INT J LANG COMMUN DISORD, JANUARY–FEBRUARY 2011,
VOL. 46, NO. 1, 108–119

Research Report

Narrative comprehension in 4–7-year-old children with autism: testing the Weak Central Coherence account

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(*Received 25 September 2009; accepted 10 February 2010*)

Abstract

Background: Despite somewhat spared structural language development in high-functioning autism, communicative comprehension deficits persist. Comprehension involves the integration of meaning: global processing is required. The Weak Central Coherence theory suggests that individuals with autism are biased to process information locally. This cognitive style may impair comprehension, particularly if inferencing is required. However, task performance may be facilitated by this cognitive style if local processing is required.
Aims: The current study was designed to examine the extent to which the 'weak central coherence' cognitive style affects comprehension and inferential processing of spoken narratives. The children with autism were expected to perform comparatively poorer on inferences relating to event scripts and comparatively better on inferences requiring deductive reasoning.
Methods & Procedures: Fourteen high-functioning children with autism were recruited from databases of various autism organizations (mean age = 6:7, 13 males, one female) and were matched on a receptive vocabulary and a picture-completion task with 14 typically developing children recruited from a local childcare centre (mean age = 4:10, seven males, seven females). The children were read short stories and asked questions about the stories.
Outcomes & Results: Results indicated that the children with autism were less able to make inferences based on event scripts, but the groups did not differ significantly on inferences requiring deductive logical reasoning. Despite similar group performance on questions relating to the main idea of the stories, only for the typically developing group was good performance on extracting the main idea of the narratives significantly correlated with performance on all other comprehension tasks.
Conclusions & Implications: Findings provide some support for the Weak Central Coherence theory and demonstrate that young children with autism do not spontaneously integrate information in order to make script inferences, as do typically developing children. These findings may help to explain communicative problems of young children with autism and can be applied to intervention programme development. More research on the link between a 'weak central coherence' cognitive style and communicative comprehension in autism will be valuable in understanding the comprehension deficits associated with autism.

Keywords: autism, narrative, language.

What this paper adds

Research shows that children with autism have specific difficulties with verbal comprehension, in particular inferential processing. Also, children with autism are characterized by a detailed focused cognitive style, a 'weak central coherence'. Little research on the relatedness of these two aspects in autism has been conducted; therefore, this study was conducted to further knowledge of language-processing difficulties in autism. Results show that children with autism did not create a conceptual framework based on the main idea of the stories in the same manner as typically developing children. Children with autism were found to have specific difficulties answering questions of verbal narratives relating to event scripts. It seems children with autism have difficulty chunking information in a meaningful way, which may lead to impaired comprehension in communicative contexts. This information is useful for intervention programme development for young children with autism.

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International Journal of Language & Communication Disorders
ISSN 1368-2822 print/ISSN 1460-6984 online
DOI: 10.3109/13682822.2010.484847

Introduction

Despite somewhat spared structural language development in high-functioning autism, communicative comprehension deficits persist (Lord and Paul 1997). Although not a formal diagnostic category, 'high-functioning' autism is the label given to those on the spectrum who have a full-scale intelligence quotient (IQ) score of 70 or above and fluent speech after the preschool years (Minshew *et al.* 1992). High-functioning individuals with autism have a noted impairment understanding what others say, with severe difficulties using contextual cues to appreciate the meaning of interactions (Happé 1994a, Lord and Paul 1997). This is illustrated in their tendency for over-literal interpretation of messages without an awareness of a speaker's intention (Lord and Paul 1997). A further example is in their impaired comprehension of phrases, although the comprehension of single words that make up the phrase is unaffected (Minshew *et al.* 1995). Preliminary evidence suggests that, in particular, inferencing skills, the ability to fill in information that is not overt in a message, are poor in high-functioning autism. Inferential processing skills are not only essential to comprehension, but also are important for more general social functioning (Gopnik *et al.* 2000).

However, few autism studies have focused on this area of comprehension. Minshew *et al.* (1995) gave a series of language and literacy tests to children with high-functioning autism and IQ-matched controls and found the most striking group performance discrepancy was on tasks of inferencing and processing of metaphoric expressions. Norbury and Bishop (2002) found that children aged 6–10 with high-functioning autism were less able to make inferences about spoken narratives that were relevant to the story context, despite comparable performance on factual questions. Thus, their inferences reflected content knowledge without an appreciation of the story context at hand. Jolliffe and Baron-Cohen (1999) used a bridging inference task, which requires participants to choose a sentence to link two sentences together in a coherent way. Success on this task required an integration of contextual cues given in the sentences with the individual's own content knowledge. Individuals with high-functioning autism performed poorly on this task compared with the IQ matched control group. Likewise, Jolliffe and Baron-Cohen (2000) asked individuals with high-functioning autism inference questions about spoken narratives and found that they performed comparatively poorer compared with a comparison group with typical development matched on IQ, despite good performance on recall questions and questions about the main character's goal. Taken together, these findings suggest that individuals with high-functioning autism demonstrate difficulties with inferential processing, which appears to reflect an inability to integrate the immediate context with their own content knowledge.

Message comprehension requires an integration of meanings of individual words, sentences and paragraphs, as well as key ideas and themes. General knowledge needs to be applied to varying contexts. Information from various sources needs to be incorporated as a whole, using 'gestalt-like' global processing (Oakhill and Cain 2004). Instead of spontaneously employing global processing (the default processing style in typically developing individuals), it is argued that individuals with autism are biased to process information on a local level, with particular attention to detail; they have a 'weak central coherence' (Frith 1989). By contrast, typically developing individuals are characterized by a 'strong central coherence' (Frith 1989). As comprehension requires global processing, this local processing bias may account for some comprehension problems in autism.

A specific comprehension skill involved in communicative contexts is *narrative comprehension*. Narrative comprehension skills refer to the ability to process a narrative, which is a series of an actions and events that unfold over time according to causal principles (Graesser *et al.* 1980). Children are surrounded by narratives from their earliest language experiences (Skarakis-Doyle and Dempsey 2008). For instance, parents model the structure of narratives to their children by telling stories of personal experiences to others in their presence (Fiese and Sameroff 1999). Narratives become important for communicative comprehension, as they become the framework for the expression of daily experience, and are thus interwoven into everyday social interactions. While children have developed a repertoire of knowledge about narratives by the age of 3 (Stein and Albro 1996), there is a great deal of development in narrative skills between the ages of 4 and 8 years (Berman and Slobin 1994).

Whether fictional or non-fictional, the processing of narratives includes three key skills: the ability to infer causal relationships between events, to distinguish the goal and internal states of the people mentioned and to conceptually integrate different sections of the story or account (Graesser *et al.* 1994). Many interrelated microskills are common to communicative and narrative comprehension, including vocabulary and syntactic knowledge, and prepositional and relational concepts (Skarakis-Doyle and Dempsey 2008). Additionally, short-term auditory memory and attention skills are important. Therefore, studying verbal narrative comprehension can provide information on comprehension of fictional stories and comprehension in conversational contexts.

For a narrative to be taken as a coherent unit, inferential processing skills are required to build a mental

representation (Graesser *et al.* 1994; Skarakis-Doyle and Dempsey 2008). Consider this example based on Charniak (1972):

> Jane was invited to Jack's birthday party. She wondered if he would like a kite. She went to her room and shook her piggy bank. It made no sound.

Many inferences need to be made in order to appreciate this message fully: if the piggy bank made no sound then there is no money. If there is no money, a gift cannot be bought for Jack, whose birthday is coming up or has just passed since he is having a birthday party. To make an inference as to the meaning of Jane's actions, one must draw on *event schema* of birthday parties and associated conventions.

Event schemas are mental representations of what happens in common real-life events. They are highly organized knowledge structures, in which the script of the event, and certain goals and sub-goals, are represented in generalized terms (Schank and Abelson 1977). Event schemas are built up and based on experience, thus involve constructive and reconstructive memory processes, by which the information central to the theme or story is retained and minor details are omitted (Slackman and Nelson 1984). They provide a framework for understanding events, accounting for the infinite variability in event details (Loth *et al.* 2008). In familiar situations, schematic event representations are thought to be automatically activated, providing expectations and guiding comprehension, action and later recall of the event (Slackman and Nelson 1984). Thus, event schemas include relational information of parts to the whole and to each other (Slackman and Nelson 1984).

Inferences based on event schemas are *script inferences*. As script inferences require global processing of event schemas, it can be hypothesized that inferences of this type would be harder for individuals with autism. Some evidence supports this view. For example, Volden and Johnston (1999) found that high-functioning children and adolescents with autism aged 6:10–18:6 were less able to generate core elements to the scripts spontaneously, focusing more on irrelevant or minor details, while Loth *et al.* (2008) found that individuals with autism aged 8:5–28:8 demonstrated intolerance to event variability, insisting that optional aspects were either always present or not present at all (for example, buying ice cream is an optional aspect of going to the supermarket). However, there is also counter-evidence. For example, Volden and Johnston (1999) also found that their sample of high-functioning children and adolescents with autism could correctly predict the next core activity in videotaped vignettes of familiar events, and Loveland and Tunali (1991) reported that participants with autism behaved appropriately in an acted out tea-party situation.

Script inferences can be contrasted with *propositional inferences.* Propositional inferences are based on logical relations between story statements. The underlying structure of these inferences is based on formal deduction whereby two premises are given, from which a logical conclusion is drawn. As propositional inferences rely on local processing, not the integration of previously acquired knowledge, it is hypothesized that individuals with autism would be at an advantage on these types of inferences. In support, Scott *et al.* (1999) found superior logical reasoning skills in children and adolescents with autism aged 7:9–18:0, compared with verbally matched controls. An example of an item they used is as follows:

> Major premise: All cats bark.
> Minor premise: Rex is a cat.
> Conclusion (test question): Does Rex bark?

The typically developing children probably considered that in the real world cats do not bark, and that Rex is a typical name for a dog. Children with autism presumably perform well on tasks like this because they do not let real-world knowledge determine their response (Markovits 1995). That is, the children with autism performed well on the tasks because of a local processing bias, as predicted by the 'weak central coherence' account. They reacted to the information provided rather than drawing on existing knowledge. Thus, a 'weak central coherence' cognitive style may help to explain superior, as well as impaired comprehension, depending on the task at hand.

Consistent findings have also shown that individuals with autism lack a Theory of Mind; it is generally argued that they are unable to comprehend the social world due to an inability or reduced ability to attribute mental states to others and to themselves, such as intentions, desires and beliefs (Baron-Cohen 1995). However, recent findings have shown that higher functioning individuals with autism can pass theory of mind tests, such as false belief tasks (for example, Happé 1994b, and Ozonoff *et al.* 1991). Despite this, social interaction and communicative difficulties among this sub-group of autism persist (Klin *et al.* 2007). By contrast, the weak central coherence cognitive style of autism seems to characterize individuals on the spectrum, regardless of their language or socio-cognitive function (Happé 1994a). Evidence for this cognitive style is mounting (for a review, see Happé and Frith 2006), but one must consider that there may be sub-types of individuals with autism for whom this cognitive style does not apply. The Weak Central Coherence (WCC) theory does, nevertheless, help to account for the specific

comprehension problems and local processing advantages experienced by individuals with autism, as mentioned above.

The original conception of the WCC theory was that this detail processing style was at the expense of global processing or meaning extraction (Frith 1989). However, many tasks aimed at assessing weak coherence have placed global and local processing in a direct trade-off, a point recently raised by Happé and Booth (2008). Thus, it is unclear whether results indeed reflect poor global performance in autistic spectrum disorder (ASD), enhanced local processing, or both. Research has shown that when high-functioning individuals with autism are primed for global processing, they can perform similarly to typically developing individuals (Happé and Frith 2006). For example, Snowling and Frith (1986) emphasized the special status of homographs before administering tasks in which children with autism had to disambiguate their pronunciation and meaning (on the basis of preceding sentence context); they found 'the impairment' noted by others (for example, Frith and Snowling 1983) was not apparent. If adequate priming is provided, individuals with autism are capable of global processing or meaning extraction.

Previous research on the WCC theory in autism has focused on the visual–spatial influences of this cognitive style. For example, a common finding is that individuals with autism demonstrate superior performance on the Block Design sub-test from the Wechsler Intelligence Scales (for example, Shah and Frith 1993). Much less research has been conducted on how this cognitive style affects verbal–semantic processing, especially in regards to inferential processing. In an empirical review of studies which aimed to assess coherence in individuals with autism, Happé and Frith (2006) reported on 43 studies in the visual modality, six in the auditory modality and nine using verbal tasks. Of these nine, five focused on homograph selection. Although informative, comprehension studies on homograph disambiguation do not provide information on the everyday comprehension problems of individuals with autism. Moreover, homograph studies are guilty of the local versus global trade-off mentioned above (Happé and Booth 2008). Only three of nine studies included tasks on inferential processing of stories (Norbury and Bishop 2002, Jolliffe and Baron-Cohen 1999, 2000) (see also above), possibly because the standardized instruments currently available to assess inferential processing or central coherence in young children are limited. The researchers of these studies concluded that individuals with autism demonstrated difficulties in inferential processing due to poor global processing. The question of whether the two main facets of weak central coherence, enhanced local processing and impaired global or integrative processing, are cross-modality phenomenon is still under debate. Lopez and Leekam (2003) note that most evidence for poor integrative processing comes from studies in the verbal–semantic modality whereas the overwhelming evidence for enhanced local processing mostly comes from the visual–spatial modality (Happé and Frith 2006). In their study, Lopez and Leekam (2003) found that children with high-functioning autism (mean age 13:10) did not differ from an IQ-matched control group in their ability to use context in either a visual task or a verbal task. Rather they found specific impairments in the children with high-functioning autism's ability to disambiguate homographs, concluding that they have specific problems with complex verbal stimuli. Hoy *et al.* (2004) found similar results with homophones and concluded that their results reflected verbal ability rather than diagnostic status (with/without autism). Therefore, autism researchers are not in agreement on this issue, and more research in weak coherence and its pervasiveness across modalities is required to add to our state of knowledge.

The main aim of the present study was to assess the communicative comprehension of children with autism using short spoken narratives. A further aim was to test the predictions of the WCC theory in relation to verbal–semantic processing. This theory has proved useful in understanding perceptual differences in autism, but more research is needed in the verbal–semantic domain to determine whether it is also useful in explaining the comprehension skills in young children with high-functioning autism. As part of a longer study, tasks were included to examine whether the 'weak central coherence' cognitive style affects comprehension of spoken narratives for individuals with autism. Three hypotheses were made:

- If children are primed to the event type by the title of a story, children with autism would perform comparable on questions relating to the main idea in short narratives and better than typically developing children on questions about detail.
- Children with autism would perform worse than a typically developing group on script inferences, but better on propositional inferences because only local processing is required for the latter.
- In relation to the visual–spatial and verbal–semantic relatedness of a WCC cognitive style, good performance on a block design task would be associated with good performance on comprehension tasks focusing on detail and logical relations. Since good local processing is not at the expense of global processing, for the children with autism, good performance on local processing tasks would not be associated with poor performance on tasks requiring global processing.

Methods

Participants

A total of 28 children comprised two groups, 14 children with autism (13 males, one female) aged 4:6–7:11 (mean = 6:7, standard deviation (SD) = 13.72 months), and 14 typically developing children (seven males, seven females), aged 4:2–5:4 (mean = 4:10, SD = 4.05 months). All children with autism had a documented formal diagnosis of autism from different diagnostic teams. In Melbourne diagnostic teams rely on the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association 1994) criteria; the Autism Diagnostic Observation Schedule (ADOS; Lord *et al.* 1999) is not regularly used. The children with autism were all considered to be high functioning by these professionals. The children with autism were matched in ability on a verbal and non-verbal measure of intelligence from the Wechsler Preschool and Primary Scale of Intelligence—Third Edition (WPPSI-3; Wechsler 2002) (see the Materials and Methods section for matching procedures and the sub-tests used). They were recruited from Irabina Childhood Autism Services, Autism Victoria, and a registry of families interested in participating in autism research (Olga Tennison Autism Research Centre, La Trobe University). Exclusion criterion for the typically developing children were any identified developmental delay as indicated by their parents or by performance on the verbal and non-verbal measure of intelligence mentioned above. Typically developing children were recruited through the La Trobe University Children's Centre. As the assessments were in English, English was the primary language of all children included in the study. Approval to conduct the research was obtained from the La Trobe University Central Human Ethics Committee.

Materials

Matching

Groups were matched on the Receptive Vocabulary and Picture Completion sub-tests from the WPPSI-3 (Wechsler 2002), controlling for age; Receptive Vocabulary, $F(1,25) = 0.36$, $p = 0.55$, partial $\eta^2 = 0.01$; Picture Completion, $F(1,25) = 0.17$, $p = 0.68$, partial $\eta^2 = 0.01$. This approach was taken to ensure that group differences were not due to receptive vocabulary knowledge or non-verbal ability, which are both important in verbal comprehension.

Block design

The Block Design sub-test from the WPPSI-3 (Wechsler 2002) was used as a marker of weak central coherence. The Block Design task includes 20 test items. For each item the child is asked to recreate a block design made by the researcher and/or presented in the stimulus book. The purpose of this sub-test is to assess the ability to analyse and synthesize abstract visual stimuli.

Understanding spoken paragraphs

The Understanding Spoken Paragraphs supplementary task, from the Clinical Evaluation of Language Fundamentals—4 Australian version (CELF-4; Semel *et al.* 2003), was used as one measure of verbal comprehension. Each of three stories had five related questions of which two were appropriate for this study: the Main Idea and Detail questions. For example, in a story about a boy's first day of primary school, the Main Idea question was 'Why was Marcus feeling frightened and excited?' and the Detail question was 'What did Marcus get when he went shopping?'

Inferential processing (IP) task

Given the inadequate instruments available, a second task was developed based on Slackman and Nelson (1984). Six short stories (five to seven sentences in each) were included, each with three questions, one Factual, one Script and one Propositional. The factual question asked children a piece of information given in the story, and was used to make sure they had listened to the story. One of the stories is given below (for the full set of stories and questions, see appendix A):

> Debbie had a birthday party. She didn't want any more dolls for her birthday. There were five candles on the cake. Debbie blew out the candles. Then Debbie opened her presents. She got some games and a doll.

The questions (and expected answers) were as follows:

> Factual: Who's birthday was it? (Debbie's)
> Script: How old is Debbie? (Five)
> Propositional: Did Debbie like *all* her presents? (No, she didn't want any more dolls)

Procedure

The testing sessions were organized, depending on the child's age, to minimize fatigue. The two WPPSI-3 sub-tests were generally administered in the first session of the longer study, and the two comprehension tasks (Understanding Spoken Paragraphs and IP) in the second. For the children with autism, the second session was generally administered on the same day after a break of about 20 minutes. For the typically developing children, session 2 was administered within one month (mean interval of 14 days). The children with autism were tested in their homes, at the Language Research

Unit at La Trobe University, or at Irabina Childhood Autism Services. The typically developing children were tested in a designated room at the La Trobe University Children's Centre.

All standardized tests were administered following the test protocol, with the exception that a title was added as a global processing prompt for the Understanding Spoken Paragraphs task; the story title was read out (for example, Marcus's Big Day) before the story content. For the IP task, instructions were as follows:

> I'm going to read you a few more short stories and then ask you some more questions about them, like we did before [in the Understanding Spoken Paragraphs task]. Listen carefully because I can only read the stories to you once.

The questions for each story immediately followed it (no story title was not announced for this task).

All answers were scored as correct or not correct; there were no partial scores given.

Results

All outcome variable distributions were normal, shown by an evaluation of skewness and kurtosis with the critical value set at ± 3.29 (Tabachnick and Fidell 2007: 96). No outliers were identified. To compensate for the age difference between the groups, age in months was used as a covariate in all analyses. This method was deemed appropriate as there was a linear relationship between age and each of the dependent measures (mean $r = 0.41$). The homogeneity of variance and homogeneity of variance–covariance were adequate for each analysis, as assessed by the Levene's test and Box's test, respectively. Table 1 shows the raw score mean and standard deviation for each task by group.

To test if the children with autism performed significantly better on the Detail questions but not on the Main Idea questions, two one-way between-subjects analyses of covariance (ANCOVAs) were performed on the scores from the Detail and Main Idea questions of the Understanding Spoken Paragraphs. No significant group effects were found on the Detail questions, $F(1,25) = 1.06$, $p = 0.31$, partial $\eta^2 = 0.04$ or Main Idea questions, $F(1,25) = 2.25$, $p = 0.15$, partial $\eta^2 = 0.08$.[1]

Before testing hypothesis 2, to confirm that any group differences on inferencing skills were not due to inattention to the task, a one-way ANCOVA was performed on the IP Factual questions. No significant group difference was found, $F(1,25) = 0.77$, $p = 0.39$, partial $\eta^2 = 0.03$. Two one-way between-subjects ANCOVAs were performed on the Script and Propositional inferences of the IP to test for group differences.

Table 1. Descriptors of central tendency and variability on the raw scores of all measures.

	Autism		Typically developing	
	Mean (range)	SD	Mean (range)	SD
WPPSI-3				
Receptive Vocabulary	27.43 (20–34)	4.40	25.29 (19–29)	3.17
Picture Completion	25.21 (19–30)	3.07	21.71 (15–29)	4.10
Block Design	27.21 (20–39)	5.54	24.00 (18–30)	3.76
Understanding spoken paragraphs (maximum score of 3 for each question type)				
Main Idea	1.50 (0–3)	1.10	1.29 (0–3)	0.99
Detail	1.29 (0–3)	1.14	1.29 (0–3)	0.99
Inferential processing (maximum score of 6 for each question type)				
Factual	2.93 (0–6)	1.64	3.00 (0–5)	1.52
Script	3.29 (0–6)	2.13	4.00 (1–6)	1.52
Propositional	2.64 (0–5)	1.65	2.43 (0–5)	1.60

Note: SD, standard deviation.

Table 2. Partial correlations between central coherence measures, controlling for age.

	Autism group					Typically developing group				
Task	BD	MI	D	S	P	BD	MI	D	S	P
BD	–	0.30	0.17	0.18	0.42*	–	0.01	0.22	0.35	0.23
MI		–	0.23	0.29	0.20		–	0.70***	0.67***	0.48**
D			–	0.55**	0.61**			–	0.66***	0.79***
S				–	0.51**				–	0.53**
P					–					–

Notes: BD, Block Design; MI, Main Idea; D, Detail; S, Script; and P, Propositional. *$p < 0.10$, **$p < 0.05$, and ***$p < 0.01$.

The groups differed significantly on Script inferences, $F(1,25) = 11.12$, $p < 0.01$, partial $\eta^2 = 0.31$, with the mean score for the autism group lower than the typically developing group. For Propositional inferences, the mean score for the autism group was higher than the typically developing group; however, the difference was non-significant, $F(1,25) = 0.27$, $p = 0.61$, partial $\eta^2 = 0.01$.

To test for associations between the Block Design scores and scores from the Detail and Propositional inference comprehension questions, a partial correlational analysis (Pearson) was conducted for each group, controlling for age (table 2). Thus, the effect of age was partialled out. Performance on Block Design did not significantly correlate with performance on the Detail questions in either group; however, for the children with autism, performance on Block Design correlated significantly with performance on Propositional inferences.

In support of hypothesis three, inverse correlations were not found between performance on local processing tasks (Block Design, Detail questions and Propositional inferences) and performance on global processing tasks (Main Idea questions and Script inferences). Additionally, for the typically developing group, scores on Main Idea questions correlated significantly with scores on Propositional and Script inferences, as well as with those on Detail questions. For the autism group, performance on Main Idea questions did not correlate with any question or inference type.

Discussion

The purpose of the study was to examine the comprehension of narratives by children with autism within the theoretical context of the Weak Central Coherence (WCC) theory. No group difference on comprehension was found for the Main Idea questions. It is not a global processing deficit that characterizes children with autism but a detailed focused bias, which can be overcome which sufficient priming of the main idea (Happé and Frith 2006). In the current study, the children were primed with the title of the story. However, the children with autism did not score higher on the Detail questions of the Understanding Spoken Paragraphs sub-test, which would be expected by WCC theory predictions. Although, on responses to questions requiring global processing of the main idea, the inclusion of details was evident. For example, the Main Idea question relating to a story about a class trip to the zoo was 'What is Mrs. Johnson's class going to do?' One child with autism responded with: 'Ah, to see a bear, a snake, a monkey, and a dolphin, and a lion and tiger, and a leopard. And a leopard and a zebra, and a monkey, and a giraffe.'

The children with autism scored significantly lower than the typically developing group on the Script inferences of the inferential processing (IP) task. This finding is consistent with the predictions of the WCC theory and with previous research on event schemas in autism. Children with autism have been shown to be less able to generate core elements for (Volden and Johnston 1999), and tolerate the variability of (Loth *et al.* 2008) events. As previously argued (Loth *et al.* 2008), individuals with autism may lack 'hierarchical structure' in the schematization of events, instead encoding each instance separately. Extracting core components allow events to be grouped by type, which supports the development of event schema. Rather than extracting the core, and importantly, timeless elements, children with autism seem to encode events for each occasion.

In the context of the present study, it is reasonable to assume that children with autism were impaired in their ability to make inferences based on event scripts as they failed to integrate existing knowledge of events with information described in the narratives. Further evidence for this proposition comes from the connectivity of brain regions during comprehension. Just *et al.* (2004) found that, compared with verbal IQ-matched controls, individuals with high-functioning autism had consistently lower functional connectivity whilst engaged in a sentence comprehension task, concluding that the basis of the cognitive deficit in autism is rooted in the underfunctioning integrative circuitry of autistic brains (the major proposition of the 'underconnectivity theory' which overlaps to a large extent with the WCC theory). The comparable event script knowledge between children with autism and typically developing children reported in other studies is likely to be a function of the tasks included (for example, role play was used by Loveland and Tunali 1991).

No group differences were found on Propositional inferences of the IP task. This finding is not consistent with previous research on the formal reasoning skills of individuals with autism (Scott *et al.* 1999), and does not support the proposed local-processing advantage in autism. Scott *et al.* (1999) used a different question type from that used in the current study (counterfactual syllogisms), which may explain the discrepancy in results. The items used in that study were not representative of actuality, and thus would not be readily integrated with previous knowledge. This may have assisted the performance of children with autism. In the current study, the Propositional questions were viewed as local-processing, but they were integrated into stories that were themed by events, which would have affected the performance of the children with autism. For both groups, performance on the Propositional inferences was significantly correlated with performance on the Script inferences.

Loth *et al.* (2008) reported that one child with autism insisted all restaurants have Chinese lanterns. The authors found that these concrete-example 'slotfiller' descriptions were related to the children's central coherence score, as measured by three subtests; the Embedded Figures Test, Block Design and the Sentence Completion Task. The authors' conclusion was that event representation in children with autism was related to their weak central coherence cognitive style. In the current study, Block Design scores were used as a measure of central coherence. In the autism group only, these scores were related to Propositional inferencing. Thus, partial support was found for the relatedness of the WCC cognitive style across visual–spatial and verbal–semantic domains. This finding suggests that, in autism, a similar and related set of analytic skills is employed for the Block Design task and for the processing of Propositional inferencing; these skills involve attending to details.

In a study by Toichi and Kamio (2001), performance on the Raven's Progressive Matrices, a task that requires local-processing and pattern detection skills and which has also been used as a measure of central coherence (Happé and Frith 2006), was associated with semantic processing of related words. Thus, in autism, pattern detection skills seem to be important in semantic processing; they compensate, perhaps, for a lack of spontaneous global processing.

For the typically developing children, the Main Idea question was significantly associated with all other questions and inferences, whereas in the autism group the Main Idea question was not related to any other measure. For the typically developing children, extracting the main idea from verbal narratives was associated with good performance on the comprehension and inferencing tasks, which was not the case for the children with autism. Thus, getting the 'gist' of the story even for the very short narratives included in the study was not related to improved comprehension for the children with autism. This finding suggests that although individuals with autism may perform similarly to children with typical development on a specific task, they may be employing different strategies for processing, a conclusion previously reached by others (for example, Toichi and Kamio 2001). The Propositional inference questions in the current study are a good example of this. For the typically developing children good performance on this task was associated with good performance on the Main Idea questions, a global task. By contrast, the children with high-functioning autism's performance on Propositional inference questions was related to performance on a local task. Neuroscientific research has found support for this notion of different strategies for processing. Ring *et al.* (1999) evaluated the functional magnetic resonance imaging (fMRI) activity during the performance of the Embedded Figures Task (EFT; another visuo-spatial marker for weak coherence) in individuals with autism. They found that while some regions were equally activated in both groups, the comparison group additionally activated prefrontal cortical areas, which are associated with working memory, while individuals with autism activated ventral occipitotemporal regions, which are associated with visual object features analysis (Ring *et al.* 1999). A recent study by Manjaly *et al.* (2007) replicated these results with a larger sample and with an improved experimental design. Instead of comparing EFT activation against rest fixation (as in Ring *et al.* 1999), Manjaly *et al.* (2007) included a control task which comprised all cognitive aspects of the EFT but had minimal local visual search requirements. A task-by-group interaction was found; EFT performance was comparable, but individuals with autism performed slower on the control task. Thus, individuals with autism perform better on tasks that necessitate local processing relative to their own performance on tasks that do not, whereas typically developing individuals do not demonstrate the same relative local processing advantage. Different cognitive processing has also been raised in relation to overall IQ scores masking the complex nature of cognitive abilities of individuals with autism (Kuschner *et al.* 2007). Studying comprehension from a process versus outcome approach may provide more insight (Volkmar *et al.* 2004).

As hypothesized, scores on the Detail questions and Propositional inferences were not negatively associated with scores on the Main Idea questions and Script inferences. Thus, high scores on the local processing tasks were not associated with low scores on the global processing tasks, which is consistent with the updated view of the WCC theory (Happé and Frith 2006) in that a local processing bias is not at the expense of global processing.

Summary

In summary, two aspects of narrative processing were examined within the WCC theory: local processing (Detail questions and Propositional inferences) and global processing (with Main Idea questions and Script inferences). Although scores on the local processing tasks were comparable between groups, no support was found for enhanced local processing in autism. Children with autism extracted the main idea of stories with priming from the title, but did not spontaneously make inferences regarding event scripts. For the typically developing children only, extracting the main idea was found to be associated with enhanced performance on other comprehension tasks. Thus, the children with autism seem to have failed to employ global

processing to integrate contextual clues and content knowledge into a conceptual framework of understanding. Lack of such integration leads to impaired comprehension in communicative contexts.

Limitations, future directions and clinical implications

There are limitations to the study. There was an overrepresentation of females in the typically developing group. In addition, the age range in the group with autism, as in many studies with autistic samples, was large. The groups were matched on receptive vocabulary but any difference in performance on the narrative task might be influenced by experience (for example, in developing scripts), which would be greater in older children. However, the older children with autism may have had fewer opportunities to develop their general worldly experience due to the social limitations of autism. Matching on expressive vocabulary, rather than receptive might have led to different results. We chose to match on receptive language given we were testing comprehension. The focus on verbal comprehension, however, meant that the typically developing children were in the four to five age group, for which appropriate standardized comprehension measures are particularly limited. The relatedness of a WCC cognitive style and communicative comprehension is an important area of research, but there are few standardized materials for young children that include comprehension questions requiring global processing and local processing. In future studies it would be valuable to include more questions, and also an inferential task that is less language-dependent, one with a visual reference.

Despite the limitations, the findings from the preliminary study offer directions for future research and intervention. The results show that the processing of the main idea of stories is related to enhanced comprehension in typically developing children. Thus, it would be of value to examine differing levels of priming to investigate how much prompting children with autism require to identify the main idea. In addition, as script inferencing was found to be poorer in the children with autism, intervention might focus on developing a 'map' of events, placing the core elements of an event in the middle, and the optional or nonessential details in the periphery.

Acknowledgements

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Note

1. We entered gender into an analysis for the Main Idea, Detail, Factual, Script, and Propositional questions with the typically developing children. No significant gender effect was found. All *p*-values were greater than 0.140, and effect sizes were low.

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Appendix A: Inferential Processing (IP) stories and items (based on Slackman and Hudson 1984)

IP Narrative 1

Joseph and his Mum and Dad were going to McDonald's. Joseph's Dad told him he could have dessert if he ate all his dinner. They waited in line. They ate their hamburgers. And then they had ice cream.

Questions and correct responses:

(F) What did they eat for dinner?	Hamburgers/McDonald's
(S) Why did they stand in line?	To order their food
(P) Why did Joseph have ice cream?	Because he ate all his dinner

Note: F, Factual; S, Script; and P, Propositional.

IP Narrative 2

Debbie had a birthday party. She didn't want any more dolls for her birthday. There were five candles on the cake. Debbie blew out the candles. Then Debbie opened her presents. She got some games and a doll.

Questions and correct responses:

(F) Who's birthday was it?	Debbie's
(S) How old is Debbie?	Five
(P) Did Debbie like *all* her presents?	No, she didn't want any more dolls

Note: F, Factual; S, Script; and P, Propositional.

IP Narrative 3

On Mondays, Luke doesn't go to school. Today, Luke put on his clothes. Then he ate his breakfast with his Mum and Dad. And then his Dad left. And Luke watched television all day.

Questions and correct responses:

(F) What did he eat with his Mum and Dad?	His breakfast
(S) Where did Luke's Dad go?	To work
(P) What day is it in the story?	Monday

Note: F, Factual; S, Script; and P, Propositional.

IP Narrative 4

It's Susie's birthday party tomorrow. Susie and her Mum go to the supermarket to buy food for the party. Susie really hopes her Mum buys her a chocolate cake. They get a cake, some lollies and some chips. Then they pay the cashier. Susie leaves the store smiling and feeling happy. And they take the food home.

Questions and correct responses:

(F) Where do they first go in the story?	To the supermarket
(S) Why did they give money to the cashier?	To buy the food (for the party)
(P) Why was Susie happy when they left the store?	Because Susie's Mum bought a chocolate cake

Note: F, Factual; S, Script; and P, Propositional.

IP Narrative 5

One morning, Simon woke up. He thought to himself, 'if it's cold today I will wear my new beanie and scarf'. He took off his pyjamas. Then he put on his school clothes. And then he put on his new things.

Questions and correct responses:

(F) What time of day was it (morning, afternoon or evening)?	Morning
(S) Why did he take off his pyjamas?	So he could get ready/dressed (for school)
(P) What was the weather like that day?	It was cold

Note: F, Factual; S, Script; and P, Propositional.

IP Narrative 6

If Alison's friend calls to say she will come to visit tomorrow, Alison and her Mum will bake some cookies today. The phone rings, it's Alison's friend. Alison talks to her and then says goodbye. Alison and her Mum mix the cookie dough. And put then they put the tray of cookies in the oven'.

Questions and correct responses:

(F) Who did Alison make the cookies with?	Her Mum
(S) Why did they put the cookies in the oven?	So they could bake
(P) Why did they make cookies?	Because Alison's friend [called to say she] is coming over tomorrow

Note: F, Factual; S, Script; and P, Propositional.