Can examination of gesture help us to understand the development of theory of mind in children with Down syndrome?

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The term theory of mind covers a range of cognitive skills which develop rapidly in a child's first 6 or so years and continue to be refined into adulthood. A mature theory of mind enables the possessor to understand the mental states of others, how these mental states relate to the world and how they influence the owner's behaviour. Those adults who have a well developed theory of mind are capable of representing others' mental states in order to make psychological sense of the world around them (Wellman, 1990).

The earliest indications that a child has theory of mind skills are available at around 9 months when the child is able to follow an adult's gaze to share a referent. This skill develops into joint attention and instrumental pointing and requesting over the next year (Butterworth, 1995). Even at this early stage the child is able to understand that others around him have a view of the world and that their view is able to be shared and, in a limited way, to be manipulated (Tomasello, 1995).

As the child's sense of self grows, so does his sense of others. By the age of 2 children are beginning to engage in pretend and symbolic play (Harris, 1993), both alone and with other people, sharing a make-believe world and developing an insight into others thoughts and actions (Astington, 1993). By age 4 children are developing an understanding that, whilst they may share with others a common understanding of the world, different people may interpret and think about that world in different ways.

By the time the child reaches 5, most will have a relatively sophisticated theory of mind; one that enables them to think abstractly about the world and understands that we may have individual beliefs. Children can further reason that our actions are guided by beliefs, and that sometimes those beliefs may be false (Wellman et al., 2001b). It is at this point that children are considered to have a theory of mind which can be tested in laboratory settings, although it will continue to develop in sophistication right into adulthood.

Much research has been carried out to understand theory of mind, beginning with the seminal work from Premack and Woodruff and their attempts to discover if apes had a theory of mind (Premack and Woodruff, 1978), through to Baron-Cohen's extensive work on the theory of mind of people with Autistic Spectrum Disorders (see e.g. Baron-Cohen et al., 1985, Baron-Cohen, 1989, Baron-Cohen, 1991) and complemented with a body of research which has largely focussed on discovering at

what age children can pass a variety of theory of mind tasks. (For some key papers see: Wellman et al., 2001a, Wimmer and Perner, 1983, Clements and Perner, 1994, Peskin and Ardino, 2003). More recent studies have used a microgenetic method of following children closely over a number of weeks as their theory of mind skills are practiced and developed to examine the cognitive changes which occur in children as theory of mind develops. Using this method Amstelaw and Wellman (2006) and Flynn, O'Malley and Wood (2004) have suggested that the development of theory of mind in 3-4 year olds is patchy and inconsistent, with a significant period of instability that might be indicative of a transitional time in development. If this is an accurate picture of development this should have an impact on how we interpret the results of testing theory of mind in young children; failing a task at one time point may not mean theory of mind has *not* developed, it may just be develop*ing*.

The current study seeks to add to the existing body of research into theory of mind by introducing a clinical group who have not been extensively studied and who may be able to shed further light on when and how theory of mind develops. By using a range of analysis techniques we aim to draw together much of the work on the origins of theory of mind (Meltzoff, 1999, Moore and Dunham, 1995), prior studies on a diverse range of clinical groups, such as deaf children in hearing families (Peterson and Siegal, 2006) and studies on the social and dynamic nature of the development of theory of mind (Dunn, 1988, Astington, 1993).

Individuals with Down syndrome develop a range of cognitive and physical differences as a result of the replicated chromosome 21. Whilst research continues into the nature of how and why these differences occur, the identification of behavioural (Fidler et al., 2006, Fidler et al., 2009) and cognitive phenotypes (Silverman, 2007) have helped practitioners and researchers delineate areas of relative strengths and weaknesses in individuals with Down syndrome compared to typically developing children (Buckley, 2005). Most notably, and of particular relevance to theory of mind, individuals with Down syndrome generally have speech and language difficulties (Abbeduto et al., 2007) and inefficient working memories (Jarrold and Baddeley, 2001).

Within theory of mind research, children with Down syndrome have tended to be an underrepresented group and they are most often used as controls for studies on other clinical populations, such as children with autistic spectrum disorders (Baron-Cohen et al., 1985), or studies which have been carried out on much older populations (Zelazo et al., 1996). The addition of children with Down syndrome into the well-established field of theory of mind research may give us useful insights into atypical development and also feed into our understanding of how theory of mind unfolds in the typically developing child.

Moreover, alongside the academic value of this work, the successful education of children with Down syndrome is of upmost importance. Given a specific and appropriate education many individuals with Down syndrome are able to live and work independently as adults (Buckley et al., 2006, Cuskelly et al., 2008). We know

that many children with Down syndrome are cognitively delayed (Silverman, 2007), so we may hypothesise that the development of their theory of mind skills could also be delayed. If this is true we must then assess what impact this will have on their education, if it is false it will add to our knowledge of the cognitive profile of individuals with Down syndrome.

Individuals with Down syndrome have a number of speech and language issues which range from mild to severe. Physiological differences lead to lack of clarity in speech sounds; a small oral cavity but normal sized tongue means certain sounds are distorted, making speech difficult to understand (Abbeduto et al., 2007). Studies have also shown that although the receptive vocabulary develops in line with cognitive functioning, the expressive vocabulary is often further delayed in children and adults with Down syndrome (Roberts et al., 2007). Language pragmatics, grammar and syntax are also delayed and remain underdeveloped into adulthood (Paterson, 2001). In addition to specific language difficulties, working memory, which is an essential part of speech comprehension and production, can be significantly impaired in individuals with Down syndrome (Jarrold et al., 1999).

In contrast to these speech and language difficulties, children with Down syndrome are considered visually orientated (Buckley, 2001, Fidler and Nadel, 2007) enabling them to use visual, spatial and kinaesthetic spheres to aid their learning. Because of this parents of children with Down syndrome are advised to begin using a sign language with their infants (Buckley, 2003, Clibbens, 2001). Teaching children with Down syndrome to sign is thought to bridge the communication gap that may be left by relatively delayed verbal communication and support language learning in early years (Foreman and Crews, 1998).

Although studies have produced conflicting evidence as to whether children with Down syndrome possess a ‘gestural advantage’ over typically developing children (Stefanini et al., 2007), most researchers agree that the development of gesture in children with Down syndrome is at least as good as that of typically developing children in early childhood (Iverson et al., 2003). Infants with Down syndrome are able to use gesture to initiate joint attention, however some studies have highlighted a divide between requests for joint attention and instrumental requests (Mundy et al., 1988, Kasari et al., 1995). Instrumental pointing is considered to be one of the earliest indicators of understanding others; it requires the infant to recognise they have a desire, that the adult doesn’t share that desire and therefore needs to be directed to the object of desire (Meltzoff, 1999). Fidler et al. (2005) found that children with Down syndrome are less likely to use instrumental pointing to control the behaviour of others (i.e. for requesting). As children with Down syndrome mature they continue to use iconic gesture to support their spoken language. However, unlike typically developing children, children with Down syndrome’s use of iconic gestures is less likely to predict the onset of speech (Iverson et al., 2003). It appears that children with Down syndrome may use gesture for longer and for a different

purpose and that speech and gesture have a particular relationship in helping to convey meaning which is lacking in speech (Stefanini et al., 2007).

There has been little research on the use of gesture in older children with Down syndrome. In particular the issue of whether the use of gesture in communication remains, or whether speech 'takes over' as it does in typical development. In either case the heterogeneity of the Down syndrome population means that caution is required when generalising from a sample of children or adults who, while they may be very similar in chronological age may have substantially different language and gestural abilities, as can be seen in the study presented below.

Design

The study presented here forms part of a larger study investigating the developmental trajectory of theory of mind in children with Down syndrome. Two prior studies examines pre-cursors of theory of mind in two groups of younger children aged 2-3 years (n=14) and 4-5 years (n=8). The study presented here examines explicit theory of mind skills in a group of children with Down syndrome aged between 6-9 years (n=15).

Participants were recruited from Down syndrome support groups in the Yorkshire, Humber and Durham counties. Parents replied to a request to join the study, therefore the group of participants was self-selecting. Individuals were excluded from the study if they had a current dual diagnosis of Down syndrome and an autistic spectrum disorder. As discussed above some individuals with autistic spectrum disorders may have a specific deficit in theory of mind skills which could have confounded our results.

Method

Each child in the study was tested twice, with more than 2 weeks between visits for most participants, either at school (n= 10) special school (n=1) home (n=1) or at their support group (n=3). Session length varied according to each child's needs and ranged from 23 minutes to 54 minutes (mean = 34 minutes). At each session another familiar adult was present. In all cases this was either a parent or teaching assistant.

The mean age of the children in this group was 7.2 years, ranging between 6.0 years and 8.11 years.

Each session included the following tasks; British Picture Vocabulary Scales (BPVS), False belief 1, Working memory task, False belief 2 story, False belief 3 ipad, False contents, False belief 4. The sessions were modified according to the individual child's needs to ensure that the child could engage with some of the tasks. Discussed in the case studies below are examples from the BPVS and the False belief tasks.

Tasks

The BPVS III (Duun, 2009) was administered as per the authors' instructions with some modifications to meet the needs of this group. The children were given verbal and signed instructions and had three practice words before the test began. Children were required to listen to a word and point to its counterpart picture from a choice of four. The test is stopped when the child gets more than 7 wrong out of a set of 12. Throughout the testing period this had to be modified somewhat, as the children tested were generally not very responsive to the test. Sometimes the test was stopped and then resumed later, sometimes it was abandoned before a basal and ceiling set were established and for 2 participants at T1 the test was not able to be administered.

False belief 1. This task has been widely used in theory of mind research (See: Wellman et al., 2001b for a meta analysis). Usually known as the Sally/Anne task our version had slightly modified elements to help the children in our study understand and relate to the story.

Participants were shown a girl doll, called Dinah and a boy doll, called Maxi. Memory questions were administered to ensure the names had been learnt. The dolls were used to act out the following storyline, which was also signed throughout using Makaton:

Dinah has a special toy, she hides it from Maxi in a drawer because she doesn't want him to play with it. Then she goes outside to play. Whilst she is outside Maxi takes her toy and hides it in his box. Dinah comes back in and wants to play with her toy.

2 control questions are asked; reality: 'Where did Maxi hide the toy?' and memory: 'Where did Dinah hide the toy?' and the final false belief question 'Where will Dinah look for her toy?' In order to pass this task participants must answer all three questions correctly across three out of the four repetitions of the task.

Results

Although not the focus of this paper, the results of the BPVS and the False belief tasks are reproduced here.

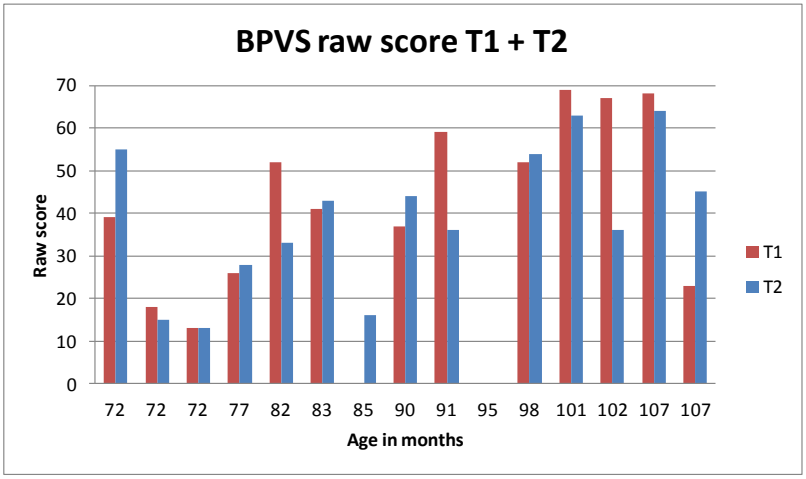

Fig. 1 BPVS Raw scores at T1 and T2 by age of participant.

The BPVS is reported here as a raw score; the results could not be standardised as the participants' scores were all too low, only 4 participants were able to score above the 3.9 years

comprehension age cut-off, of which 2 varied across time points. Further, it must be remembered that not all participants had a basal and ceiling set from which to accurately work out the raw score. Where this occurred the set closest to the basal (closest to 1 mistake) and the set closest to the ceiling (closest to 7 mistakes) were used. In order for the BPVS data to be useful it must be used as within-group data. What we see in the raw scores are some gains in comprehension according to age, however this is by no means stable across the group or across time points. In fact, the difference in points across time points was sometimes so great that some children were able to score very different comprehension ages. Presented below are the three participants whose scores differed enough that one time point was <3.9 but the other was able to be transformed into an age equivalent score. Interestingly, the direction of improvement in these three participants was not consistent, as we can see with the rise and fall in raw scores across the whole cohort, some participants made gains to T2 and others performed not as well in T2.

Child	Age in months	Raw 1	Standard 1	Percentile 1	Age equivalent 1	Raw 2	Standard 2	Percentile 2	Age equivalent 2
N	72	39	***	***	<3.09	55	71	3	4.00
A	91	59	***	***	4.05	36	***	***	<3.9
J	102	67	***	***	4.10	36	***	***	<3.9

Fig. 2 Participants scores on BPVS T1 and T2 whose performance differed enough to change their age equivalent score.

Whilst we can see that this is 'rough' data, in that we are not able to get standardised scores from the participants, it supports earlier research which suggests we cannot make educational or psychological judgements based upon one time point testing for this group (Wishart, 2001, Wishart and Duffy, 1990).

The false belief task was passed consistently in 4 out of 4 tasks by 1 participant in the group of 15. Three other participants passed the task 1 out of 4 tasks and one participants passed the task twice, however these are not considered to be a secure enough score to be an overall pass.

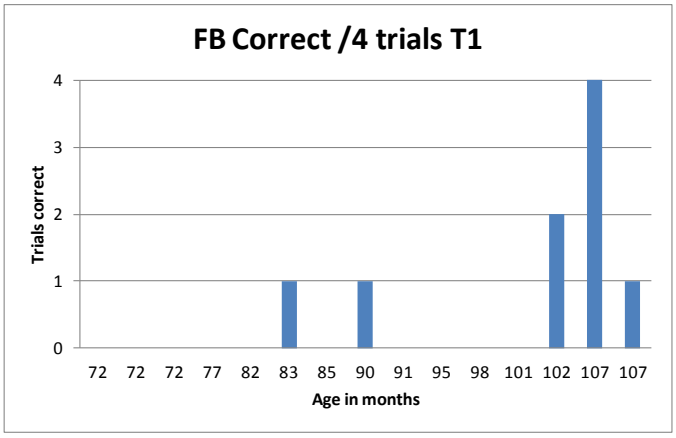

Fig. 3 Passes of False Belief trials by all participants at T1, by age.

These quantitative results were not unexpected; we had hypothesized that many of the participants would fail the false belief task and that the BPVS may cause problems for some children. What is more interesting is whether these quantitative

results are true reflections of the children's abilities. When we consider the differences in participants' performance at T1 and T2 in the BPVS, it is clear that not all the children are performing consistently and there is distinct variation in scores across the two time points. The case studies below highlight the inconsistencies we can see in the way the children responded to the BPVS and suggest alternative methods the participants used to convey their understanding of vocabulary and false belief.

Case studies and discussion

Whilst other discussions of this study will examine quantitative and other qualitative aspects of the participants' contributions, the focus here is on the participants' use of gesture to express their understanding of others. For this we have focussed on 4 case studies taken from the original cohort of 15. The four cases were picked because of the interesting use of gesture the participants showed during their sessions and, whilst they are not representative of the whole cohort (the group is too diverse to suggest that), they open some interesting discussions about how some children in this group compensate for a lack of verbal dexterity and how others are able to express some understanding of false belief, even though they fail the task.

Iconic gesture in social interaction

Taking part in social interactions is a key way that we learn about the cultural codes and conventions which guide us to understand others' thinking (Dunn, 1988). Social interaction allows us to engage with others' minds and forces us to consider the difference or similarity between our own and others' desires.

> *During her first session M signs 'sad' (using Makaton) when the Dinah doll comes back into the room to play with her toy.*

M appears to have used this expressive term to describe another's state of being, one different than her own and possibly based upon the knowledge that Dinah will not be able to find her toy as it had been moved. This was reinforced later in the session when M tapped the researcher on the arm and again signed 'sad' after the Dinah doll had fallen over. It would appear from this that M purposefully drew the researcher's attention to her signing, thereby ensuring an exchange of information.

> *During her second session M again draws the researcher's attention to her signing. The researcher asks, during the BPVS, for M to point to the picture of swimming. Instead of pointing M signs 'M' for her name and then points to herself. The researcher doesn't respond, and M repeats the point to herself with eye contact with the researcher.*

The teaching assistant clarifies that M likes swimming and goes with her father. After a further prompt, M correctly chooses the swimming picture.

In this example it appears that M is keen to gain the researcher's attention to ensure her signing is seen and understood. This would imply that M understands that in order for the researcher to know there is communication she has to see the exchange of information happening (in the instance of signing). Furthermore, M appears to want to exchange information about her life; a social activity which requires understanding of the conversation partners' knowledge.

M was unable to access the BPVS at T1 and failed all her trials of the FB task.

Social interaction; more reliable than pointing behaviours?

As outlined earlier Fidler et al. (2005) found that the instrumental requesting behaviours in children with Down syndrome lagged behind that of typically developing children. Children with Down syndrome were less likely to use instrumental requesting to instruct others to meet their needs, which could mean that this group might not fully develop using pointing as a means of instruction. During the course of this research we found that in general many of the children's pointing responses were inconsistent with other knowledge they were showing us:

Res: When Dinah comes back in she wants her toy, where is Dinah going to look for her toy?

L taps drawers with forefinger (incorrect answer)

Res: Do you want to help her *(pushes doll forward. L takes doll)* find her toy?

L picks up the bag (correct answer) and puts fingers in to search.

L was able to correctly answer the two control questions, by pointing to the correct items, but his answer to the false belief question was incorrect. However, when he was asked to help the doll find her toy, he went straight to the correct place. A simple reason for this may be that he did not receive any feedback from the researcher after answering the FB question. Earlier research shows that children with Down syndrome are susceptible to success and failure cues and will often use social distraction or changing their minds as a way out of the perceived failure (Wishart and Duffy, 1990, Wishart, 2001). An alternative reading of this situation is that L was unable to inhibit the salience of the real place of the toy when asked to point, but when asked to contribute socially *to help her find her toy*, he was able to use his theory of mind to suppose what she was 'thinking'. Judy Dunn is clear in her evaluation of research with young typically developing children that they are able, in situations which are relevant and appeal to their self interest, to show 'practical understanding of others' feelings and intentions.' (Dunn, 1988, P.66)

L passed the FB task on one occasion.

Iconic gesture expressing knowledge about knowledge

A key aspect of developing a theory of mind is being given the language to express and understand the concept of an internal world. In typical families children are exposed to the everyday mental state language of belief and desire through discussion (What do you *think*?), through argument (I *know* that you did it!) and through conversation (I *hope* its chips for tea.) Children who do not have access to the inner life of their parents and siblings, such as deaf children born into non-signing, hearing families, have been found to progress much more slowly in developing their theory of mind than their typically developing peers (Woolfe et al., 2002). Similarly Ontai. L (2008) found that the frequency and type of parent and child discourse contributed positively to the child's later performance on theory of mind tasks. What we see in families of children with Down syndrome is that some of these early factors may be at risk. Mothers' are less likely to use complex sentence structures and more likely to alter their type of speech to their child's developmental stage (Iverson et al., 2006). This could mean that early in development children could be missing out on important mental state terms and this adversely affects their own speech competence (Tingley et al., 1994). Without these mental state terms children may find it difficult to express and manipulate their own internal states and to understand mental states in others. In which case we would expect profound difficulty, which we have experienced in this study, in passing the false belief task. However, what we have seen in some participants are clear understandings of their own, and other's, mental states:

> Res: Money
>
> *M points to 2 pictures. Then signs 'forgot/remember'.*
>
> Res: Which one M? *(Signing which)*
>
> *M points to correct picture*

In this example M appears to be referring to her own mental state of forgetting. She is aware that she knows the word but is also aware that she cannot retrieve it. Although M would not have the spoken, or signed, language to formulate such a complex idea into a sentence, she is able to use a single sign to show some insight into her own mental state of forgetting.

Gesture word mismatch – expressing knowledge through gesture

Perry, Church and Goldin-meadow (1992) have suggested that children who show a gesture - speech mismatch may be going through a transitional stage in their acquisition of knowledge, an idea built on by Alibali et al (1999) who conclude that the gestures may externally express something of the representational mind which is missing in speech. Indeed Carlson et al. (2005) suggest that gesturing may help to

'redistribute cognitive resources to visuospatial working memory, thereby freeing up resources for task performance' (P. 84). In some of our cohort there was a clear mismatch between the picture the child pointed at in the BPVS, and the sign they used to identify the word:

> Res: Can you see, who is happy?
>
> *E signs 'happy'. Points to the picture of the sad child.*
>
> Res: Is she happy?
>
> *E points to picture of crying child, looks to researcher.*
>
> Res: Oh, he's crying.
>
> *E points to both other pictures on the page, looks to researcher after each point.*

E uses her knowledge of the signed word 'happy' to identify the word the researcher has spoken (not signed) however she is unable to identify the correct picture. This could suggest that this word is in E's lexicon, but the images presented are too salient for E to ignore. The choice of images on this particular sheet of the BPVS presented difficulties for many of the participants and many chose the crying child over the target word 'happy', even though this word was clearly in their vocabulary.

A further interpretation of this example is a gesture (pointing) / sign mismatch which could indicate a development in the way the representational mind is being used. E can sign the target word, but does not yet have the cognitive resources to supress her interest in the pictures of the crying child. Since she also looks to the researcher after pointing to other pictures on the page, we could suggest that, although the word 'happy' is within her lexicon, she does not yet know how the word 'happy' may be visually, and somewhat abstractly as the pictures have no context, presented in a picture. E's gesture and sign mismatch may be a signpost as to her stage of representational and/or linguistic development.

E did not pass any of the FB tasks.

Although the standard false belief task, as we used here, has been replicated and standardised many times over the last 30 years (Wellman et al., 2001b), there remain some doubts as to how well it captures both the dynamic change process of a developing theory of mind, and the practical, social application of a child's theory of mind (Bloom and German, 2000). Certainly the four examples above indicate that the children are able to employ some aspects of their understanding of themselves as thinking, mentalising beings and are beginning to apply this knowledge to other people. Without looking carefully at the children's alternative means of expression; pointing, gesture, sign we would be missing some important signals about the children's abilities. All of the case studies above had a comprehension age of lower than 3.9 years, according to the BPVS, and all failed the false belief tasks. If we take

these as true reflections of their abilities, we may be seriously underestimating this group. What we may conclude from these small case studies is that these children are going through the dynamic change process of developing and refining aspects of their theories of minds, and to do this they are employing the means which are most useful to them; the physical and spatial dimensions of communication.

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