

# Inductive and deductive reasoning in Obsessive-Compulsive Disorder

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## Abstract

This study examined the hypothesis that individuals with obsessive-compulsive disorder (OCD) show a selective deficit in inductive reasoning but are unimpaired in their ability to make deductive inferences. 100 participants from an analog sample made inductive or deductive inferences about arguments that differed according to causal consistency and validity. They also completed a task examining sensitivity to the implications of diverse evidence in induction. Participants who were high or low on obsessive-compulsive symptoms showed similar patterns of induction based on causal knowledge and similar patterns of deduction. However, those with the highest level of OCD symptoms showed less of a preference for diverse evidence when evaluating inductive arguments, compared to those with the lowest level of symptoms. This difference was found across both OCD-relevant and OCD-neutral items, and persisted when the effects of group differences in general ability were controlled. These results indicate that both inductive reasoning based on background knowledge and deductive reasoning are intact in individuals with high OCD-trait but the use of inductive heuristics such as evidence diversity is impaired.

**Keywords:** inductive reasoning, deductive reasoning, psychopathology, cognitive neuropsychiatry

## Introduction

Obsessive-compulsive disorder (OCD) is characterized by the experience of unwanted, repetitive intrusions in the form of thoughts, impulses or images. These obsessions are often accompanied by compulsions (repetitive behaviors or mental acts) that represent attempts to reduce or neutralize the marked distress that the obsessions cause.

A variety of biological, cognitive and social factors affect the onset and maintenance of OCD symptoms (Riggs & Foa, 1993). Recently, a number of theoretical accounts have suggested that deficits in reasoning contribute to OCD symptomatology. Some of these accounts suggest that people with OCD have difficulty in reasoning about uncertain or probabilistic information (O'Connor, 2002; Pélissier & O'Connor, 2002); that is, they show a deficit in some forms of *inductive reasoning*. These accounts suggest that this is a global deficit, such that people with OCD show poorer inductive reasoning compared to controls across a range of stimulus materials and content domains. Moreover, this impairment in inductive reasoning is thought to be found together with a relatively intact ability to reason deductively. Unlike induction, deduction involves the evaluation of arguments that are *certain* to be either valid or

invalid on the basis of logical rules (Heit, Rotello, & Hayes, 2012).

A review of the empirical evidence however, reveals only mixed support for this “impaired induction but spared deduction” account of OCD. In support of this account, Pélissier and O'Connor (2002) found that individuals with OCD had more difficulty than controls in drawing plausible probabilistic conclusions from a set of verbal statements about everyday situations. This impairment in inductive reasoning was found together with apparently intact deductive reasoning, as measured by performance on the Wason Selection Task and ability to discriminate between valid and invalid verbal syllogisms. Moreover, this pattern was found with stimulus materials that had little connection with the content of OCD patients’ obsessions.

Other work however, has suggested that the reasoning deficit in OCD extends to deduction as well as induction. For example, Simpson, Cove, Fineberg, Msetfi, and Ball (2007) found that people with OCD were poorer than controls at discriminating between logically valid and logically invalid syllogisms with OCD-neutral content.

This mixed pattern of evidence reflects, at least in part, a general problem with the methods used in previous attempts to examine inductive and deductive reasoning in people with OCD. These studies have made little attempt to match tasks that ostensibly assess inductive and deductive reasoning on dimensions such as overall task difficulty, stimulus content and task familiarity. Hence, differences in performance between nominally inductive and deductive tasks may actually reflect task-specific characteristics rather than in the cognitive processes that underlie inductive and deductive reasoning.

A major aim of the current studies was to re-examine inductive and deductive reasoning in those with OCD-related traits and controls, using a method that addressed this major limitation of previous work. The general approach is patterned after Rips (2001) and Heit and Rotello (2010) who asked university undergraduates to evaluate a set of verbal arguments that varied in both logical validity and inductive plausibility. Crucially, different groups evaluated the set of arguments on the basis of logical necessity (deduction condition) or the overall plausibility (induction condition) of the conclusions.

Another important aim was to carry out a more exhaustive examination of possible deficits in inductive reasoning in those with OCD-related traits. A review of

research on induction in people without OCD (typically university undergraduates) suggests that such reasoning is influenced by at least two distinct factors (cf. see Hayes, Heit, & Swendsen, 2010 for a detailed review). On the one hand, people often evaluate inductive arguments using their prior knowledge of causal or taxonomic relations between argument premises and conclusions (Medin, Coley, Storms, & Hayes, 2003). For example, Rips (2001) found that participants were more likely to accept conclusions in inductive arguments when these were consistent with background causal knowledge (e.g. see the top right cell of Table 1), than when they were causally inconsistent (e.g. see the bottom right cell of Table 2), even though neither conclusion is logically entailed by the premise.

A second factor influencing induction is the use of general heuristics for assessing probabilistic evidence (Heit, Hahn, & Feeney, 2005; Osherson, Smith, Wilkie, López, & Shafir, 1990). Such heuristics include the sample size (or “monotonicity”) principle in which the strength or plausibility of an inductive conclusion tends to increase with the number of instances of positive evidence observed (Osherson et al., 1990). Another important heuristic is premise diversity. All things being equal, more diverse evidence (e.g., *cows and mice have property X*) is usually seen as a stronger basis for inductive generalizations (e.g., *mammals have property X*) than less diverse evidence (e.g., *cows and horses have property X*). Although there is some debate about the normativity of this principle (e.g., Lo, Sides, Rozelle, & Osherson, 2002), a large body of evidence shows that most reasoners use this heuristic when evaluating inductive evidence (see Heit et al., 2005 for a review).

Previous work on inductive reasoning deficits in OCD has blurred this distinction, with some researchers examining induction based on background knowledge (e.g., Pélissier & O’Connor, 2002), while others have examined the use of domain-general heuristics in probabilistic and inductive reasoning (e.g., Fear & Healy, 1997). We sought to clarify the nature of inductive deficits in people with OCD by assessing those with low and high levels of OCD-related traits on each of these two types of inductive tasks.

## The Current Study

To re-examine inductive and deductive reasoning in individuals high and individuals low on OCD symptoms, we administered two tasks. The first examined inductive and deductive reasoning using a common set of stimulus materials. Following Rips (2001), participants were asked to judge either the inductive strength or deductive validity of four types of arguments. Table 1 illustrates this design with arguments that vary in logical validity and consistency with causal knowledge. Crucially, different groups were instructed to evaluate the same set of arguments on the basis of either deductive validity or inductive plausibility.

Previous work with undergraduates (e.g., Heit & Rotello, 2010; Rips, 2001) has found that this instructional manipulation interacts with argument type. In particular, Rips (2001) found that under deduction conditions, binary

judgments of argument strength were primarily affected by validity, regardless of causal consistency. In contrast, those given induction instructions were highly sensitive to causal consistency. In this condition, causally-consistent but logically invalid arguments (e.g., arguments like those in the top right cell of Table 1) were judged to have similar argument strength to logically valid arguments. According to Rips (2001), this pattern shows that people use qualitatively different criteria for evaluating arguments when doing induction and deduction.

If those with OCD-symptomology exhibit spared deductive reasoning but impaired inductive reasoning, then they should show a different pattern of performance on the Rips induction-deduction task. Specifically, they may show sensitivity to logical validity under deduction instructions but may not show the same sensitivity to causal consistency as controls, when given induction instructions.

Table 1: Examples of the argument types used in the Rips induction - deduction task. Participants were asked to evaluate the conclusion (below the line in italics) assuming the premises (above the line in normal font) to be true.

Causal status	Validity	
	Valid	Invalid
<b>Causally Consistent</b>	If Jill rolls in the mud, Jill gets dirty. Jill rolls in the mud.	Jill rolls in the mud.
<b>Causally Inconsistent</b>	<i>Jill gets dirty.</i> If Jill rolls in the mud, Jill gets clean. Jill rolls in the mud.	<i>Jill gets dirty.</i> Jill rolls in the mud.
	<i>Jill gets clean.</i>	<i>Jill gets clean.</i>

Note that the Rips task examines induction based on background causal knowledge. With the aim of providing a more comprehensive examination of possible inductive deficits in OCD, we also administered an inductive reasoning task which tested sensitivity to the diversity heuristic. In the diversity task, participants were asked to make judgments about which of two pairs of premises would provide better evidence for a more general inductive conclusion (see Table 2 for an example). One premise pair (non-diverse set) contained two very similar premises, while another (diverse set) contained premises that were less similar (but still nested within the conclusion category).

Those with no OCD-symptomology were expected to show a robust preference for the diverse set (cf. Heit et al., 2005; Osherson et al., 1990). However, if inductive reasoning is impaired in people with OCD, then we would expect to see less evidence of the diversity heuristic in those with OCD symptoms. Indirect support for this prediction comes from the finding that relative to controls, individuals with OCD often make repeated observations of the same or similar items before making a probability judgment (e.g., Fear & Healy, 1997; Volans, 1976). As shown in Table 2, the prediction about differences between diversity-based reasoning in those low or high in OCD traits was examined

using “OCD-neutral” arguments as well as arguments with content relevant to common obsessions (OCD-relevant).

Table 2: Examples of the four argument types used in the Diversity task. The premises are given in normal font above the line and are assumed to be true. Conclusions are given in italics below the line.

Premise Sets	Content	
	OCD-Neutral	OCD-Relevant
Diverse	All cows have an ileal vein	All gold coins are contaminated by the bacteria <i>hemonasella coli</i>
	All mice have an ileal vein	All dollar bills are contaminated by the bacteria <i>hemonasella coli</i>
	<i>All mammals have an ileal vein</i>	<i>All forms of money are contaminated by the bacteria <i>hemonasella coli</i></i>
Non-Diverse	All cows have an ileal vein	All gold coins are contaminated by the bacteria <i>hemonasella coli</i>
	All horses have an ileal vein	All silver coins are contaminated by the bacteria <i>hemonasella coli</i>
	<i>All mammals have an ileal vein</i>	<i>All forms of money are contaminated by the bacteria <i>hemonasella coli</i></i>

It is important to note that unlike many previous studies (e.g., Péllié & O’Connor, 2002; Simpson et al., 2007), we did not test patients who had received a formal diagnosis of OCD. Instead we employed an “analog-sample” of undergraduates who showed relatively low or high levels of OCD symptomology as measured by a widely used self-report screening questionnaire. This approach is justifiable given that non-treatment seeking individuals who score highly on self-report measures of obsessive-compulsive symptoms often do meet diagnostic criteria for OCD (Burns, Formea, Keortge, & Sternberger, 1995).

## Method

**Participants.** One-hundred undergraduate students who spoke English as their primary language participated for course credit.

These participants were all assessed using the Obsessive-Compulsive Inventory-Revised (Foa et al., 2002). This is an 18-item self-report measure that assesses subjective experience of OCD symptoms in the past month. Item ratings are made on a 5-point Likert scale (0=not at all distressing, 4=extremely distressing). The OCI-R has been shown to reliably distinguish between individuals with OCD and non-OCD controls, and to have high internal consistency and test-retest reliability (Foa et al. 2002). Individuals high on obsessive-compulsive symptoms were defined as those scoring equal to or greater than 21 on the

OCI-R ( $n = 44$ ,  $M = 29.95$ ,  $SD = 7.19$ ), which is consistent with the cut-off used for distinguishing between non-anxious controls and those with OCD (Foa et al., 2002). Of these participants, the majority were female ( $n = 30$ ) and the mean age was 18.75 years ( $SD = 1.64$ ). Low-OCD individuals were defined as those scoring less than 21 on the OCI-R ( $n = 56$ ,  $M = 10.85$ ,  $SD = 5.42$ ); the majority of these participants were female ( $n = 30$ ) and the mean age was 20.46 years ( $SD = 6.67$ ).

## Design and Procedure.

All participants were tested individually in the UNSW Cognition and Reasoning lab. All were administered a Rips induction-deduction task and a premise diversity task, with order of task presentation counterbalanced across participants. After completion of the reasoning tasks, all participants also completed a test of general ability (the two-subtest short-form of the Wechsler Abbreviated Scale of Intelligence) (WASI; Wechsler, 1999), and the OCI-R. The general ability test was included so that possible group differences in reasoning performance could be differentiated from group differences in overall cognitive ability.

**Rips induction-deduction task.** The Rips induction-deduction task consisted of 16 arguments that varied factorially in logical validity (valid vs. invalid) or causal consistency (consistent vs. inconsistent) (see Table 1 for examples), such that there were four argument types. The valid items were based on either the inference form modus ponens (If  $p$  then  $q$ ,  $p$  therefore  $q$ ) (as in the Table 1 example) or conjunctive syllogism (not ( $p$  and  $q$ ),  $p$  therefore not  $q$ ), such that valid items followed an acceptable logical structure but invalid items did not. Item content for 12 of the arguments was taken from Rips (2001), and the remaining four arguments were generated by the researchers.

Instructions for evaluating these arguments (deduction vs. induction) were manipulated between subjects, with approximately equal numbers allocated to each condition. Those in the induction condition were told that *strong* arguments are those for which “assuming the information above the line is true, this makes the sentence below the line plausible”, whilst those in the deduction condition were told that *valid* arguments are those for which “assuming the information above the line is true, this necessarily makes the sentence below the line true”. They were instructed to examine each argument and make a binary judgment about the conclusion (“strong” or “weak” in the induction condition; “valid” or “invalid” in the deduction condition). Arguments were presented one at a time on a computer screen in random order, and responses were made via on-screen buttons. There was no time limit on responding.

**Premise Diversity task.** This consisted of 30 items, each made up of two pairs of premises (one diverse, one non-diverse) and a general conclusion (see Table 2 for examples). Assignment of premises to the diverse or non-diverse set was based on pre-test ratings of the similarity

between the categories mentioned in the premises (e.g., cows and horses) by an independent group of participants who took no part in the main experiment. This pre-test established that diverse premise pairs ( $M = 4.52$ ,  $SD = 1.31$ ) were reliably perceived as less similar to one another than the non-diverse pairs ( $M = 7.94$ ,  $SD = .54$ ),  $t(10) = 11.75$ ,  $p < .01$ . Premise and conclusion categories (e.g., cows, horses, mammals; gold coins, silver coins, money) were selected so that they would be familiar to participants, but the properties attached to each (e.g., "have an ileal vein", "are contaminated by *hemonasella coli*") were unfamiliar (cf. Osherson et al., 1990). For each item, participants had to choose which of the premise pairs provided stronger evidence for the conclusion, as illustrated in Table 2.

Half the diversity items were content-neutral (related to animals), whilst the other half were OCD-relevant (containing emotional content related to common OCD-related concerns, such as washing and checking). The left-right positioning of diverse and non-diverse premises was randomized, as was item order. The full set of items is available from the authors.

## Results

**Preliminary Analyses.** A one-way ANOVA analysis of general ability scores between OCD-high and OCD-low groups indicated that the groups did not differ in estimates of general ability,  $F(1, 98) = 3.36$ ,  $p = .07$ . However, general ability estimates for those scoring in the highest quartile on the OCI-R ( $M = 105.37$ ,  $SD = 11.62$ ) were lower than those in the lowest quartile ( $M = 112.4$ ,  $SD = 7.55$ ),  $F(1, 98) = 298.04$ ,  $p < .01$ . As there were general ability differences in the lowest and highest quartiles of OCD symptoms, general ability was controlled in all analyses.

**Rips Induction-deduction task - Proportion of positive responses.** The proportion of trials in which OCD-high and OCD-low participants judged an argument as "valid" in the deduction condition or "strong" in the induction condition is given in Figure 1. As Figure 1 indicates, the proportion of positive responses across item types is clearly affected by argument consistency,  $F(1, 98) = 261.94$ ,  $p < .01$ , and validity,  $F(1, 98) = 223.33$ ,  $p < .01$ .

The key question however, is whether responses to valid-inconsistent (V-I) and invalid-consistent (Inv-C) items differ as a function of instruction and OCD-group status. Crucially, as in Rips (2001), we found a crossover interaction between the relative likelihood of making a positive response to V-I and Inv-C and the instruction manipulation,  $F(1, 96) = 10.82$ ,  $p < .01$ . Figure 1 shows that under deduction instructions, there was a higher rate of positive responding to V-I items than to Inv-C items, but that this pattern reverses under induction instructions. This suggests that people applied qualitatively different criteria to evaluating argument strength in the induction and deduction conditions. Notably, as is clear from Figure 2, this effect was found in both OCD-low and OCD-high groups (i.e. there was no significant group  $\times$  item  $\times$  instruction

interaction,  $p = .595$ ). All of these results remained robust when group comparisons were restricted to the highest and lowest quartile groups on the OCI-R (OCD-low,  $n = 24$ ; OCD-high,  $n = 27$ ). These results challenge the view that induction involving the use of background causal knowledge is selectively impaired in OCD.

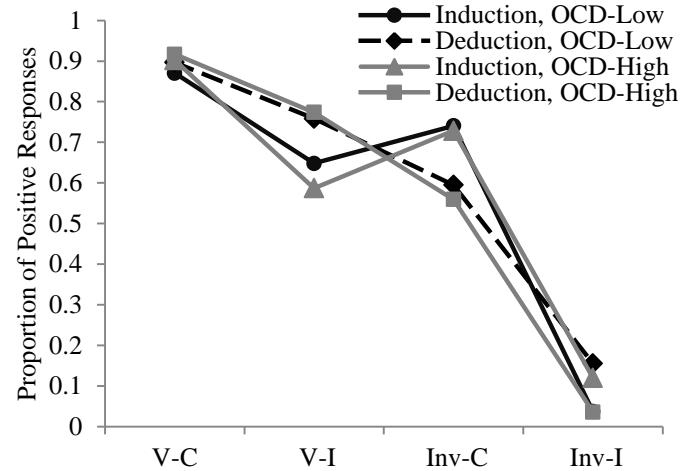


Figure 1. Proportion of positive responses ('strong' or 'valid') for each item type, by instruction condition and group. V-C = Valid + causally consistent items; V-I = Valid + causally inconsistent items; Inv-C = Invalid + causally consistent items; Inv-I = Invalid + causally inconsistent items.

A further analysis of the deduction data was carried out by calculating an "interaction index", which measures the influence of causal consistency on positive responding for valid and invalid problems, whilst correcting for response bias (see Dube, Rotello, & Heit, 2010). The interaction index was calculated using the formula;

$$\text{Interaction index} = (H_I - F_I) - (H_C - F_C) \quad (1)$$

$H$  denotes the rate of hits (responding "valid" to a logically valid item).  $F$  denotes false alarms (responding "valid" to a logically invalid item), and  $C$  and  $I$  denote causally consistent and causally inconsistent arguments respectively. The index is scaled such that a positive index suggests that people find it easier to discriminate between valid and invalid items with unbelievable conclusions. An interaction index score was calculated for each participant and mean scores were compared between the OCD-low ( $M = 0.39$ ,  $SD = .05$ ) and OCD-high ( $M = 0.34$ ,  $SD = .07$ ) groups. Consistent with previous work, the interaction index calculated for the OCD-low group was positive (Dube et al., 2010), as was the index calculated for the OCD-high group. The interaction index scores did not differ between these groups,  $F(1, 95) = .38$ ,  $p = .54$ . In other words, there were no OCD-group differences in the impact of causal consistency on judgments of logical validity. Again it appears that OCD-low and OCD-high show similar patterns of reasoning based on background causal knowledge.

**Proportion of Diverse Pairs Chosen.** Overall, both OCD-high and OCD-low groups were more likely to choose the diverse premise pairs as providing stronger evidence for inductive generalization than would be expected by chance, (OCD-low,  $t(55) = 7.98, p < .01$ ; OCD-high,  $t(42) = 4.05, p < .01$ ). The relative preference for diverse pairs in OCD-high and OCD-low groups was compared. There was no effect of OCD status for overall proportion of diverse pairs chosen,  $F(1, 106) = 1.35, p = .25$ . Participants showed a reliable diversity effect (i.e. selection of diverse pairs above chance) for both OCD-neutral,  $t(99) = 7.27, p < .01$ , and OCD-relevant items,  $t(99) = 9.24, p < .01$ .

We again reanalyzed these data restricting group comparisons to those individuals showing the most extreme scores on the OCI-R (i.e. the lowest and highest quartiles). As can be seen in Figure 2, individuals exhibiting the highest OCD symptoms show reduced preference for diverse evidence in induction than those with low levels of OCD symptoms,  $F(1, 51) = 7.41, p < .01, d = 1.09$ . Individuals with high scores on the OCI-R were less likely to show a preference for diverse evidence, regardless of whether item content was neutral,  $F(1, 51) = 5.95, p < .05, d = 1.06$ , or emotionally relevant,  $F(1, 51) = 7.89, p < .01, d = 1.01$ . Moreover, this difference persisted when group differences in general ability were controlled by using individual scores on the ability test as a covariate.<sup>1</sup>

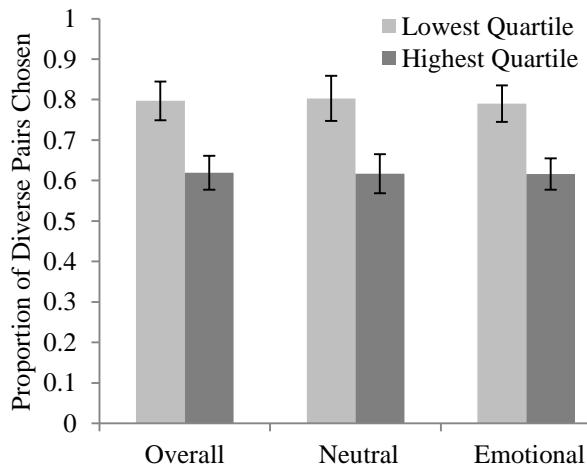


Figure 2. Proportion of Diverse Pairs Chosen by Lowest and Highest Quartiles on the OCI-R.

Overall, these data suggest that non-clinical adults with the highest levels of OCD symptoms were less likely to make use of the diversity heuristic in inductive reasoning than those who show low levels of symptomatology.

<sup>1</sup> Moreover, linear regression analyses showed that scores on the OCI-R explained a significant amount of variance in the proportion of diverse pairs chosen overall after the common variance explained by general ability had been controlled (i.e. when OCI-R scores were entered into the equation after general ability),  $R^2 = .33, F(1,97) = 5.95, p < .01$ , and for both neutral items,  $R^2 = .35, F(1,97) = 6.77, p < .01$ , and OCD relevant items,  $R^2 = .29, F(1,97) = 4.42, p < .05$ .

## General Discussion

Previous work (e.g. Péliéssier & O'Connor, 2002) has suggested that people with OCD show a selective deficit in inductive reasoning but unimpaired ability to reason deductively. This study tested this hypothesis in two ways. First, we compared the inductive and deductive performance of those with low or high levels of OCD-related traits using a common stimulus set for both tasks. Second, we examined the performance of these two groups on two types of inductive problems; one based on the use of background knowledge to determine inductive validity and another examining the inductive heuristic of evidence diversity.

Overall there was mixed support for the hypothesis of a selective inductive deficit in people with OCD-related traits. Results from the Rips induction-deduction task replicated the main findings of other comparisons of inductive and deductive reasoning in nonclinical populations (e.g. Heit & Rotello, 2010; Rips, 2001). Induction and deduction instructions led participants to evaluate arguments in qualitatively different ways. Evaluations of inductive strength were based on consistency with prior knowledge. Evaluations of deductive validity were evaluated according to logical necessity. Crucially, there were no differences between OCD-low and OCD-high groups in patterns of inductive and deductive reasoning. These data provide little support for a selective deficit in inductive reasoning based on background knowledge in people with OCD.

An important finding however is that those who showed the highest level of OCD symptomatology exhibited an atypical pattern of induction based on the diversity heuristic. Those in the highest OCD symptom quartile were less likely to see diverse premise pairs as a stronger basis for inductive generalization than those in the lowest quartile. This difference persisted when the effects of general ability were factored out. This suggests that although inductive reasoning based on consistency with background knowledge may be intact in people with high-OCD symptoms, this group does show an impaired understanding of the implications of evidence diversity. Moreover, this appears to be a global impairment, affecting inductive reasoning about both OCD-related and OCD-neutral items.

Further work is needed to identify the specific source of this inductive impairment. It is notable that although sensitivity to evidence diversity is robust in nonclinical groups (Heit et al., 2005), there are some cases where this heuristic interacts with other factors, such as property knowledge. When diverse premises share a highly specific or idiosyncratic property, inductive generalizations based on diverse premises may actually be weaker than those based on non-diverse premises (Feeney & Heit, 2011). For example, Medin et al., (2003) found that people were less likely to generalize a property shared by *camels* and *desert rats* to other mammals, than a property shared by *camels* and *rhinos*, even though the first set of premises was rated as more diverse. It seems unlikely however, that this type of mechanism could explain the weakening of the diversity effect in people with OCD-symptoms. If this effect was

driven by the high OCD group inferring more specific or idiosyncratic relations between diverse premise pairs, one could reasonably expect that this effect would be stronger in items with OCD-relevant content. However, the weakening of the diversity effect in people with OCD symptoms was found across both OCD-relevant and neutral items.

A more likely explanation of reduced sensitivity to diversity in the OCD-high group relates to preservative tendencies observed in other studies of probabilistic and inductive reasoning in OCD patients (e.g. Fear & Healy, 1997; Volans, 1976). Such studies have found that when asked to evaluate evidence for an uncertain conclusion, people with OCD-related traits often repeatedly choose to examine similar or redundant types of evidence.

Overall, we found some evidence for impaired inductive reasoning in people with OCD-related traits, but only when a general inductive heuristic was involved. By contrast, high-OCD individuals did not differ from controls in induction based on background knowledge or in deductive reasoning. Clearly, given the analog nature of our samples, we must be cautious in generalizing the deficit in the use of the diversity heuristic to clinical populations. However, given that the level of OCD symptomatology is likely to be more severe in those seeking or undergoing treatment, it seems reasonable to speculate that such individuals will also show impairment in diversity-based inductive reasoning.

This study is one of the first to apply contemporary methods and theories of induction and deduction to examine reasoning deficits related to a specific clinical condition. Our view is that a careful examination of patterns of spared and impaired reasoning in such groups can contribute to the understanding of reasoning in both clinical and non-clinical populations (cf. Caramazza & Coltheart, 2006). For example, the finding that OCD-related symptoms are associated with impairments in some forms of induction but not others suggests that more than one underlying cognitive process drives inductive reasoning.

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