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BRIEF REPORT

Brief Report: Mediation of Treatment Effect in a Communication Intervention for Pre-School Children with Autism

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Abstract Tests of mediation in treatment trials can illuminate processes of change and suggest causal influences in development. We conducted a mediation analysis of a previously published randomised controlled trial of parent-mediated communication-focused treatment for autism against ordinary care, with 28 children aged 2–5 years (Aldred et al. in J Child Psychol Psychiatr 45:1–11, 2004). The hypothesised mediating process, targeted by the intervention, was an increase in parental synchronous response within parent–child interaction. The results showed partial mediation, with change in synchrony accounting for 34% of the positive intervention effect on autism symptomatology (Autism Diagnostic Observation Schedule communication and social domain algorithm); the result was confirmed by bootstrap estimation. Improved parental synchronous response to child communication can alter short-term autism symptom outcome with targeted therapy.

Keywords Pre-school child · Intervention trial · Parental synchrony · Mediation

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Abbreviations

ADOS	Autism diagnostic observation schedule
RCT	Randomised controlled trial

Introduction

A number of developmentally informed intervention studies have been recently reported in early autism (for instance, Yoder and Warren 2001; Drew et al. 2002; Aldred et al. 2004; McConachie et al. 2005; Kasari et al. 2006, 2010; Dawson et al. 2010; Green et al. 2010). The interventions have varied in target (individual or group, parent-mediated or direct with the child) and method (video-aided or direct therapist intervention), but all have been founded on important mechanisms from the psycholinguistic and speech and language literature relating to typically developing pre-verbal infants, language-impaired children as well as children with autism. For example, a style of parent–child interaction, which is characterised by synchrony and mutual shared attention, has been shown to enhance language development and social engagement in children with autism (e.g. Siller and Sigman 2002; Bruinsma et al. 2004; Wimpory et al. 2007; Adamson et al. 2009; McDuffie and Yoder (2010). Parent attentional cues which maintain the child's focus of attention help children continue to play with an object, whereas cues that redirect attention or introduce new items reduce child object play (Brigham et al. 2010), partly because young children with autism have difficulty with shifting attention (Sanders et al. 2008). Thus interventions which are parent-mediated are expected to be effective where there is focus on training parents to follow the child's lead, that is, to be sensitive in

noticing child cues and responsive to them (Iovannone et al. 2003; Rocha et al. 2007; Smith et al. 2010; Wallace and Rogers 2010).

These intervention studies have shown encouraging effects in relation to a variety of measured outcomes (Rogers and Vismara 2008) but there has been little focus on the process of change and how treatment effects are mediated (McConnell 2002). Mahoney and colleagues (Kim and Mahoney 2005; Mahoney and Perales 2005) are one group to have addressed some aspects of process in their relationship-focused early intervention for preschool-age children with autism spectrum disorder or developmental disabilities. They found that the intervention did increase parental responsiveness and affect as well as child attention, initiation and joint attention—and that this parental change was associated with child outcome. Similarly, Coolican et al. (2010) found that, over time, as parents implemented pivotal response treatment techniques with greater skill, children's functional use of language increased.

We report here a one of the first systematic studies of the mediation of treatment effect, using a secondary analysis of one of these communication intervention trials. Aldred et al. (2004) was a randomised controlled trial of a communication-focused parent-mediated intervention added to treatment as usual (TAU) compared to TAU alone (total $n = 28$). Child participants were aged 24–71 months at referral, with a clinical diagnosis of core autistic disorder confirmed by assessment with ADOS (Lord et al. 2000) and ADI-R (Lord et al. 1994) by the assessing professional team. The trial intervention was 6 months of monthly clinic sessions and 6 months of bi-monthly maintenance sessions; measurement was at baseline and primary endpoint of 12 months. The manualised parent-mediated and video-aided intervention programme was organised into six incremental developmental stages, reflecting the progression of early social, pre-linguistic pragmatic communication and language skills (further details in appendix 2). The proximal therapeutic target of the intervention was the enhancing of parental responses to child communications, with the aim that this would in turn increase child communication and development of child language. There was no direct work with the child in this intervention. The main programme was delivered by speech and language therapists in a clinic base, with an additional home programme to encourage parents to generalise the use of play-based adapted communication interaction and daily activities with their child. The 2004 paper reported a positive treatment effect over control on the pre-specified primary outcome of endpoint autism symptoms (ADOS social–communication algorithm score), as well as in secondary outcomes of parent synchrony in communication, gains in child expressive vocabulary and child communication acts in parent–child play. The trial design also included specific measurement of hypothesised mediating processes by including a new measure of Parent–Child Interaction (PCI) that addresses key aspects of dyadic communication described above as relevant to development in this area, particularly the balance of interaction between child language and communication development and parent response. This measure allowed us to investigate systematically the mediation processes in the intervention, the subject of this report.

In addition to the value of understanding treatment process, appropriate analysis of process and mediation in experimental trials in this way can give the additional benefit of illuminating aspects of developmental theory related to causal influence (Green and Dunn 2008; Howe et al. 2002). The argument here is that if an intervention is successful in specifically changing a key mediating process in the development of a disorder, then a randomised allocation trial of the intervention can also be interpreted as a developmental study of matched parallel cohorts–one of which receives an intervention designed to alter a key variable in the development. Looking at the consequences of the 'developmental perturbation' in the target cohort can then be a powerful means of allowing causal influence about characteristics of the development of the disorder.

Methods

Measures

Parent–Child Interaction measure (PCI) used a 10-min video coding of free play between parent and child using a standard set of toys. Standardised event sampling was carried out recording the frequency of parent synchrony/asynchrony and parent and child communication acts (see "Appendix 1" for details of coding and reliability). The key PCI variable reported in this paper is the number of total parent communication acts which were synchronous; that is, comments, statements, acknowledgements or social interaction maintaining the child's responses (Shapiro et al. 1987).

Autism Diagnostic Observation Schedule. The total social communication algorithm score on the ADOS (Lord et al. 2000) was the pre-specified primary outcome measure in the main trial analysis (Aldred et al. 2004): and was therefore used as the outcome measure in this analysis. Administration and coding procedures on the ADOS were detailed in Aldred et al. (2004); module one or two was used in the standard way, depending on the language competency of the children. Two independent coders were trained to standard 85% ADOS reliability and all codings were made blind to allocation status and order, with great

attention paid to minimize generalized learnt effects by using a separate examination environment and materials in a different location to the intervention.

Macarthur Communicative Development Inventory (MCDI; Fenson et al. 1993) was used as a parent report measure of expressive language.

Analysis

Effect of intervention on the baseline and endpoint PCI variables was initially investigated using two-way repeated measures ANCOVA covarying for baseline age and expressive language (MCDI, Aldred et al. 2004). The variable emerging most strongly from this analysis, change in parent synchrony, was examined here against other variables and subjected to formal test of statistical mediation, using a standard sequential regression approach with simultaneous entry of variables (Baron and Kenny 1986). The treatment outcome tested was the ADOS social communication algorithm total score. Independent variables examined in the analysis were: treatment allocation in the context of the intention to treat analysis, baseline ADOS social-communication algorithm total score and change in parental synchrony. Given the relatively small sample size, focus in the analysis was on effect sizes with confidence intervals (that can be estimated independent of sample size) rather than significance levels (which are dependent on sample size for their estimation). The robustness of this estimation of mediation was then formally tested using a specific bootstrap procedure for mediation models (Preacher and Hayes 2008).

Results

Children in the treatment and control groups were well matched at baseline (Table 1).

Over the 12-month intervention period, the treatment group showed significant improvement in parental synchronous communication acts (mean increase of 7.3 acts) compared to controls (mean decrease of 7.6 acts; Table 2, Figs 1, 2). Change in parental synchrony was independent of baseline measures of child's age ($r = -.03$, $p = 0.8$) and expressive language ($r = .29$, $p = 0.14$). Qualitatively, intervention parents demonstrated an increase in comments and statements contingent on the child's focus, action and events whereas control parents continued to use more asynchronous than synchronous responses with use of language aimed at re-directing the child's attention, shifting topic, or eliciting non-verbal or verbal answers from the child.

Increase in parent synchrony was associated with increase in children's active participation in the interaction as measured by total child communication acts ($r = .39$, $p = .043$). Qualitatively at post treatment assessment, children in the treatment group were noted to use a range of single words socially to seek attention, request and direct attention and reduced frequency of echolalic responses. This contrasted with control participants who were more likely to use words for labelling objects, with less intentionality or communicative effect.

Increase in parent synchrony was also correlated with a mean 4.5 point reduction in the child's ADOS algorithm score, that is, becoming less impaired ($r = -.47$, $p = 0.014$), whereas the control group showed reduction in synchrony and a small mean increase of mean 0.5 points in ADOS score (Table 2, Figs 1, 2).

Table 1 Baseline child characteristics

	Treatment	Control
Boys:girls	13:1	12:2
	Mean (SD)	Mean (SD)
Age (months)	51.4 (11.8)	50.9 (16.3)
Vineland adaptive behavior composite	25.6 (9.2)	22.0 (5.6)
Vineland communication sub-domain	22.6 (13.3)	20.0 (10.8)
Vineland social sub-domain	18.2 (5.8)	16.3 (3.6)
	Median (range)	Median (range)
MacArthur Communicative Developmental Inventory words produced	69.5 (467)	78.5 (683)
MacArthur Communicative Developmental Inventory vocabulary comprehension	95.0 (381)	144.0 (426)
	Mean (SD)	Mean (SD)
PCI-child communication acts	30.8 (10.2)	30.1 (11.1)

Test of Mediation

The standard Baron and Kenny (1986) approach tests whether the proposed mediator (M) mediates the effect of the Treatment (X) on outcome (Y). The analysis conducts a sequence of multivariate analyses testing the effect of X on Y, X on M, and X on Y in the presence of M (Table 3). In summary, our analysis showed: (1) the large effect size (0.94), as previously reported, of the treatment on ADOS outcome (B = 4.25 (1.73) $p = .022$); (2) a large effect size (0.81) of treatment on the hypothesised mediator, change in parental synchrony (B = −14.8 (7.06) $p = .047$). (3) Simultaneous entry of hypothesized mediator and treatment into the model predicting outcome (step 3, Table 3) produced a reduction (1.45) in the coefficient of the treatment effect, which then became non-significant. This

Table 2 Parent-child interaction and ADOS scores at baseline and follow up

Variable	Group	Baseline mean (SD)	Follow-up mean (SD)
Parent synchrony* (frequency)	Treatment	57.8 (15.0)	65.1 (14.3)
	Control	56.4 (16.5)	48.9 (19.5)
ADOS social communication algorithm total+	Treatment	16.1 (4.5)	11.8 (6.4)
	Control	15.6 (4.9)	16.1 (4.4)

* $n = 27$ for parent synchrony–missing observation on 1 parent

+ Module 1 in 19 cases (9 treatment, 10 control); Module 2 in 9 cases (5 treatment, 4 control)

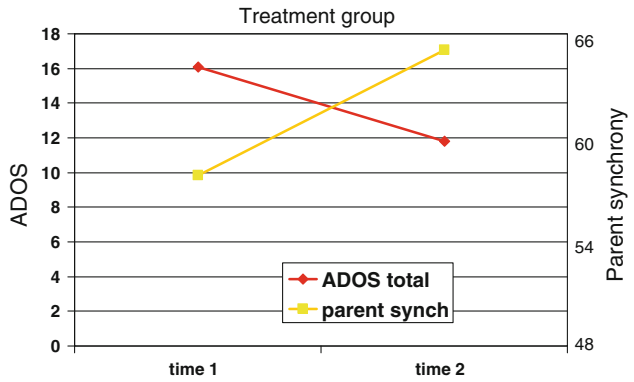

Fig. 1 Parent-child synchrony and ADOS total (treatment group)

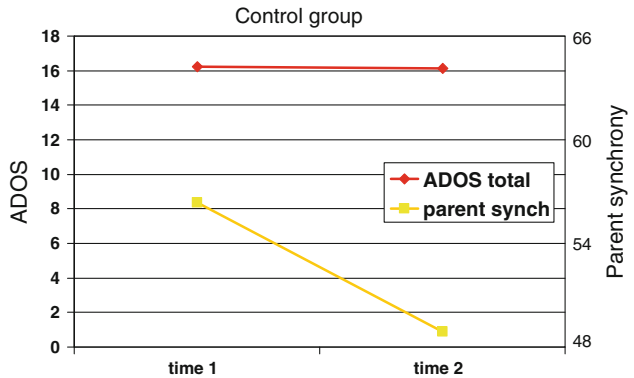

Fig. 2 Parent-child synchrony and ADOS total (control group)

finding is consistent with partial mediation of the effect of treatment on outcome by change in parental synchrony (Baron and Kenny 1986); 34% of the total effect of treatment on outcome is explained by the change in parental synchrony and there is a moderate effect size of the 'indirect path' on outcome of 0.38. Given the small sample size, the robustness of this result was then tested using a specific bootstrap procedure for mediation models (Preacher and Hayes 2008). Over 5,000 trials, the bootstrap estimated indirect effect was 1.28 (SE 0.936 CI 0.046–4.02, $p = 0.12$). The fact that the bootstrap CI does not contain zero implies that the estimated indirect effect is significantly different from zero, and confirms the mediation finding.

Discussion

Formal tests of mediation and process of treatment are rare in the autism treatment literature but crucial if lessons are to be learned about the effective components of treatment and hence development of better intervention strategies. This study tested an apriori hypothesis about the mediation of the positive treatment effect found in one pilot RCT (Aldred et al. 2004). We found evidence that the change in parental synchrony—the proximal target of the intervention in this trial—did indeed partially mediate the effect of treatment on ADOS outcome found in the trial.

The relatively small sample size in this trial was a potential limitation for the mediation analysis. For the estimation we therefore examined effect sizes with confidence intervals in the estimation, rather than rely on significance levels that are dependent on sample size; and we tested the robustness of our result with a 5,000 iteration bootstrap procedure. There were, in addition, design features in the original trial that also tended towards mitigation of the limitation of sample size; for instance the inclusion criteria in the trial were rigorous and restricted to core autism. While the results of this procedure provide strong evidence of the existence of a mediation effect, the small sample size makes it difficult to quantify its strength and our findings need replication on larger and diverse samples.

Other caveats to our conclusions need stating: The ADOS social-communication domain algorithm score was the nominated primary outcome of the trial and theoretically supported dependent variable in the analysis. Nevertheless all measures were conducted at baseline and endpoint and there was no intermediate measurement; we cannot rule out a 'reverse causality' in which a primary ADOS change in itself influenced synchrony, although the parent-mediated structure of the intervention (with no direct therapist-child work) would seem to make this unlikely. Our results only apply to relatively short-term effects of treatment (i.e. 1 year follow up) and we have no evidence as to whether these would be sustained over time or widely generalised; longer-term study of social communication intervention effects for young children with autism is needed to detect any ongoing benefits of communication focused intervention in early childhood. We considered the possibility that communication gains in the treatment group might be a non-specific effect of increased

Table 3 Analysis of mediation

Model	B	SE	95% CI	Effect size	*p*
STEP 1 *(dependent variable: ADOS T2)* Adj $r2 = 0.39$					
(Constant)	−0.54	3.41	−7.58 to 6.5		.875
ADOS total T1	.77	.20	0.36–1.18		.001
Treatment allocation	4.25	1.73	0.67–7.82	$d = 0.94$	.022
STEP 2 *(dependent variable change in parental synchrony)* Adj $r2 = 0$ .09					
(Constant)	10.6	13.9	−18.1 to 39.3		.45
Treatment allocation	−14.8	7.06	−29.4 to −0.23	$d = 0.81$	.047
ADOS total T1	−.202	.81	−1.9 to 1.46		.81
STEP 3 *(dependent variable ADOS T2)* Adj $r2 = 0.5$					
(Constant)	.48	3.2	−6.2 to 7.2		.882
ADOS total T1	.747	.19	0.36–1.1		.001
Change in parent synch	−.1	.047	−0.2 to −0.0003	$r = 0.4$	.049
Treatment allocation	2.8	1.76	−0.85 to 6.45	$d = 0.66$	.17

For effect sizes, *d* Cohen's d, *r* partial correlation

$n = 27$ for the analysis; observation of parent synchrony missing in one case

attention, counselling or simply time spent in the clinic. This was however considered to be highly unlikely given the evidence for specific rather than generic changes in parent–child interaction, in which increased parent synchrony correlated with significant increases in concurrent child social-communication skills and language on standardised measures. Finally, while this test of mediation within a randomised analysis is accepted as standard, it does depend on the assumption that the level of the mediator is determined by randomisation; in other words that there is no hidden confounding effect of mediator on outcome (Dunn and Bentall 2007). We could identify no such confounders in any measures made in the trial—but this remains a possibility to be tested in further studies.

Implications

With the caveats above, these findings firstly support the theory and modelling behind the communication-focused intervention in its proximal focus on enhancing parental sensitivity and responsivity. In this they are also consistent with the findings of Mahoney and Perales (2005) and Coolican et al. (2010) in relation to the process of change in similar autism interventions. These findings from an experimental trial also allow an inference regarding directions of effect within development (Green and Dunn 2008), namely here that the quality of parental synchrony does impact on the developmental trajectory of an autistic child's communication—which supports the direction of effect suggested by some other longitudinal observational studies (e.g. Siller and Sigman 2002). Note that there is no implication here that interactional factors such as parental synchrony have a primary causal role in autism; rather that children with autism benefit from a higher degree of synchrony in the reactions of adults who interact with them.

Findings of effective mediators in treatment trials should be used in turn to target more effectively future treatment interventions (Kraemer et al. 2002; Stahmer et al. 2010). The fact that improvement in parental synchrony was found to mediate the positive outcome of intervention in this treatment trial suggests that future treatments of this kind should incorporate a targeted approach to modifying parental synchrony. However in this context it should be noted that our subsequent replication study (Green et al. 2010), while also finding a strong intervention effect on parental synchrony and associated child communication within the child-parent dyad, did not find the downstream generalisation to autism symptoms reported here. This suggests that outcome and mediation effects found across studies will not be uniform, and that generalisation of treatment gains across contexts needs to be an equal target of intervention. Iterations of studies of both outcome and process are needed to incrementally refine the efficiency of intervention strategies for early autism. As part of such enhanced intervention targeting, measurement of parent–child interaction at baseline could also be applied to identify individual dyadic profiles between children and parents, helping further to individualise treatment strategies in the context of individual differences in parent and child functioning.

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Appendix 1. Measurement and Reliability of PCI Codes

Method

Standardised event sampling was carried out recording the frequency of parent synchrony/asynchrony and parent/child communication acts.

Code Definitions

	Description
Definition of parent codes	
Synchronous communication acts	Verbal non-directive communication acts: comments, statements or acknowledgement of the child's focus of attention
Asynchronous communication acts	Verbal acts used for the purpose of directing or to control the behaviour of another; commands, directing or seeking attention; questions or negation
Definition of child and parent code	
Communication acts (CA)	Verbal or non-verbal acts used with intent or to influence the responses of the other person including requesting, seeking attention, directing, acknowledging, questions, demands, comments or statements

Inter-rater Reliability

For the Parent–Child interaction measure, two raters independently reviewed the 10-min parent–child interaction videos along with their transcripts in 7/28 (25%) of study cases. Each parent-spoken utterance identified on the transcript was coded for synchrony. Agreement on synchrony between these independently rated codes was 95.6% (kappa = .92). Subsequently, codes with inter-rater disagreement on original scores were resolved by conference, reviewing the utterance on question on video and transcript and agreeing a consensus code to be used in the analysis. A training programme and manual is available for the dyadic measure of communication.

Note on Codes

Echolalia is defined as child responses that repeat back precisely the adult's utterance with an identical intonation pattern and do not form part of a communication function. *Imitation* is defined as the child's imitation of words with appropriate intonation, and is coded for communication intent. *Synchronous carer responses* comment on the child's focus and respond to the child's topic of talk. Details of synchrony coding are illustrated in the following transcript. The pre-treatment sample shows predominant asynchrony coding. The post treatment sample shows increased parental synchronous codes with language that expands and builds on the child's vocabulary and grammatical structures. With this there is associated increase in child communication initiation and language. Parent and child are playing with a selection of toys (plastic food, tea set, cutlery, puppet, figures, animals, garage and vehicles).

Pre treatment (baseline)

Mum: have some dinner now (Asynchronous)

D: Uh? Mum: have some dinner? (Asynchronous)

Mum: there's your plate to have some dinner, there's daddy's, there's mummy's (Asynchronous)

Mum: have you got your knife and fork? (Asynchronous)

D: fork (echolalia not coded as communication)

Mum: I'm going to have my dinner now. There you are, there's your plate. What do you want to eat? (Asynchronous)

D: eat? (Echolalia not coded as communication)

Mum: what do you want to eat? (Asynchronous)

D: eat; fork (Echolalia not coded as communication)

Post treatment (12 month follow-up)

D: wash little girl (holding small figure near toy sink) (Communication initiation)

Mum: washing hair little girl (Synchronous)

D: shampoo (showing small bottle to mum) (Communication initiation)

Mum: shampoo? (Synchronous)

Mum: put shampoo on, nice and clean (Synchronous)

D: freezing cold (Communication initiation)

Mum: yes she's freezing cold (Synchronous)

D: need a toilet, need a wee (pointing to miniature toilet) (Communication initiation)

Mum: she needs the toilet; she needs a wee, (Synchronous)

Mum: here you are, here's the toilet. (Synchronous)

Mum: She needs to wash her hands now. (Synchronous)

D: wash hands… good girl…(Communication initiation)

D: tap off…(Communication initiation)

D: pull the chain…wash her hands (Communication initiation)

Mum: wash hands little girl, (Synchronous)

Mum: turn the tap off (Synchronous)

D: need a toothbrush (showing small stick representing tooth brush) (Communication initiation)

Mum: let's find a toothbrush (Synchronous)

Mum: this can be a toothbrush (Synchronous)

Mum: there she's wiping her mouth now (Synchronous)

Appendix 2. Intervention Procedures

This parent mediated intervention trained parental communication responses adapted to the individual child's communication skills. The treatment is mannualised with 6 stages to reflect the developmental progression of pre-linguistic skills. Child meaningful communication responses were enhanced, reducing echolalia or scripted speech. The intervention trains parents in adapted communication using video-aided feedback of parent–child play. Parents attend monthly 3 h clinic sessions for 6 months and 3 maintenance session for 6 months. The therapists use a reflective style to elicit heightened parent observation, understanding and progress whilst framing the focus of the observations within the stages of the manual. Parents undertake to spend 30 min daily between clinic sessions practising strategies recorded in the written home programme. The pace of work is individualised to the parents' style and progress and the child's accomplishment of developmental goals at each stage. Not all children progressed to stage 6.

The intervention goals firstly aim to and increase parental synchrony and sensitivity by increasing timely reciprocal responses matched to the child's observed communication. Shared attention is elicited by the parental observing the child's focus and intent. Incremental development of child communication is facilitated through the stages of the manual and the treatment gains are generalised into everyday routines. Parent–child video observation established the level of accomplishment at each of the stages in the manual.

Stages of the treatment programme:

- Eliciting shared attention, communication, enjoyment
  - *Parents observing the child's focus, inferring intentions*
- Enhancing parental synchronous response
  - *Parents using timely reciprocal comments, acknowledging the child's focus, avoiding asynchronous responses that re-direct, question or make demands on child responses.*
- Adapted communication strategies for parents
  - *Parent matching language use to child understanding, semantically contingent on child play*
- Eliciting child anticipation initiation and participation
  - *Predictable sequences, routines, repetition, rehearsed play, imitation*
- Developing child communication initiation/pragmatic functions
  - *Communication teasers*
- Elaborating child communication
  - *Language extensions/elaboration*
  - *Conversational reciprocity*

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