Heuristics and Biases in Autism: Less Biased But Not More Logical

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Abstract

In this study we compared the performance of autistic and typically developing adolescents on three well-known tasks from the heuristics and biases literature. As heuristic reasoning is based on the contextualisation of problems (e.g., Stanovich, 2003) and autistic people are known to be less sensitive to contextual features (e.g., Frith & Happé, 1994) we expected them to exhibit less bias on these tasks. In line with our predictions, autistic children were less susceptible to the conjunction fallacy, and they also gave more base rate responses in one version of the engineers and lawyers task. However, their performance on the control tasks indicated that they were not any more sensitive to probabilistic information than the control group (i.e., they were not more logical in a normative sense).

Keywords: cognitive development; psychology; reasoning.

Introduction

Heuristics are ‘‘mental shortcuts’’ used in reasoning and decision making. They save time and effort, and most of the time they lead to good solutions to problems. In certain cases, however, they lead to systematic errors (i.e., biases). Decision theorists have identified so many such reasoning errors that their study has developed into an independent field known as ‘‘heuristics and biases’’ (e.g., Gilovich, Griffin, & Kahneman, 2002). According to dual-process theorists (Evans & Over, 1996; Stanovich, 1999) heuristics reflect the tendency for people to automatically contextualize presented information. As a consequence, in cases when context needs to be disregarded, reasoners can only do it through conscious effort.

In contrast to the findings in the general population, a number of studies have reported that autistic participants do not automatically contextualize information. Autistic children show very good performance on tasks which require attention to local features, such as the embedded figures task (Joliffe & Baron-Cohen, 1997; Shah & Frith, 1983) and the block design task (Shah & Frith, 1993). On the other hand, they are less able than typically developing children to benefit from sentence context in disambiguating the meaning of homographs (Frith & Snowling, 1983; Joliffe & Baron-Cohen, 1999), and they do not show the expected facilitatory effects of context on text comprehension and reading (see Happé & Frith, 2006 for a review) an effect which seems to be limited to complex verbal stimuli (Lopez & Leekham, 2003). Importantly, it appears that this effect cannot be attributed to deficits in the automatic inferences involved in text comprehension, or to the lack of activation of relevant knowledge (Saldana & Frith, 2007). This also does not seem to be specific to text comprehension in the social domain, as stereotypes are activated and used as readily by autistic as typical populations (Hirschfeld, Bartmess, White & Frith, 2007). According to the Weak Central Coherence (WCC) theory (Frith & Happé, 1994; Happé, 1999) the reason for this difference is that typically developing individuals tend to engage in global processing which encodes the overall meaning of the input at the expense of local features. This process involves integrating incoming information with its context in order to derive higher level meaning. By contrast, autistic individuals engage in more detailed, local or piecemeal processing, lacking the drive for global coherence.

In the present study we compared autistic and typically developing adolescents’ performance on three well-known tasks from the heuristics and biases literature: the conjunction fallacy (Tversky & Kahneman, 1983), and two versions of the engineers and lawyers problem (Kahneman & Tversky, 1973). The conjunction fallacy violates a fundamental rule of probability, that the likelihood of two independent events occurring at the same time (in "conjunction") should always be less than, or equal to the probability of either one occurring alone ($P(A) \geq P(A \& B)$). People who commit the conjunction fallacy assign a higher probability to a conjunction than to one or the other of its constituents. In the original demonstration of the fallacy (Tversky & Kahneman, 1983) people read a description of Linda, a 31-year-old, smart, outspoken woman who was a philosophy major, concerned with discrimination and social justice, and a participant in antinuclear demonstrations. When asked to judge a number of statements about Linda according to how likely they were, most people ranked the statement “Linda is a bank teller and is active in the feminist movement” above the statement “Linda is a bank teller,” thus committing the fallacy.

In the classic “engineers and lawyers” problem (Kahneman & Tversky, 1973) participants were told that descriptions have been prepared of 30 engineers and 70 lawyers (the base rates were reversed in another condition). Then participants were shown a description of a person from this sample, and they had to decide whether it referred to an

Conjunction fallacy	
Conflict *Sue is a very intelligent woman, who works in a hospital. She wears glasses and a green uniform. Her bookshelves in her office are full of medical books. Mark the following statements with number 1 to 4 according to how likely they are. (1: most likely, 4: least likely)* ______*Sue is a plumber.* ______*Sue is a doctor.* ______*Sue is a doctor and a mechanic.* ______*Sue is a mechanic.*	***Non- conflict*** *Brian has a studio, where he works alone. He is a very creative man, and he likes to experiment with colours. He takes his work to exhibitions, and sells some of them too. Mark the following statements with number 1 to 4 according to how likely they are. (1: most likely, 4: least likely)* --------Brian is an aerobics instructor. --------Brian is a painter. --------Brian is an aerobics instructor and an accountant. --------Brian is an accountant.
Engineers and lawyers problem – representative description	
Conflict *A group of tourists visit the Eiffel tower in Paris. There are 15 old people in the group and 3 young ones. The tourists can choose between taking the lift or climbing up the tower (which takes half an hour). Only one person wants to climb up the tower. Do you think it is more likely that it's an old person, or that it's a young one?* • It's more likely that it's a young person. • It's more likely that it's an old person. • Both are equally likely.	***Non-conflict*** *In a bird-watching club there are 6 women and 30 men. After a nice bird-watching trip a member of the club decides on going to a pub to watch a cricket-match. Who do you think is going to the pub?* • A man. • A woman. • Both are equally likely
Engineers and lawyers problem – non-representative description	
Conflict *Laura is a member of a sailing club and she also sings in a choir. She has 20 friends in the sailing club and 4 friends in the choir. Now she's going to Spain with a friend. Do you think it is more likely that she goes to Spain with somebody from the sailing club or with somebody from the choir?* • It's more likely that it's somebody from the choir. • It's more likely that it's somebody from the sailing club. • Both are equally likely.	***Non-conflict*** *In a chocolate factory 10 people's offices are in Building A, and 2 people are working in Building B. They are working on a new chocolate drink, and they want to decide who should try the drink first, so they organize a raffle. Do you think it is a person who works in building A or is it a person who works in Building B who's going to try out the drink first?* • It's more likely that it's somebody who works in Building A. • It's more likely that it's somebody who works in Building B. • Both are equally likely.

Figure 1: An example of the 'conflict' and 'non-conflict' version of each problem.

engineer or a lawyer. Participants' judgments were mostly based on the description, and base rates had a significant but very small effect on responses. When participants were given a non-representative description (that was not characteristic of either a lawyer or an engineer) the average rating of the likelihood of the person being a lawyer/engineer was 50%. This indicated that participants tended to disregard base rates (which were readily available) even when there was no other information provided. Instead, if an individual's description was neither characteristic of an engineer or a lawyer they concluded that their group membership could not be determined.

Based on the WCC theory (Frith & Happé, 1994; Happé, 1999) we predicted that autistic children will give less heuristic responses to the conjunction fallacy and to the engineers and lawyers problems, because heuristic responding is based on the perceived contextual links between the task and a particular response option, and autistic children are less sensitive to contextual cues. Besides the traditional "conflict" versions of the problems which pit heuristic responses against a normative rule, we included control (non-conflict) problems. This allows for a direct comparison between the two groups in terms of their capacity to observe a normative rule (i.e., to base their responses on probabilistic information). This makes it possible to discard the alternative explanation, that autistic children are less biased because they are more sensitive to the logical structure of the tasks (and not because they are less able to or inclined to contextualize).

Method

Participants Twenty-three high functioning children with autism took part in the study (mean age 14 years). Diagnostic records of the children showed that every child had received a diagnosis of autism by experienced clinicians. No child had a diagnosis of Asperger's syndrome or Pervasive Developmental Disorder. Additionally, 41 typically developing children (mean age 13 years 2 months) participated in the study as a control group.

As a measure of general intelligence we used a short form of the Wechsler Intelligence Scale for Children (WISC-III, Wechsler, 1991) consisting of the block design and the vocabulary subtests. Additionally, we used Set 1 of the Raven Advanced Progressive Matrices (Raven, Raven & Court, 1998) consisting of 12 items, as a measure of fluid intelligence. We also administered the counting span task, a typical measure of verbal working memory with a processing and a storage component (see Handley, Capon, Beveridge, Dennis, & Evans, 2004).

There was no significant difference between the groups on the measures of cognitive ability apart from a marginally significant difference on the working memory measure ($t(57)=1.89$, $p=.06$) indicating a trend for the autistic participants to score lower on this task. There was also a significant difference in the mean age of the two samples, the autistic group being significantly older than the control group ($t(62)=2.06$, $p<.05$). In order to take account of these differences, we included age and working memory as covariates in our main analyses. None of the effects were moderated by these variables. Consequently we report the simpler ANOVA models below.

Materials and procedure We used twelve tasks, four tasks (two conflict, and to non-conflict problems) measuring each type of heuristic (the conjunction fallacy, the representativeness heuristic, and the equiprobability bias - see Figure 1 for examples). In the conjunction fallacy tasks participants had to rate four statements according to their likelihood. In the *conflict* tasks the measure of the conjunction fallacy was whether participants judged the probability of the conjunction of a representative and a non-representative statement as more likely to be true than the non-representative statement alone. In the *non-conflict* tasks the dependent measure was whether participants judged the conjunction of two non-representative events as more likely to be true than either of the non-representative events alone.

In the engineers and lawyers tasks participants had to choose between three response options. In the *representative conflict* tasks participants were given a heuristic point if they chose the representative response, and a normative point if they chose the response that corresponded to the base rates. In the *representative non-conflict* task the representative response corresponded to the base rates. In the *non-representative conflict* version of the task paricipants were given a heuristic point if they gave the "equally likely" response, and they were given a normative point if they chose the base rate response. In the *non-representative non-conflict* tasks we did not provide any individuating information about the groups that would invite an association of the groups with social stereotypes (instead of "engineers and lawyers" or "people who go sailing and people who sing in a choir" we called the two groups "people working in building A and B", for example). Here we expected participants to mostly choose the base rate response.

All the problems were presented in a booklet with different types of problem mixed together in a pseudo-random order. The experimenter read out the instructions and the participants worked through the problems at their own pace. The individual differences measures were administered individually in a separate testing session.

Results

Conjunction fallacy. Our first analysis aimed to address two questions. First we wanted to determine whether the conjunction fallacy was more common amongst the control group than the autistic group. The second aim was to evaluate whether autistic participants show greater sensitivity to the conjunction rule. We conducted a 2 (group) x 2 (problem type) mixed ANOVA to compare fallacy rates on the conflict and non-conflict problems for the two groups (see Table 1 for descriptive statistics). The analysis revealed a main effect of problem type ($F(1,62)=12.14$, $p<.01$, $\eta_p^2 = .16$) showing, as expected, higher rates of conjunction fallacy for the conflict compared to the non-conflict problems (82% vs. 61%). There was no main effect of group which indicates that the autistic participants are not in any general sense more sensitive to the conjunction fallacy than the control group. There was also a significant interaction between group and problem type ($F(1,62)=4.9$, $p<.05$, $\eta_p^2 = .07$) which indicated that the control group made more conjunction errors on the conflict problems (88%) than on the non-conflict problems (56%). In contrast, there was no significant difference in the number of errors made on the conflict (72%) and non-conflict problems in the autistic group (65%). This analysis confirms that the lower rates of the conjunction fallacy amongst the autistic group cannot be attributed to increased sensitivity to the conjunction rule.

Table 1: Mean proportion of conjunction fallacies committed for each type of problem across groups (standard deviations in brackets).

	Conflict	Non-conflict
Typically developing	.88 *(.32)*	.57 *(.51)*
Autistic	.72 *(.45)*	.65 *(.49)*

We also compared the proportion of participants in each group who rated the representative item as the most likely option on the non-conflict problems (where there was no difference between groups in fallacy rates). The purpose of this analysis was to evaluate whether both groups identified the representative item as the most likely to the same degree. This would indicate that similar knowledge was activated and employed in making judgments about the simple options. The analysis revealed no significant difference in the proportion of participants from the two groups ranking the representative item as the most likely (78 vs. 65% of the control and the autistic group, respectively, gave the representative option the highest rating on both tasks, and 20 vs. 22 % of the children in each group gave the

Table 2: Mean proportion of representative, non-representative and other responses for each type of problem across groups on the *engineers and lawyers problem with representative description* (standard deviations in brackets).

	Representative		Non-representative		Equibrobable	
	Conflict	Non-conflict	Conflict	Non-conflict	Conflict	Non-conflict
Typically developing	.74 *(.32)*	.77 *(.32)*	.15 *(.25)*	.08 *(.21)*	.10 (.20)	.15 (.27)
Autistic	.73 *(.33)*	.81 *(.25)*	.17 *(.28)*	.05 *(.15)*	.10 (.25)	.14 (.23)

highest rating to the representativeness option on one task; $\chi^2(2)=3.02$, n.s.).

Engineers and lawyers problem with representative description: Table 2 shows the mean proportion of representativeness-based, base rate and equally likely responses for each of the problem types and groups. First we wanted to determine whether there was any difference in the tendency to give representativeness-based (heuristic) responses between the autistic and the control group. We conducted a 2 (group) x 2 (problem type) mixed ANOVA to compare representativeness-based responses on the conflict and non-conflict problems for the two groups. The analysis revealed no effect of problem type or group. This indicated that autistic participants' responses were as much driven by representativeness as the control groups'. A similar ANOVA on the non-representative responses showed a significant effect of conflict ($F(1,62)=5.19$, $p<.05$, $\eta_p^2 = .07$), but no effect of group, and no interaction. This indicated that children in both groups tended to choose the non-representative option more often if it corresponded to the base rates. Thus, both groups showed equal sensitivity to probabilistic information.

Engineers and lawyers problem with non-representative description: Table 3 shows the mean proportion of base rate, equally likely, and other responses for each of the problem types and groups. Our first analysis was aimed at determining whether there was any difference in the tendency to give equiprobability responses between the autistic and the control group. We conducted a 2 (group) x 2 (problem type) mixed ANOVA to compare equiprobability responses on the conflict and non-conflict problems for the two groups. The analysis revealed no effect of problem type or group. This indicated that there was no difference between groups in their tendency to give equiprobability responses and the number of equiprobability responses was the same in the conflict and non-conflict tasks. A similar ANOVA on the base rate responses showed a significant effect of conflict ($F(1,62)=7.89$, $p<.01$, $\eta_p^2 = .10$) and a significant group by problem type interaction ($F(1,62)=4.01$, $p<.05$, $\eta_p^2 = .05$). This indicated that typically developing children gave less base rate responses when the groups could be associated with social stereotypes, but when the groups were neutral (i.e., the groups' descriptions were not informative) children in the autistic and control group gave the same amount of base rate responses. This showed that autistic children were not more sensitive to probabilistic information, but they were less inclined to engage in further processing based on contextual cues (i.e., presumably because they did not assume that the individuating information provided about the groups should be taken into consideration). Instead they continued to rely on base rates which were readily available.

Discussion

The findings presented here suggest that the *conjunction fallacy* is less likely to occur with autistic participants. This effect was predicted because autism has been associated with deficits in contextual processing, the sort of automatic processing commonly claimed to underlie the conjunction effect (Kahneman & Frederick, 2002). In addition, the comparison between the experimental and control problems demonstrates that autistic participants are not generally more sensitive to the conjunction rule; that is, they do not show improved normative performance on the non-conflict problems. Finally, an examination of the likelihood judgments on the representative item alone indicates that the groups do not differ in the degree to which they are influenced by background knowledge in their ratings of the simple options.

Performance on the *engineers and lawyers problem with representative description* showed similar tendencies. Autistic children were as much influenced by the representativeness of a description as typically developing children, mostly ignoring base rates. More specifically, they showed the same significant but not very strong effect of conflict between base rates and representativeness as the control group. This result is in line with the finding on the conjunction fallacy tasks where there was no difference between groups in their ability to choose the representative option as most likely. This also concurs with the findings of Hirschfeld *et al.* (2007) who reported similar activation and use of stereotypes in autistic as in typical populations. In addition, (just as in the conjunction fallacy task) the two groups were equally sensitive to probabilistic information.

On the *engineers and lawyers problem with non-representative description* autistic children showed less sensitivity than the control group to whether the description of groups could be associated with social stereotypes or not. Although the performance of the two groups was indistinguishable on the control problems (which confirmed once more that autistic children were not any more sensitive to probabilistic information than the control group). However, typically developing children gave less base rate responses than the autistic group when the description of the groups in the task seemed socially meaningful. This shows, in accordance with the findings on the conjunction fallacy task, that autistic children are less inclined to engage in

Table 3: Mean proportion of base rate, equiprobable and other responses for each type of problem across groups on the *engineers and lawyers problem with non-representative description* (standard deviations in brackets).

	Base rate		Other		Equibrobable	
	Conflict	Non-conflict	Conflict	Non-conflict	Conflict	Non-conflict
Typically developing	.30 *(.33)*	.60 *(.42)*	.30 *(.35)*	.13 *(.22)*	.40 *(.37)*	.27 *(.32)*
Autistic	.54 *(.39)*	.60 *(.39)*	.19 *(.29)*	.16 *(.24)*	.27 *(.33)*	.23 *(.33)*

contextual processing than the control group based on subtle cues. This corresponds to the lower impact of context on complex verbal processing in autism that was reported by a number of studies (for a review, see Happé & Frith, 2006).

In two out of three types of task autistic children engaged in less contextual processing than typically developing children. This raises the question of how the contextualization process involved in the three tasks might differ. Lopez and Leekham (2003) suggested that autistic children were able to use context to draw simple inferences, but they were impaired in the contextual processing of complex material. One possible way of defining complexity could be through the amount of cognitive effort needed to carry out an operation. Recently, we found evidence that amongst children between the age of 5 and 11 committing the conjunction fallacy (and giving heuristic responses on some other tasks) was positively correlated with cognitive abilities (Morsanyi & Handley, 2008). However, this trend reverses for older children and adults (Kokis, Macpherson, Toplak, West & Stanovich, 2002) resulting in a developmental pattern where young children with higher cognitive ability give more heuristic responses than lower ability children from the same age group. Later on the contextualization process becomes effortless and automatic, and at this stage suppressing contextual processing (i.e., decontextualization) requires conscious effort. As a result, amongst adolescents higher ability participants give less heuristic responses than their lower ability peers. Similar reversed U-shaped developmental patterns have been found in the area of conditional reasoning (De Neys & Everaerts, 2008) and false memories (Brainerd, 2004).

It is possible that for autistic children contextual processing requires more cognitive effort than for typically developing children. Consequently, it occurs less often than amongst typically developing adolescents where these effects are the result of more automatic contextualization processes. If this conjecture is right, then we would expect that the relationship between working memory capacity and heuristic/normative responding amongst the autistic and the control group might be different, at least on the tasks where we found a difference in response patterns between groups.

In the present study, we collected data from the counting span task, a typical measure of working memory capacity. Consistent with the analysis above the correlation between the number of conjunction fallacies made on the conflict tasks in the autistic group and working memory scores was significant and positive ($r(21) = .44$, $p<.05$), whilst the correlation in the control group was negative and non-significant ($r(38) = -.09$, n.s.) indicating that committing the conjunction fallacy was the result of effortful reasoning in the autistic, but not in the control group.

Giving heuristic (representativeness-based) responses in the first version of the engineers and lawyers problem (where we found no difference between the autistic and the control group) was not correlated with working memory capacity in either the autistic ($r(21)=-.26$, n.s.) or the control group ($r(38)=-.02$, n.s.). This indicates that choosing the representative option was a fairly automatic process for both groups.

Applying the same procedure for the base rate responses on the conflict version of the engineers and lawyers problem with a non-representative description, we found that it was positively correlated with working memory capacity in the control group ($r(38)=.30$, $p<.05$), whilst the correlation in the autistic group was non-significant and negative ($r(21)=-.07$, n.s.). This suggests that resisting the heuristic in the case of this task requires conscious effort for the control group. By contrast, autistic children could resist the heuristic effortlessly, presumably because they did not engage in the contextualization process in the first place. This is also indicated by their virtually identical performance on the conflict and non-conflict version of this task.

Taken together, the correlational patterns suggest that the tasks that we used in this study differed in the complexity of the contextualization process involved. The engineers and lawyers problem with a representative description involved a simple matching of the description with a response option which was done with equal ease in the autistic and the control group. Committing the conjunction fallacy involved a more complex contextualization process which was automatic (i.e., effortless) for the typically developing group but which was effortful for the autistic children. This corresponds to the findings with younger typically developing children (Morsanyi & Handley, 2008), and it suggests a delay in the autistic group in developing the ability to contextualize. Finally, on the engineers and lawyers task with a non-representative description, giving the normative response (which is presumably based on the inhibition of the heuristic equiprobability response – see e.g., Kokis et al., 2002) required conscious effort in the typically developing sample, whereas it was effortless in the autistic group, suggesting that the contextualization process did not occur in the autistic group - again giving the impression of a developmental delay.

Although dual-process theories (e.g., Stanovich, 1999) generally assume that the contextualization process that underlies heuristic reasoning is automatic and effortless, this is mostly based on evidence with adult participants. The developmental data in Morsanyi and Handley (2008) together with evidence from the area of conditional reasoning (e.g., De Neys & Everaerts, 2008) and with the data from the present study suggest that contextualization does not take place automatically in the case of young children, and autistic adolescents. Instead of being more rational or more sensitive to the logical structure of the problems, autistic participants were less able to integrate contextual information into their representation of the tasks, or, potentially, less able to combine information from different sources. Autistic children can process complex nonverbal information, and they are also able to reason with relations, as suggested by their performance on the Raven test (e.g., Dawson et al., 2007), and pictorial tests of analogical reasoning (Morsanyi & Holyoak, in press). Nevertheless, in the case of the present tasks autistic children showed less contextualization than the control group. Moreover, when contextualization did occur it required more effort than in the control group. Taken together these data suggest a delay in the development of the ability to contextualize complex verbal material in the autistic group (see also Lopez & Leekham, 2003).

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