or no functional language (i.e. no more than single words), have no sensory impairment, be aged between 4 and 11 years and not using PECS beyond Phase 1.

Informed consent and ethical approval

Written informed consent to participate in the study was obtained from the parent or guardian of each child and from a senior member of staff from each school. The original trial protocol was prospectively reviewed and approved by the Wandsworth Local Research Ethics Committee (Ref. IAS/der/02.42.6).

Describing the group at baseline

To obtain baseline data on autism severity, all children were assessed using Module 1 of the Autism Diagnosis Observation Schedule (ADOS, Lord, et al., 2000). The ADOS is an interactive semi-structured assessment of communication, social interaction, imagination and repetitive and stereotyped interests. Assessment consists of a range of activities and social presses providing a standardised context in which to observe specific behaviours. There are four modules. Module 1 was used in this study, designed for use with preverbal individuals or for those whose expressive language is still at single word or simple phrase level. Seventy-five children met the ADOS criteria for a diagnosis of autism; 9 children met criteria for autism spectrum disorder. Score from item A1 of the ADOS was used as an index of expressive language ability (0=regular use of utterance of 2 or more words; 1=occasional phrases only, mostly single words; 2=recognisable single words only; 3=at least one word or word approximation but fewer than five words; 4=no words or word approximations). Thirty-eight children (45%) used no words or word approximations during the ADOS, 31 (37%) used single words and 15 (18%) used at least one phrase. Most children (64%) scored zero on the Expressive One Word Picture Vocabulary Test (Brownell, 2000). Non-verbal developmental quotient (NVDQ = non-verbal mental age equivalent/chronological age *100) was ascertained using the Mullen Scales of Early Learning (Mullen, 1995). Group median NVDQ was 29.90 (inter quartile range was 21.20 – 40.52). In summary, the sample comprised children with clear autism and who were very impaired with regard to verbal and non-verbal skills.

Design of the RCT

As a group-randomised control trial, class groups (each including approximately 6 children and 2-3 staff) were assigned into one of three intervention groups. The

Immediate Treatment Group (ITG: 5 class groups, 26 children) received training immediately after the baseline assessment; the Delayed Treatment Group (DTG: 6 class groups, 30 children) received training about 9 months later, immediately after Time 2 assessment; the No Treatment Group (NTG: 6 class groups, 28 children) received no training. Staggering of treatment across two time periods maximised the number of children involved in the study and allowed investigation of the continued effectiveness of any immediate treatment effects noted. The data analyses incorporated each child contributing all measurements within all control, treatment and post-treatment periods, thus statistical power was not compromised by the 3-arm approach to data collection. Differences between the three groups at baseline were analysed and reported in Howlin et al. (2007). The analysis was designed to adjust for these differences. Figure 1 shows recruitment, the points at which intervention was delivered and when each of the three groups was observed.

Insert Figure 1 about here

Outcome measurement

The outcome measure was a 15-minute videotaped observation, intended to be an ecologically valid measure of communication skills. Children were filmed in their class snack sessions at Time 1 (baseline) and twice further over a period of 20 months (2 academic years). Snack sessions were selected as these were likely to create the most opportunities for children to make spontaneous requests. Furthermore, daily snack sessions occurred in all the classes and were broadly similar. These sessions usually lasted approximately 15 minutes and involved all children and class staff sitting at tables in the classroom or school kitchen. Drinks and food snacks such as fruit or cookies were given out or were on offer for children to request. Where classes used picture cards, these were usually made available for children, e.g. by placing a large board at the front of the classroom or by handing out books with the cards inside.

Children's communication was coded from the videotape using an observation schedule designed specifically for this study (Classroom Observation Schedule for Measuring Intentional Communication (COSMIC); Pasco, Gordon, Howlin & Charman, 2008). The primary outcome variable was frequency of child-initiated communication (*IC*). Frequencies of different communication modalities used (such as the number of times a child used a picture card (*P*) and/or speech/vocalisation (*S*) to communicate) were also recorded; communication functions were recorded by counting each time a child communicated for the purpose of requesting objects (*R*) and for the purpose of requesting a social interaction or commenting (D). In this way, a single communication act might produce 3 or more codes, e.g. as a spontaneous initiation (*IC*), of the use of a picture card (*P*) and for the purpose of requesting (*R*).

Data analysis

Where outcomes are numerical counts of relatively rare events, Poisson regression is a useful method for analysis (Dobson, 2002). The Poisson regression model expresses the log outcome rate as a linear function of a set of predictors. In this study, Poisson regression models were produced for each of the five outcome variables of interest, concerned with form or function of children's spontaneously initiated communication: spontaneous communicative initiation using picture cards (*IC-P*); spontaneous communication using speech (*IC-S*); spontaneous communication using both simultaneously (*IC-PS*); spontaneous communication to request for objects (*IC-R*) and spontaneous communication to request for social routine or commenting (*IC-D*). The regression models were created within the Stata IC version 10 (StataCorp., 2003).

As can be seen from Figure 1, the dataset comprised data from 3 time points in the three different experimental groups. We used multilevel models that took account of the longitudinal nature of the measurements, time trends, differing treatment regimes within the same individuals over time and within child correlations between repeated measurements (Goldstein, 2003). The standard errors of the model parameters were thus adjusted for any within child (across time) or within class (between children) correlations. Models also allowed adjustment for any group differences at baseline in terms of age, developmental level, expressive language and autistic symptom severity. Each model included an independent binary intervention variable (i.e. intervention or no intervention), a further binary variable to denote follow-up (this occurred at Time 3 for the ITG group only), a time variable (continuous in order to adjust for differences in the actual lengths of time between observations, i.e. Time 1 = 0 days) and an offset to adjust for the difference in the lengths of snack times for individual children.

In Poisson regression, effect size is represented by the rate ratio (RR) that estimates the relative rate of change in the mean number of events attributable to each explanatory variable. For example, for a binary intervention variable, the RR represents the relative difference in mean frequency of spontaneous initiations for children in the intervention group compared to those not in the intervention group. For continuous variables, e.g. baseline age (months), the RR represents the relative difference in the mean frequency of initiations for every increase in 1 unit of the explanatory variable – in this case for every month older the child was at baseline. An RR of 1 indicates no change, and so, for example, an RR of 1.2, represents an increase of 20% for each unit increase; an RR of 0.7 represents a decrease of 30% for each unit increase. Rate ratios for estimates from the five models (for each of the five outcome variable) are reported along with 95% confidence intervals and *p* values. These models were not independent and were interpreted jointly taking into account the relationship between the various outcomes.

Testing for intervention moderators. Where PECS had a significant effect, a second round of analyses was conducted in order to identify potential intervention response moderators.

If baseline factors (i.e. chronological age, autistic symptomatology, expressive language or developmental quotient) independently predicted progress at post-intervention (shown in Table 1), tests for “intervention x baseline factor” interactions were conducted to explore whether they also predicted specific intervention response. The rate ratio for the interaction term represents the impact of the baseline variable on the outcome *over and above* any existing variance due to a main intervention effect or a main effect of the baseline factor.

Results

The results are presented in two parts. Firstly the impact of PECS training on children’s spontaneous communication using three different communication modalities and for two different functions was examined. Secondly, controlling for differences, baseline variables were tested for their potential moderating effect on the intervention.

Change in spontaneous communication following PECS training

Table 1 shows the median rate of initiations per minute for the five variables in each of the three treatment arms at each of the three time points. The rates emboldened and underlined are immediately following the PECS training in the Immediate and Delayed treatment groups. The underlined rates are at 9-month follow-up (Immediate treatment group only). These figures indicate some changes following PECS training. For example, in the Delayed treatment group the median rate of spontaneous initiation of communication using picture cards went from 0 to 0.44 per minute, that is, more than 6 times per 15-minute snack session. In the Immediate treatment group the median rate of spontaneous communication using speech or vocalisation went from 0.03 to 0.13 per minute and in the Delayed treatment group the median rate of spontaneous requesting rose from 0.03 to 0.46 times per minute. Despite these group effects, for each of the form and function variables, some children remained at zero, even after PECS training. For example, of the 56 children in the Immediate and Delayed treatment groups, 12 were still not using picture cards to spontaneously communicate at all after the training and 9 were still not making spontaneous requests.

Insert Table 1 about here

Table 2 shows the results of the Poisson analysis for each variable. Rate ratios are shown for change attributable to the intervention immediately post-PECS training; at 9-month follow-up (for the ITG group only); and for each of the non-intervention variables measured at baseline. Initiations using picture cards (*IC-P*), using speech (*IC-S*) and using both simultaneously (*IC-PS*) all increased significantly following training (RR 1.90, 95% confidence interval 1.46 – 2.48, p<0.001; RR 1.77, 95% CI 1.35-2.32, p<0.001; RR 3.74, 95% CI 2.19 – 6.37, p<0.001, respectively). The average increase observed was similar in size for *IC-P* and *IC-S* and about twice as large for *IC-PS.* However, it should be noted that the confidence intervals are wide and in all instances the data are compatible with a 2-fold increase in the rate ratio, so we cannot necessarily infer that the effect is any greater for *IC-PS*. Spontaneous requesting for objects (*IC-R*) significantly increased following training (rate ratio= 2.17, 95% CI 1.75-2.68, p<0.001) but requesting for social routine or commenting (*IC-D*) did not (RR=1.34, 95% CI 0.83-2.18, p=0.237). Children in the ITG group (n=26) were observed again at follow-up (approximately 9 months after the end of the training period). Whilst the effect on spontaneous initiation using speech/vocalisation (*IC-S*) had persisted (RR=1.70, 95% CI 1.12-2.58, p=0.012) none of the other effects were significant (*IC-P*, RR=0.69, 95% CI 0.41-1.15, p=0.15; *IC-PS*, RR=1.90, 95% CI 0.76-4.76, p=0.17; *IC-R*, RR=1.11, 95% CI 0.76-1.62, p=0.60).

Insert Table 2 about here

Variables moderating the effect of PECS training

Baseline variables were analysed for their power to predict progress in general and to predict specific response to treatment. Seven baseline variables (shown in bold in Table 2) were independently and significantly related to general progress at post-intervention and so were testable as potential moderators of the intervention effects. Of these seven "intervention x baseline variable" interactions tested, two were found to be significant. The impact of the intervention on children's spontaneous initiation of communication using speech/vocalisation (*IC-S*) was moderated by baseline autistic symptomatology (RR=0.90, 95% CI 0.83 – 0.98), *p*=0.011). As can be seen from Figure 2, children whose autistic symptomatology score was lowest at baseline (i.e. least severe symptoms) showed the largest increases in spontaneous use of speech/vocalisation following intervention. Each unit increase in ADOS score was associated with a 10% decrease in average rate of initiation using speech/vocalisation (*IC-S*). Baseline expressive language did not moderate intervention effects for this outcome (RR=1.05, 95% CI 0.90-1.24, *p*=0.524).

Insert Figure 2 and 3 about here

Baseline expressive language moderated the effect of PECS training on children's spontaneous initiation using picture cards and speech/vocalisation together (RR=0.62, 95% CI 0.44-0.88, *p*=0.008). Expressive language was rated on a severity scale. Figure 3 shows that those children with the most expressive language at baseline (lower score represents better expressive language) showed the biggest increase in their use of picture cards and speech/vocalisation together to spontaneously initiate communication. Each unit increase in expressive language deficit score was associated with a 38% decrease in the average rate of initiations using picture cards and speech together (*IC-PS*). Neither baseline developmental quotient nor autistic symptomatology moderated the effects of the intervention for this outcome (RR=1.01, 95% CI 0.98-1.05, p=0.539 and RR=0.94, 95% CI 0.79-1.12, p=0.477, respectively). As can be seen from Table 2, baseline developmental quotient (DQ) predicted of rate of initiation using picture card (*IC-P*) and rate of initiation for the purpose of instrumental requesting (*IC-R*) immediately post-intervention but interaction tests demonstrated that this did not moderate the effects of the training on these behaviours (for *IC-P*, DQ x intervention, RR= 0.99, 95% CI 0.98-1.01, p=0.214; for *IC-R*, DQ x intervention, RR=0.99, 95% CI 0.98-1.00, p=0.212).

Discussion

PECS is recognised as an effective intervention for increasing communication in children with autism (Preston & Carter, 2009; Sulzer-Azaroff, et al., 2009) and our RCT demonstrated specifically that PECS training can significantly enhance the spontaneity of children's communication (Howlin, et al., 2007). In this paper we asked exactly how PECS training increased this communicative spontaneity and for which children. That is, we wanted to examine firstly, whether the increased spontaneity was confined to communication using the picture symbols or whether PECS also impacted on the spontaneity of children's use of speech/vocalisation. Secondly, we wished to examine whether the increased spontaneous communication was being used only for instrumental purposes (e.g. getting a snack) or whether children were also spontaneously initiating communication for more social purposes as a result of PECS training. Thirdly, we wanted to identify factors that might be moderating the effect of the PECS training and therefore predictive of which children might benefit most from the training. We used Poisson regression analysis to examine the children's spontaneous communication using different communication modalities and for different functions and to test for interactions between the intervention and baseline child variables.

The naturalistic and relatively fine-grained outcome measurement meant that it was possible to analyse exactly how PECS was enhancing children's spontaneous communication in an everyday situation. A small number of previous intervention studies have examined the form of children's communication but have not focussed purely on spontaneous unprompted communication. The present analyses revealed that whilst PECS training did lead to children spontaneously communicating more using the picture cards, it also led to increased spontaneity in children's use of speech and their use of picture cards and speech in combination. The training appears to have increased spontaneous requesting for objects or help but not spontaneous requesting for social routine or commenting.

In contrast to some other reports (Bondy & Frost, 1994; Charlop-Christy, et al., 2002), in our primary analysis of the PECS RCT we did not observe an effect of the intervention on *overall* use of speech (Howlin, et al., 2007). The present analysis revealed, however, that PECS did enhance the use of speech as a modality to spontaneously initiate communication, as well as enhancing spontaneity using picture cards. So, whilst it would appear that PECS training did not enhance speech development per se, for those children who were already using some speech or vocalisation, PECS appears to have provided a structure for them to use this mode to communicate without prompting. It would seem that PECS fostered spontaneity more generally across modalities rather than just acting to increase children's use of picture cards. Furthermore, the effect of PECS training on children's spontaneous speech/vocalisation appears to have been particularly robust as it was also observed 9 months after the end of the training period in the group who received PECS training early on. There was no long-term effect on spontaneous use of picture cards.

Detailed analysis of the functions of spontaneous communication in autism intervention is also rare. In this study, analysis revealed a clear effect on children's spontaneous communication for the purposes of requesting for objects, such as a drink or a toy, which is the first communicative function taught through the PECS teaching phases

(Frost & Bondy, 2002). This replicates findings from earlier research (Schwartz, et al., 1998; Yoder & Stone, 2006a, 2006b). There was no effect of training on children's spontaneous communication for social purposes. This might be due to the fact that the children in this sample had severe autism symptoms and as a group were very delayed with regard to verbal and non-verbal skills. Furthermore, the discrepancy between instrumental and social communication is perhaps to be expected given that the children were observed in class snack sessions. It is possible that observation of children in other non-snack sessions might have revealed effects of training on communication for other non-instrumental purposes. Also, it is possible that if the training had persisted for longer or had been more intense, changes in spontaneous social, non-instrumental communication might have been seen. Some case study reports have described children successfully learning to communicate for social interaction purposes such as commenting (e.g. Schwartz, et al., 1998; Webb, 2000) although, to date, no experimental trials have demonstrated this effect of PECS.

Two baseline variables appeared to moderate the effect of the PECS training. First, less severe autistic symptomatology at baseline predicted the greatest increases in spontaneous speech. Second, higher level of expressive language at baseline predicted greater increases in spontaneous use of speech and picture cards together. This is to be expected, as more severe autism and greater language disability are not independent. Thus the fact that the least severely autistic children and those with the most expressive language showed the greatest improvements in these areas is consistent with the autism intervention literature more generally (e.g. Harris & Handleman, 2000; Kasari, et al., 2008). We observed no interactions between PECS training and any of the abilities measured at baseline on children's spontaneous use of the picture cards or spontaneous requesting. Yoder and Stone's study (2006a, 2006b) has been the only other systematic examination of moderators of PECS intervention. They compared PECS with RPMT and although there was no overall difference between the interventions, children who were *most* impaired in baseline language and joint attention skills gained most in terms of their joint attention skills from PECS training, whilst the more able children made better progress with RPMT. The present study did not replicate the finding that the less able children benefited more from PECS. A potential explanation is that, as a group, the children in the present sample were less able than Yoder and Stone's sample. In Yoder and Stone's sample the mean nonverbal mental age was 18.8 months (standard deviation 4.5 months) at 3 years of age (Table 1, Yoder & Stone, 2006a), meaning that mean nonverbal developmental quotient (NVDQ) was approximately 50 whilst the mean NVDQ in our sample was around 30.

Despite the fact that all children in the present study were very impaired in terms of their verbal and non-verbal skills, spontaneous use of pictures to communicate and spontaneous requesting did increase and this was not predicted by better baseline language or less severe autism symptoms. This suggests that PECS training was equally accessible to these children in terms of teaching these skills specifically. This seems to support the idea that, beyond the need for some very basic cognitive skills required in order to exchange the cards (e.g. object permanence), few pre-existing verbal or non-verbal skills are required to learn to use PECS (Bondy & Frost, 1998).

Strengths and limitations of the study

The unique quality of the data presented here is that they are derived from an examination of "real world" effectiveness. The study took an inclusive approach to recruitment, aiming to include all suitable schools within a defined but large geographical area in the South East of England and included all suitable children whose parents consented. As the trial was community-based, intervention was delivered to teachers and classroom staff via a workshop and follow-up visits to the schools. Teachers had to implement the programme in amongst all the other pressures and distractions of running a classroom for children with special educational needs and from a wide variety of backgrounds. Children were required to access the intervention in spite of their severe autistic symptoms, language impairments and perhaps other comorbid problems. In other words, the PECS training that was delivered and evaluated seemed to be a realistic representation of the PECS training most children are likely to receive.

The design of the study and analysis ensured that the use of three treatment groups did not detract from the numbers effectively used for the intervention and no intervention groups. The study was, in fact strengthened by having within-individual comparisons (i.e. the delayed intervention group) as well as between group comparisons over the same time frame. The use of the multilevel model allowed for efficient use of data in the three-treatment arm format adopted in this study, taking into account correlations between repeats from the same individuals and allowing for the serial nature of measurements under different treatment conditions. The design also enhanced the power to investigate the immediate effects of the intervention and enabled investigation of the longer-term effects of the training. The incorporation of baseline data further strengthened the results.

The interaction analysis applied in this study is relatively novel to this field and demonstrates the possibility of using relatively sophisticated statistical models to test for moderator effects on interventions for children with autism. As has been discussed above, this has been rarely done in the autism field in the past and thus there is very little reliable information about who benefits most from various interventions for children with autism.

As this trial was conducted primarily in schools, we had little direct contact with parents, aside from their consenting for their child to take part in the study. As a consequence we did not collect systematic information on family variables such as ethnicity and other background factors (social economic status, parental income) that might also be related to differential outcome, nor did we collect detailed information on potential school moderating factors. Instead the study focused on child characteristics as moderating factors. Generalisation of these findings will require replication in samples with well-described demographic information, as well well-characterised schools/classrooms.

For logistical reasons (i.e. limited resources), we were limited to observing children in their classrooms. We opted to observe them during snack sessions as this was a session that created more opportunities for children to make spontaneous requests, relative to less structured sessions, and this was a common feature on the timetables of all classes involved in the study. However, the snack sessions are relatively brief periods, when children are usually highly motivated to make approaches for food and so the data may not represent changes in children's communication in other less structured or less motivating contexts. Observations of children communicating in other class sessions or at home would have revealed the extent to which the observed effects generalised out of the relatively structured setting of class snack time.

With regard to the analysis of intervention response predictors, we were limited to testing four child factors measured at baseline. It is possible that other factors, not measured, were moderating the intervention effects, including those that were external to the children (i.e. environmental factors). It is likely that differences between the classes and the ways in which PECS was implemented also influenced children's progress. Treatment fidelity measures will be important for future studies of psychosocial interventions.

A limitation of the analysis of response predictors was that, whilst relatively sophisticated, essentially it was based on comparing sub-groups and the study was not primarily powered for this. The chance of type II errors is thus increased. The results do, however, provide a good basis for further discussion. In the future, as more intervention studies are conducted and there is greater consistency in approach across research, pooling of samples may be possible thus increasing statistical power for identifying invention response moderators.

Implications

In summary, the findings show that classroom-based PECS training enhances children's ability to make spontaneous instrumental requests not only using pictures, but also using speech or a combination of both. It also shows that, similar to other interventions, less impaired children appear to show the most improvement in these areas. Where these improvements were seen, they represented noticeable change in children's communication. For example, in one treatment group the median rate of spontaneously initiated communication using PECS went from 0 times per 15-minute snack session up to more than 6 times and the median rate of spontaneous requesting rose from ~0.5 times to ~7 times per snack session. It is important to remember however, that these figures are based on group effects. Such impressive gains were not seen in all children who received PECS training and for some children no gains were made at all. Nevertheless, for a child who has not been communicating at all to request even twice in a 15-minute snack session represents a meaningful change.

The study also has important methodological implications. This paper builds on the findings of one of the larger RCTs conducted in the autism field to date (Howlin, et al., 2007) (though see Aman, et al., 2009; Green, et al., 2010, for larger studies). The adequately sized sample, well described in terms of verbal and non-verbal abilities, provides the opportunity for analysis of the specific effects of psychosocial intervention for children with autism. The study demonstrates the feasibility of applying robust statistical techniques to pragmatic, "real world" trials in this field to elucidate exactly what changes and for whom.

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Table 1. Median initiations made per minute (rounded to 2 decimal places) at each time point for each of the three treatment groups. Inter-quartile range and full range are shown in parentheses.

Spontaneous initiations using picture cards (*IC-P*)			
	Time Period 1	Time Period 2	Time Period 3
Immediate Treatment	0.03 (0.36; 0, 1.27)	**0.20 (0.34; 0, 1.13)**	0.07 (0.13; 0, 0.67)
Delayed Treatment	0 (0.13; 0, 1.11)	0 (0.26; 0, 1.32)	**0.44 (0.57; 0, 1.80)**
No Treatment	0 (0.33; 0, 1.39)	0.03 (0.35; 0, 0.87)	0.08 (0.38; 0, 1.36)
Spontaneous initiation using speech/vocalisation (*IC-S*)			
	Time Period 1	Time Period 2	Time Period 3
Immediate Treatment	0.03 (0.36; 0, 1.07)	**0.13 (0.65; 0, 2.00)**	0.13 (0.40; 0, 2.40)
Delayed Treatment	0 (0.14; 0, 1.00)	0 (0.09; 0, 0.45)	**0 (0.12; 0, 0.85)**
No Treatment	0 (0.68; 0, 1.57)	0.09 (0.37; 0, 1.32)	0.21 (0.39; 0, 1.12)
Spontaneous initiation using picture cards +speech/vocalisation (*IC-PS*)			
	Time Period 1	Time Period 2	Time Period 3
Immediate Treatment	0 (0; 0, 0.20)	**0 (0.13; 0, 0.72)**	0 (0.07; 0, 0.27)

Delayed Treatment	0 (0; 0, 0.21)	0 (0; 0, 0.43)	**0 (0.07; 0, 0.56)**
No Treatment	0 (0; 0, 1.03)	0 (0; 0, 0.53)	0 (0; 0, 0.33)
Spontaneous initiation for requesting objects (*IC-R*)			
	Time Period 1	Time Period 2	Time Period 3
Immediate Treatment	0.23 (0.46; 0, 1.47)	**0.37 (0.92; 0, 2.35)**	0.16 (0.40; 0, 1.27)
Delayed Treatment	0 (0.16; 0, 1.11)	0.03 (0.22; 0, 1.32)	**0.46 (0.51; 0, 2.21)**
No Treatment	0.19 (0.75; 0, 1.79)	0.26 (0.45; 0, 2.11)	0.29 (0.67; 0, 1.92)
Spontaneous initiation for requesting social routine or commenting (*IC-D*)			
	Time Period 1	Time Period 2	Time Period 3
Immediate Treatment	0 (0.13; 0, 0.87)	**0 (0.07; 0, 1.40)**	0 (0.07; 0, 2.40)
Delayed Treatment	0 (0; 0, 0.07)	0 (0; 0, 0)	**0 (0; 0, 0.27)**
No Treatment	0 (0.03; 0, 0.78)	0 (0.05; 0, 0.53)	0 (0; 0, 0.78)

Table 2. Rate ratio estimates (and 95% confidence intervals) for each of the five outcome variables. Significant effects of intervention in bold.

			Relationships between baseline variables and outcome independent of intervention			
Forms and functions of spontaneous initiation	Effect of PECS training post-intervention	Effect of PECS at 9-mo follow-up	Chronological age	Nonverbal developmental quotient (NVDQ)	Autistic symptomatology (ADOS score)	Expressive language (ADOS item A1 score)
Using pictures (*IC-P*)	**1.90 (1.46- 2.48), *p*<0.001**	0.69 (0.41-1.15) *p*=0.151	1.00 (0.98-1.02) *p*=0.915	**0.98 (0.96-1.00) *p*=0.022**	1.04 (0.96-1.13) *p*=0.309	1.13 (0.93-1.37) *p*=0.220
Using speech (*IC-S*)	**1.77 (1.35 – 2.32) *p*<0.001**	**1.70 (1.12-2.58) *p*=0.012**	1.00 (0.97-1.02) *p*=0.768	1.01 (0.98-1.04) *p*=0.505	**0.80 (0.71-0.92) *p*=0.001**	**0.51 (0.39-0.66) *p*<0.001**
Using pictures + speech (*IC-PS*)	**3.74 (2.19 – 6.37) *p*<0.001**	1.90 (0.76-4.76) *p*=0.170	1.01 (0.98-1.03) *p*=0.629	**0.96 (0.93-1.00) *p*=0.030**	**0.79 (0.69-0.90) *p*<0.001**	**0.55 (0.42-0.72) *p*<0.001**
Requesting for objects (*IC-R*)	**2.17 (1.75 – 2.68) *p*<0.001**	1.11 (0.76-1.62) *p*=0.600	1.00 (0.98-1.01) *p*=0.573	**0.97 (0.95-0.99) *p*=0.006**	0.95 (0.87-1.03) *p*=0.213	0.89 (0.73-1.07) *p*=0.211

Figure captions

Figure 1. Flow chart illustrating sample selection, recruitment, training and outcome assessment (reproduced with permission from Howlin et al., 2007)

Figure 2. Graph showing the moderating effect of autistic symptomatology on the effect of PECS on children's spontaneous communication using speech/vocalisation (ADOS scores are on a severity scale; higher score means more severe symptomatology)

Figure 3. Graph showing the moderating effect of baseline expressive language on children's spontaneous communication using picture cards and speech/vocalisation

Figure 1.

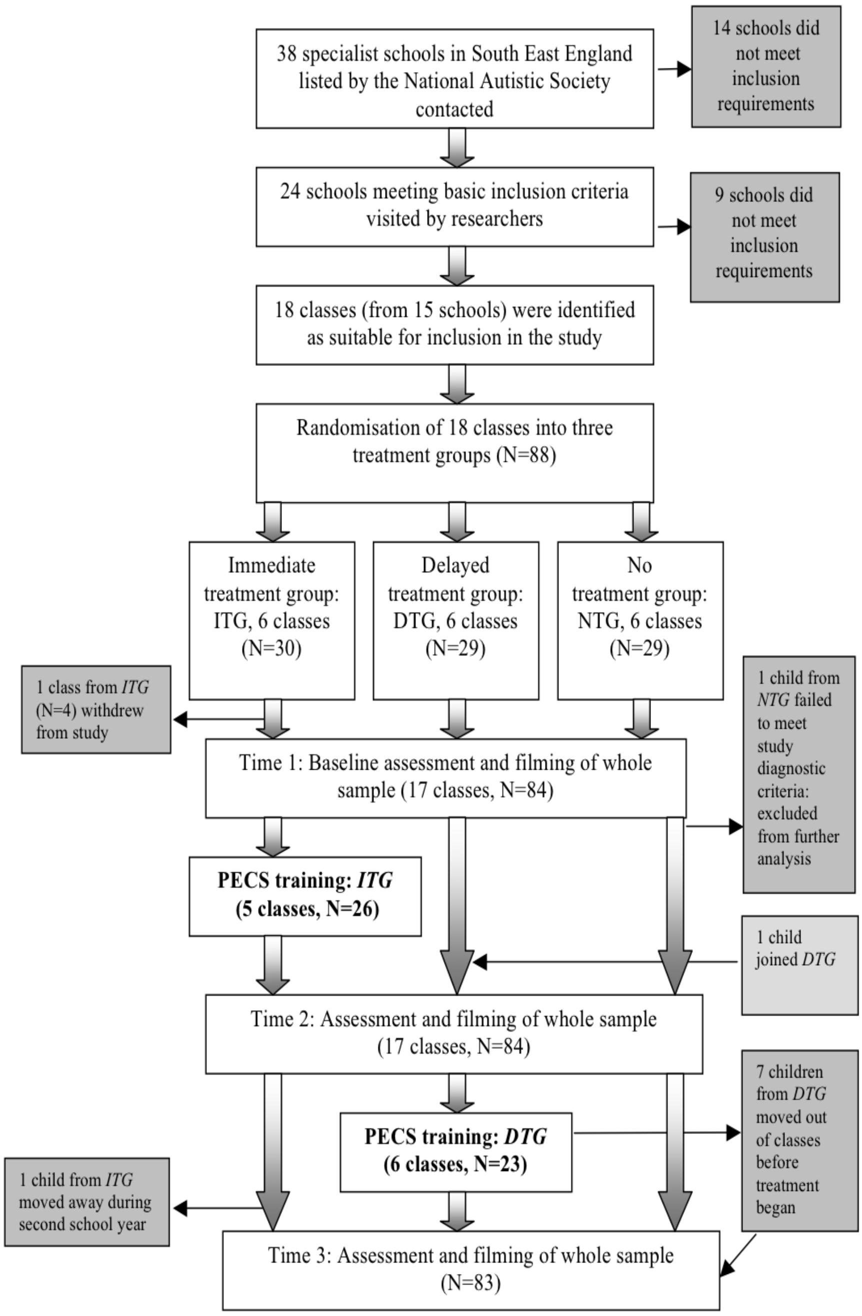

38 specialist schools in South East England listed by the National Autistic Society contacted
14 schools did not meet inclusion requirements
24 schools meeting basic inclusion criteria visited by researchers
9 schools did not meet inclusion requirements
18 classes (from 15 schools) were identified as suitable for inclusion in the study
Randomisation of 18 classes into three treatment groups (N=88)
Immediate treatment group: ITG, 6 classes (N=30)
Delayed treatment group: DTG, 6 classes (N=29)
No treatment group: NTG, 6 classes (N=29)
1 class from ITG (N=4) withdrew from study
1 child from NTG failed to meet study diagnostic criteria: excluded from further analysis
Time 1: Baseline assessment and filming of whole sample (17 classes, N=84)
PECS training: ITG (5 classes, N=26)
1 child joined DTG
Time 2: Assessment and filming of whole sample (17 classes, N=84)
PECS training: DTG (6 classes, N=23)
7 children from DTG moved out of classes before treatment began
1 child from ITG moved away during second school year
Time 3: Assessment and filming of whole sample (N=83)

Figure 2.

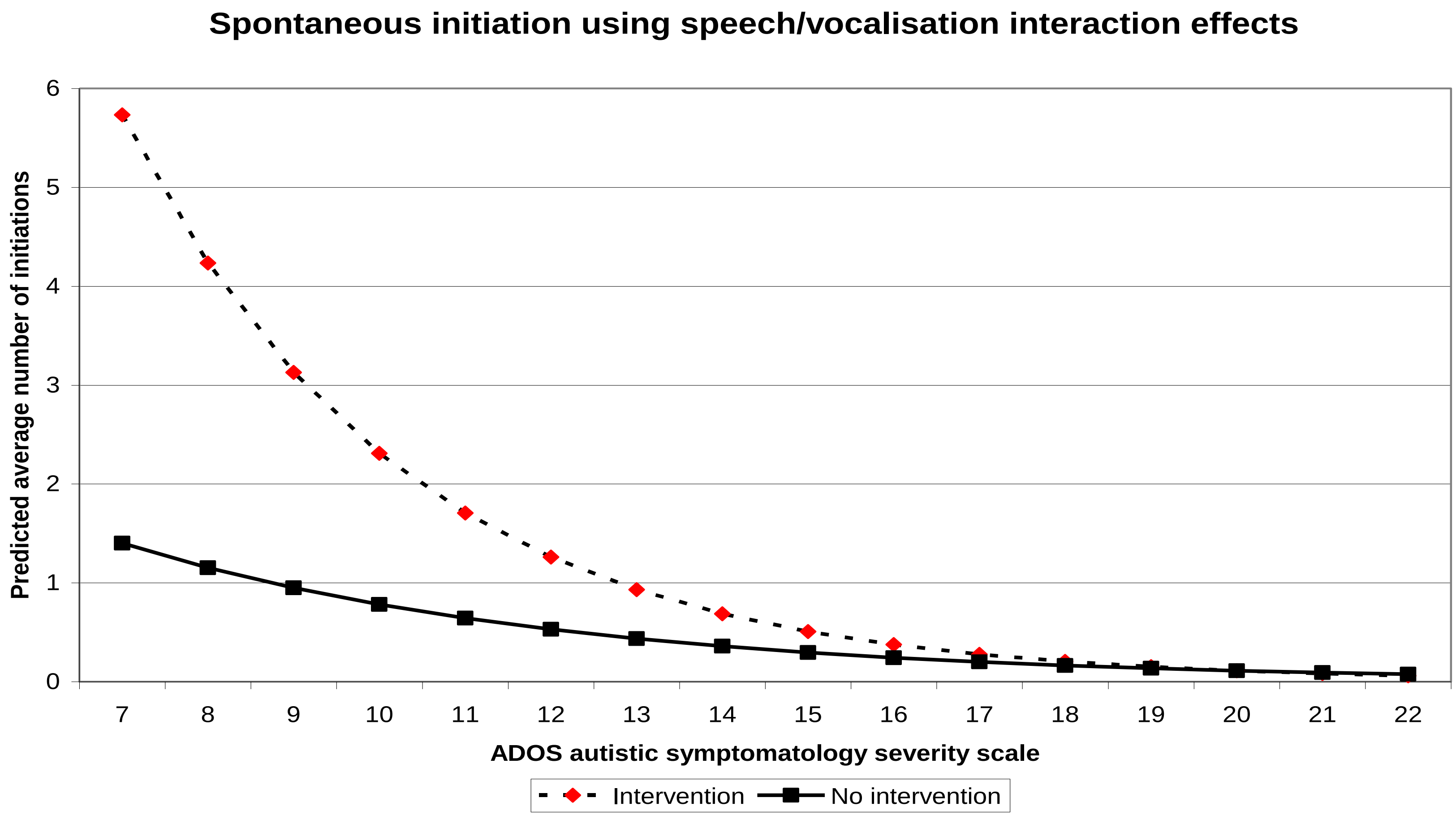
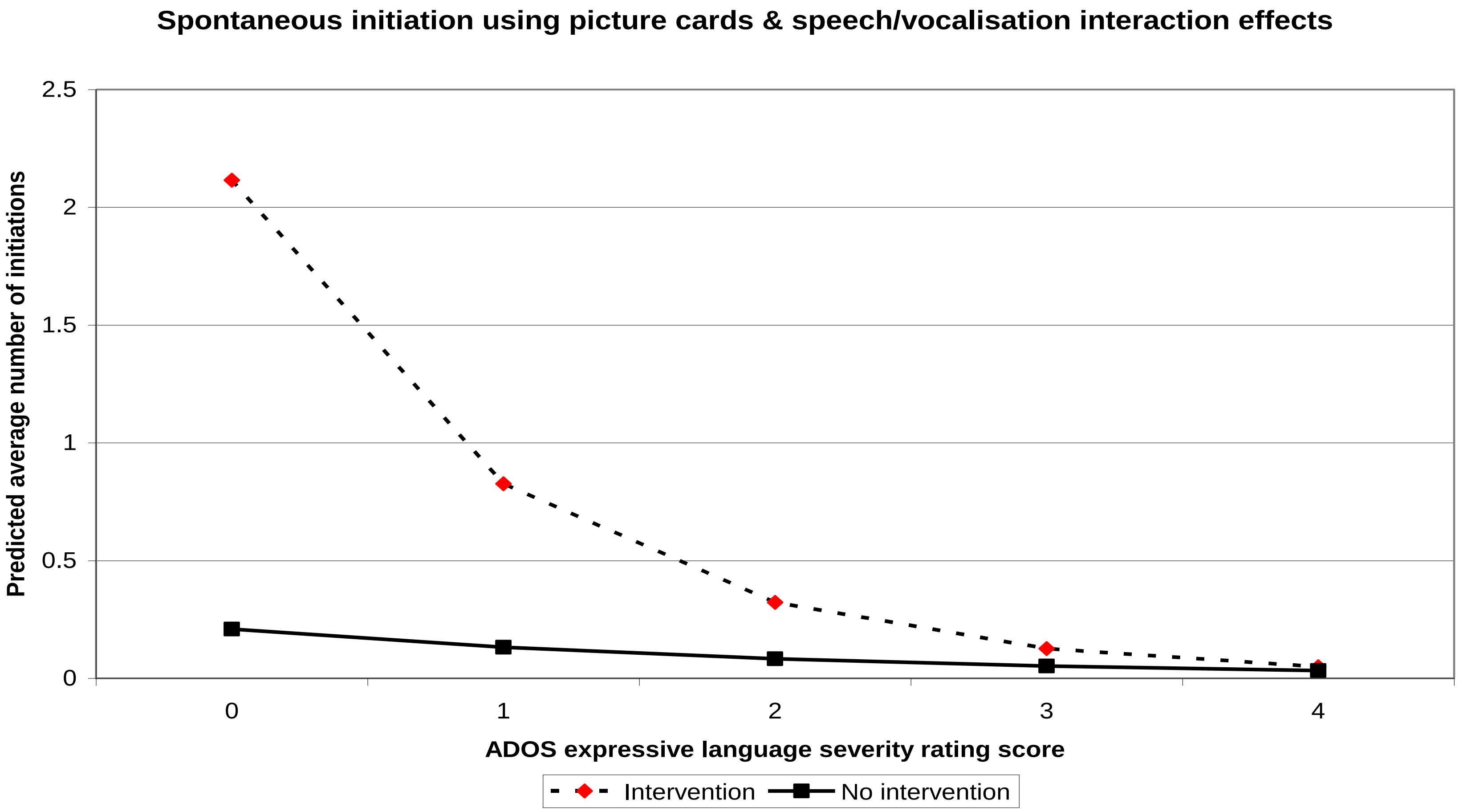

Spontaneous initiation using speech/vocalisation interaction effects
Predicted average number of initiations
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
ADOS autistic symptomatology severity scale
Intervention
No intervention

Figure 3.


Spontaneous initiation using picture cards & speech/vocalisation interaction effects
Predicted average number of initiations
2.5
2
1.5
1
0.5
0
0
1
2
3
4
ADOS expressive language severity rating score
Intervention
No intervention