

at <http://www.current-biology.com/cgi/content/full/17/12/R449/DC1>

#### Acknowledgements

We thank the Danish Environmental Protection Agency for supporting the monitoring programmes at Zackenberg Research Station, the Danish Agency for Science, Technology and Innovation for funding to MCF and NMS and numerous people for field assistance.

#### References

1. Kattsov, V.M., Källén, E., Cattle, H., Christensen, J., Drange, H., Hanssen-Bauer, I., Jóhannessen, T., Karol, I., Räisänen, J., Svensson, G. *et al.* (2005). Future climate change: modeling and scenarios for the Arctic. In *Arctic Climate Impact Assessment*, (Cambridge: Cambridge University Press), pp. 99–150.
2. Walther, G.R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T.J.C., Fromentin, J.M., Hoegh-Guldberg, O., and Bairlein, F. (2002). Ecological responses to recent climate change. *Nature* **416**, 389–395.
3. Parmesan, C. (2006). Ecological and evolutionary responses to recent climate change. *Annu. Rev. Ecol. Evol. S.* **37**, 637–669.
4. Forchhammer, M.C., Post, E., and Stenseth, N.C. (1998). Breeding phenology and climate. *Nature* **397**, 30–31.
5. Both, C., Bouwhuis, S., Lessells, C.M., and Visser, M.E. (2006). Climate change and population declines in a long-distance migratory bird. *Nature* **441**, 81–83.
6. Beckerman, A., Benton, T.G., Ranta, E., Kaitala, V., and Lundberg, P. (2002). Population dynamic consequences of delayed life-history effects. *Trends Ecol. Evol.* **17**, 263–269.
7. Menzel, A., Sparks, T.H., Estrella, N., Koch, E., Aasa, A., Ahas, R., Alm-Kubler, K., Bissolli, P., Braslavská, O., Briede, A. *et al.* (2006). European phenological response to climate change matches the warming pattern. *Glob. Change Biol.* **12**, 1969–1976.
8. Root, T.L., Price, J.T., Hall, K.R., Schneider, S.H., Rosenzweig, C., and Pounds, J.A. (2003). Fingerprints of global warming on wild animals and plants. *Nature* **421**, 57–60.
9. Holland, M.M., Bitz, C.M., and Tremblay, B. (2006). Future abrupt reductions in the summer Arctic sea ice. *Geophys. Res. Lett.* **33**, L23503.
10. Chapin, F.S., III, Sturm, M., Serreze, M.C., McFadden, J.P., Key, J.R., Lloyd, A.H., McGuire, A.D., Rupp, T.S., Lynch, A.H., Schimel, J.P. *et al.* (2005). Role of land-surface changes in arctic summer warming. *Science* **310**, 657–660.

<sup>1</sup>Department of Arctic Environment, National Environmental Research Institute, University of Aarhus, Frederiksborgvej 399, DK-4000 Roskilde, Denmark. <sup>2</sup>Department of Population Biology, Institute of Biology, University of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen, Denmark. <sup>3</sup>Department of Biology, Pennsylvania State University, 208 Mueller Lab, University Park, Pennsylvania 16802, USA. <sup>4</sup>Centre for Integrated Population Ecology, [www.cipe.dk](http://www.cipe.dk). E-mail: [toh@dmu.dk](mailto:toh@dmu.dk)

## Can autistic children predict behavior by social stereotypes?

Lawrence Hirschfeld<sup>1</sup>, Elizabeth Bartmess<sup>2</sup>, Sarah White<sup>3</sup> and Uta Frith<sup>3</sup>

Explaining and predicting behavior involves understanding others in terms of their mental states — the so-called Theory of Mind (ToM). It also involves the capacity to understand others in terms of culturally transmitted information about group membership, for example, which social groups exist in one's culture and which stereotypes adhere to these groups. This capacity typically emerges between 3 and 5 years of age, just like ToM understanding [1,2]. Are the cognitive capacities underlying ToM and stereotypes the same or do they provide independent means of understanding and predicting the actions of others? Children with autism have a profound inability to engage in everyday social interaction, as well as impairments in verbal and nonverbal communication, which have been attributed to a severe delay in ToM development [3,4]. If the use of stereotypes and mental

states were part and parcel of the same underlying cognitive process [5], then autistic children should have similar difficulties with both. We report here that 8-year-old autistic children with a mental age of 7, who fail ToM tasks, nevertheless know and use gender and race stereotypes just like normal children. This provides a powerful argument for the assumption of distinct processes in social reasoning [6] (see Supplemental data).

We assessed race and gender stereotype knowledge with the Preschool Racial Attitudes Measure (PRAM II) [7], which presents scenarios with outline drawings using a forced-choice format as shown in Figure 1. We also assessed the propensity to avoid the use of stereotypes in predicting a protagonist's behaviour by devising a novel Conflict task. Here, the child was presented with vignettes where one prediction could be made from an individual's current mental state or habitual preference, while a different prediction could be made from his or her social category membership. The mental state used was desire expressed as 'likes to', as it is virtually the first mental state that children understand [2]. We confirmed in a simple screening test that even our youngest and least able participants were able to grasp

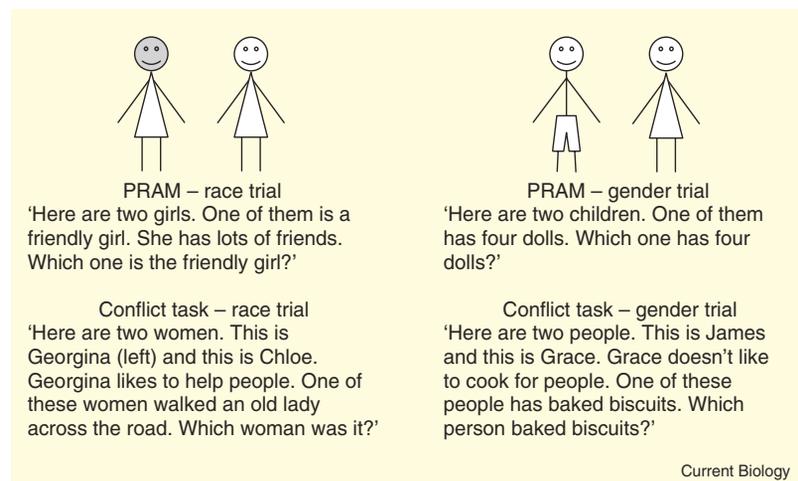


Figure 1. Examples of race and gender trials for each task.

The child sees a picture — life-like coloured line drawings of people with brown or pink skin — and hears a short vignette. In total, each child completed 24 race and 12 gender trials on the PRAM and 5 race and 5 gender trials on the Conflict task; in the latter task, different predictions can be made on the basis of stereotypes or desires.

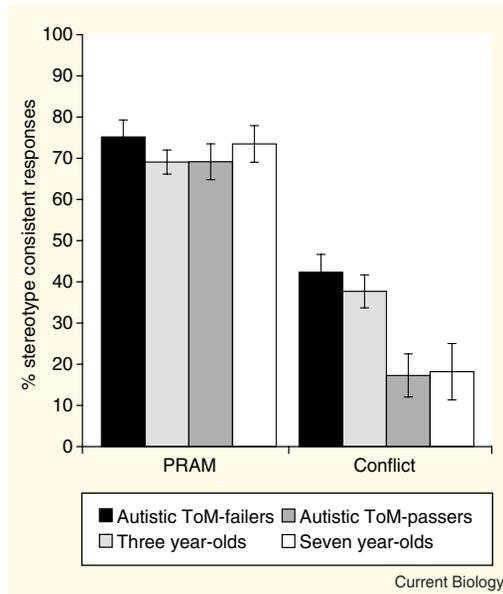


Figure 2. Contrast of PRAM and Conflict tasks.

Percentage of stereotype-consistent responses on the PRAM contrasted with the Conflict task, showing a significant task by group interaction ( $F_{(3,41)} = 3.36$ ,  $p = 0.028$ ) as well as a main effect of task ( $F_{(1,41)} = 155.73$ ,  $p < 0.001$ ). The normally developing participants consisted of 3 year-olds ( $n = 17$ ) and 7 year-olds ( $n = 11$ ); the latter are known to pass standard ToM tasks while the former are known to fail them [10]. 5–11 year-olds with autism were divided into those who failed ( $n = 10$ ; age 8 years) at least one of two well-established ToM tests [3,11] and those who passed both tests ( $n = 11$ ; age 9 years). The verbal mental age [12] of the

normally developing 7 year-olds, autistic ToM-failers and autistic ToM-passers was similar (7y 3m, 6y 8m, 7y 10m) while verbal IQ was lower for the autistic groups (106, 91, 88).

the meaning of “he/she likes to do something”.

The findings are presented in Figure 2 and are striking on several counts. First, we consider performance on the PRAM test. Here, failure in mental state reasoning did not significantly affect children’s use of common social stereotypes. This is surprising, because the lack of social orientation in young children with autism must limit learning about kinds of people from implicit cultural cues [8]. In view of these difficulties, their fluent knowledge of race and gender stereotypes is astonishing. As with normally developing 3-year olds, they could readily recruit this knowledge in a picture book context to predict and explain the protagonists’ behavior. The difficulties autistic children have with social communication in general and mental state reasoning in particular, did not hamper their acquisition of culturally transmitted knowledge about stereotypes. However this knowledge is acquired, the learning process must be remarkably robust if it works in early childhood, when social experience is limited, and in autism, when social experience is abnormal.

How are pernicious stereotypes overcome in normal development?

Performance on the Conflict task suggests that mental-state reasoning may play a role in this. We were able to test this prediction by comparing autistic children who failed ToM tasks with those who passed these tasks and therefore were better able to predict protagonists’ behavior on the basis of their mental state. These children turned out to strongly prefer mental state reasoning over stereotypical group-based reasoning, using the latter only 20% of the time when one was pitted against the other. Their performance was like that of normally developing 7-year olds, but unlike that of other autistic children who had weaker ToM ability and predicted behavior as often in line with group stereotypes as in line with the protagonist’s desire or habitual preference. Still this indicates a less pronounced choice of stereotypic responses compared to the PRAM, consistent with a degree of understanding of mental states. Three-year-old, normally developing children also showed this pattern.

Does group-based social reasoning function well also in adults with autism? A recent study [9] with high-functioning adults with autistic disorder suggests that this is the case. In this study the ability to attribute stereotypic traits to photographs of people, such as trustworthiness and status, was

found to be intact. Taken together, these results suggest that there are important aspects of social ability in autism, suggesting strengths rather than weaknesses, which are as yet unexplored.

#### Supplemental data

Supplemental data, including experimental procedures are available at <http://www.current-biology.com/cgi/content/full/17/12/R451/DC1>

#### Acknowledgements

This work was supported by MRC programme grant 65013 to U.F. and a research grant to L.H. and E.B. by the Culture and Cognition Program, University of Michigan USA.

#### References

1. Aboud, F.E. (1988). Children and prejudice, (York, NY: Blackwell).
2. Wellman, H.M., and Liu, D. (2004). Scaling of Theory-of-Mind Tasks. *Child Dev.* 75, 523–541.
3. Baron-Cohen, S., Leslie, A.M., and Frith, U. (1985). Does the autistic child have a ‘theory of mind’? *Cognition* 21, 37–46.
4. Frith, U. (2003). Autism: Explaining the Enigma, (Oxford: Blackwell).
5. Hamilton, D.L., and Sherman, S.J. (1996). Perceiving persons and groups. *Psychol Rev.* 103, 1336–1355.
6. Hirschfeld, L.A. (1996). Race in the making: cognition, culture, and the child’s construction of human kinds, (Cambridge, MA: MIT Press).
7. Williams, J.E., Best, D.L., and Boswell, D.A. (1975). The measurement of children’s racial attitudes in the early school years. *Child Dev.* 46, 494–500.
8. Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., and Liaw, J. (2004). Early social attention impairments in autism: social orienting, joint attention, and attention to distress. *Dev Psychol.* 40, 271–283.
9. White, S., Hill, E., Winston, J., and Frith, U. (2006). An islet of social ability in Asperger Syndrome: Judging social attributes from faces. *Brain Cogn.* 61, 69–77.
10. Flavell, J.H. (1999). Cognitive development: children’s knowledge about the mind. *Annu. Rev. Psychol.* 50, 21–45.
11. Perner, J., Frith, U., Leslie, A.M., and Leekam, S.R. (1989). Exploration of the autistic child’s theory of mind: knowledge, belief, and communication. *Child Dev.* 60, 689–700.
12. Dunn, L., Dunn, L.M., Whetton, C., and Burley, J. (1997). *British Picture Vocabulary Scale, Second Edition*, (Windsor, Berks: NFER-Nelson).

<sup>1</sup>New School for Social Research, Departments of Psychology & Anthropology, 65 Fifth Avenue, New York, New York 10023, USA. <sup>2</sup>University of Michigan, Department of Psychology, 530 Church Street, Ann Arbor, Michigan 48109-1043, USA. <sup>3</sup>UCL Institute of Cognitive Neuroscience, 17 Queen Square, London WC1N 3AR, UK. E-mail: [u.frith@ucl.ac.uk](mailto:u.frith@ucl.ac.uk)