Is There Evidence for Unconscious Reasoning Processes?

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Abstract

Current theories of reasoning propose that reasoning is governed by two systems: conscious and unconscious. Conscious processing directs analytical thinking and results in correct responding, while unconscious processing employs heuristics that often leads to poor performance in deductive reasoning tasks. The present study uses a classic propositional task to examine the properties that distinguish conscious from unconscious reasoning. Overall, the study did not find support for dissociable reasoning systems. Instead, the findings suggest that the features exclusively attributed to each system, by dual reasoning theorists, were equally applicable to both.

Dual Process Theories

At present there are three theories of reasoning that have divided the process into unconscious and conscious components: Evans and Over s (1996) Dual process theory; Slomans s (1966) Two systems theory and Stanovich and West s (2000) Two systems theory. Stanovich and West (1998) present a summary of the general attributes that distinguish conscious from unconscious reasoning processes. They propose that unconscious processes are inaccessible, automatic, inert, non-declarative, and non-verbalizable, while conscious processes are accessible, controllable, declarative, and verbalizable. The different characteristics also imply that the two reasoning systems serve different purposes, result in different responses, and encode information differently. Many studies developed to investigate the different systems originate from Wason s (1966) conditional reasoning task. One reason for this is that the general errors individuals make when solving this task have been the impetus for attributing unconscious mechanisms to reasoning. The aim of the present study is to examine the dual processes theories characterization of deductive reasoning using Wason s (1966) conditional reasoning task.

Wason (1966) developed a task (hereafter Wason s selection task) that has now become the mainstay of studies investigating deductive reasoning. It involves a conditional statement if there is a vowel on one side of the card, then there is an even number on the other side . Participants are told that they have to discover whether the statement is true by selecting cards to turn over from an array of four (e.g., E, K, 2, and 5), which are represented in logical notation as (P, ´P, Q, ´Q). The correct solution requires the selection of the E (P) and 5 (´Q) cards, because only this combination provides a means of confirming and falsifying the statement. Typically, only a small proportion of participants solve the task correctly (e.g., 5-10%), while most choose a range of alternative card combinations, the most popular of which is E (P) and 4 (Q).

The appeal of this task comes from the robust results it generates, in particular the regularity with which E and 4 cards are selected. The matching bias theory proposed by Evans (1972) and Evans and Lynch (1973) is the most accepted explanation of this phenomenon. They propose that instead of triggering reasoning processes the selection task incites participants to simply match their card choices with those named in the statement. Evans (1972) developed a paradigm to examine this by presenting participants negated versions of the statement. He found that participants still selected P and Q cards irrespective of the presence of negations in the statement, thus leading to the conclusion that the selection task is solved using simple heuristics. A more detailed account proposed by Wason and Evans (1975) explains the underlying processes that motivate matching behavior. They suggested that reasoning is comprised of two dissociated processes, one of which is unconscious and based on quick-fix strategies that are guided by particular preferences for a response (i.e., biases). The second process is conscious and rationalizes behavior, some of which the reasoner has little control over. These proposals were based on findings from protocols studies (Evans & Wason, 1976; Wason & Evans, 1975), which required participants to provide justifications for their card selections. Participants showed a lack of awareness of the actual processes involved in selecting cards, and rationalizations of their behavior were found to be independent of their actual card selections.

Following from Wason and Evans protocol studies, a variety of techniques have been developed to uncover unconscious reasoning processes e.g., transfer tasks (e.g., Berry, 1983), and attentional biases (Evans, 1996; Evans, Ball & Brooks, 1987; Roberts, 1997; Roberts & Newton, 2001).

The findings from some of these designs suggest that the characteristics attributed exclusively to one or other of the two types of reasoning process are inaccurate. For instance, Berry (1983) reported that participants possessed insight into the processes motivating their card selections, and that this knowledge contributed to transfer of correct responding across different versions of the selection task. This conflicts with the proposal that individuals lack awareness of the processes that contribute to solving the selection task, and that protocols are actually post hoc rationalizations of card choices (Evans and Wason, 1975).

The Present Study

The objective of this study is to examine three of the claims made by the dual process theories of reasoning.

Evans, Ball and Brooks (1987) measured the order in which cards were selected and rejected; they found that decisions were made earlier for card selections than rejections. They proposed that the reasons for this are the result of unconscious biases that motivate participants to focus their attention on cards that match those named in the statement. However, attentional bias has been inferred from measures of decision making/card selecting behavior. There have been a number of studies that have investigated aspects related to attentional bias (e.g., Evans, 1996; Evans, Ball & Brooks, 1987; Dominowski, 1995; Roberts, 1998; Roberts & Newton, 2001), and in general the findings are mixed. One of the objectives of this study is to examine the prediction that attention is first directed to cards that are selected first. Furthermore, there has been no direct attempt to try and separate out attentional processes from decision making processes, and the present study attempts to remedy this.

The three dual process theories characterize unconscious processing as inflexible, and this property has been used to account for the poor rate of correct responding following tutoring on conditional reasoning (e.g., Wason & Johnson-Laird, 1970; Wason & Shapiro, 1971). The present study investigates this effect by including a tutoring session in the experiment and measuring the extent to which performance is improvement in subsequent versions of the selection task.

Stanovich and West (2000) describe the emergence of individual differences within the two reasoning systems. They suggest that matched card selections are motivated by the same unconscious bias, which also implies that unconscious processes are ubiquitous and not subject to variation. By contrast, individual differences occur during conscious processing because participants have overcome the tendency to select matched cards, and have based their card choices from their own construal of the statement, which in turn results in a variety of construals and therefore card combinations. However, this is a rather circular argument, since evidence of individual differences is supported by the view that they only emerge during conscious processing, and similarly, conscious processing is identified by the selection of cards that are not matched to the rule. This study examines the occurrence of individual differences in card selecting behavior during different conditions.

Method

The present study combines a series of methods designed to examine unconscious reasoning that have not been used in combination in previous studies of the selection task. Three techniques in particular have been adapted for the purposes of this study.

Roberts and Newton (2001) developed a rapid response task (hereafter RRT) that limited conscious analytic processing in order to encourage automatic responding in the selection task. During this task participants were shown the example cards for 1 second, and asked to respond yes or no depending on whether they would select the card or not. In the present study participants were asked to study a statement, which based on the typical presentation of the conditional statement in standard versions of the selection task. Then, participants were exposed to the four cards A K 4 and 7 serially, for 90 msec. They were then asked to decide after each card presentation whether they would select the card or not, and told to respond as quickly as possible. Participants were also asked to rate how confident they were of their decision on a 1-7 point scale (1 not confident, and 7 highly confident). One problem that has pervaded this type of design is that while participants are looking at the cards they are also considering their selection, so it is hard to infer attentional biases when the measure might be contaminated by decision making processes as well (Roberts, 1997). It should be noted that the present study does not claim that the method elicits unconscious processing, only that it encourages attentional biases, and attempts to separate them from decision making processes.

This study also includes a tutoring session and uses some of the techniques developed by Green and Larking (1995). In the present study participants were asked to imagine what were the possible outcomes on the underside of each of the four cards when they turned them over. Participants were also asked to suggest what implications the outcomes would have for the conditional statement. After this, the experimenter explained the concept of material implicature and the necessity of falsification in order to solve the selection task correctly.

A generation task was used to measure the extent to which participants understood the concepts they were introduced to during the tutoring session. This design was originally used by van Duyne (1976) and later incorporated into a study by Legrenzi (1980). The general format of this task uses a conditional statement but no given premises (e.g., if ____, then _____.), and participants are required to generate their own statement, devise the examples, and then test the statement.

Participants

Forty-eight graduate and undergraduate students from Brunel University took part in the experiment. Each participant was screened for prior knowledge of the selection task. They were assigned randomly to one of the 48 possible permutations of the four cards presentations in the RRTs.

Procedure

In the present study each participant completed the six tasks, all of which were variations of the standard abstract selection task. Participants were required to solve the tasks in the same order starting with the first RRT (Task 1), 3 versions of the abstract selection task presented in a booklet (Tasks 2-4), followed by a tutoring session, a second RRT (Task 5), and finally, the generation task (Task 6). The instructions in the second RRT task were identical to the first with exception of the actual letters and numbers, and the order in which they were presented for each participant.

Results

Card Selections

Table 1 reports the frequencies of all the cards combinations selected in each of the six tasks. A log-linear analysis was favored over Pearson s chi-squared in order to determine statistical regularities in the data.

The following analyses of card selecting behavior across tasks are based on a collapsed version of Table 1. This included separate frequencies for the main card selections [P, P Q, P ~Q, Q, P Q ~Q], while the remaining figures were classed as residuals. Significant differences were found between the frequencies of card combinations selected in the six tasks, $G^2 = 180.320$ (25), p< .0001. On closer inspection there were no significant differences between cards selected in the three tasks presented in the booklet (Tasks 2-4), G^2 (8) = 7.960, p>.43, which suggests that the source of difference was based specifically on responses to the RRTs and the generation task.

Table 1: Frequencies of card selections for each of the six tasks

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
P	12	4	3	5	14	4
PQ	17	34	37	37	6	8
P~P	1	0	1	0	2	2
P~Q	0	1	0	1	13	17
~P	4	1	0	0	0	0
~P~Q	1	0	2	2	0	1
~PQ	0	0	0	0	2	0
P~PQ~Q	2	1	0	0	0	1
P~PQ	2	0	0	0	2	1
PQ~Q	2	0	0	0	6	11
P~P~Q	2	0	0	0	1	2
Q	2	7	4	3	0	0
~Q	0	0	1	0	0	0
Q~Q	3	0	0	0	2	1

Participants card selections in both RRTs were compared, this revealed a highly significant difference between the two tasks, G^2 (12) = 32.28, p< .001. A comparison between the frequency of cards selected in the second RRT, and the proceeding generation task revealed no significant difference, G^2 (4) = 8.257, p. > .08. Thus, the responses to both tasks presented after tutoring were not statistically different. A further analysis between card choices for the first RRT and its proceeding task (the first booklet task) showed there was a highly significant difference, G^2 (5) = 28.315, p< .0005.

Analyzing correct card choices across the six task revealed that significantly more correct responses were made in tasks after the tutoring session, than preceding it, G^2 (5) = 63.013, p< .0001, thus suggesting that tutoring facilitated correct responding.

Decision Latencies

The mean decision times for card selections and rejections between the two RRTs were compared. This analysis showed there was no significant difference, G^2 (1) = 0.354, p >. 55. An analysis based only on decision times of participants choosing the P and Q cards in both RRTs was conducted, a summary of the mean decision times for card selections and rejections is presented in Table 2.

Table 2: Mean decision times for cards selected (PQ) and rejected (´P´Q) in RRT 1 and RRT 2

	RRT 1	RRT 2
Card selections	10051.50 msec	8999.83 msec
Card rejections	9665.59 msec	8877.94 msec

There was no significant difference between decision times for rejected and selected cards, G^2 (1) = 1.513, p>.21. A further analysis was carried out on responses to individual cards. A 2 (response type: selection vs. rejection) x 4 (card type: P, ´P, Q, ´Q) analysis of variance (ANOVA) revealed no significant main effect for response type in the first RRT1, F (1, 46) = .003, MSE = 61776.125, p>.95, and the same was found for RRT2, F (1, 46) = 1.302, MSE = 28899003, p>.337. There was also no significant main effect for card type for RRT1, F (3, 138) = .803, MSE = 91337103, p>.504, and RRT2, F (3, 138) = .817, MSE = 7774520, p>.506. Finally, there was no significant interaction between response types and card type for either tasks, RRT1 F (3, 138) = 1.538, MSE = 14650821, p>.230, and RRT2 F (3, 138) = 1.928, MSE = 19278503, p>.196. These finding suggest that there is no difference between the decision times for cards selected and rejected and does not support Evans, Ball and Brooks (1987) claim that participants make earlier decisions for cards they select.

Along with measurements of decision times, confidence ratings for each decision made were recorded. The overall ratings were not significantly different across both tasks, G^2 (42) = 48.043, p>.24, further analyses were carried out comparing both RRTs based on ratings for individual cards. There was no significant difference between the ratings for the P card, G^2 (6) = 5.218, p>.5; ´P card, G^2 (6) = 4.065, p>.5; and the ´Q card, G^2 (6) = 3.112, p>.5. However participants responded with higher confidence ratings for the Q card in the second RRT compared to the first RRT, and this was statistically significant, G^2 (6) = 15.929, p< .01.

Analyses of confidence ratings between RRTs and within each RRT, for both rejected and selected cards, revealed significant differences only for the Q card. Participants were significantly more confident when deciding to select the Q card, G^2 (6) = 15.209, p<. 01, and to reject it, G^2 (6) = 13.055, p<.05 in the second RRT which proceeded tutoring. In the selection task literature the Q card has been thought to generate misunderstandings, which may account for the significant results found for confidence and latency measures based on this card.

Tutoring

During the tutoring sessions participants were asked to consider the possible outcomes (i.e., true, false) for the statement based on information represented on the underside of each card. This technique was used to gauge participants initial understandings of the statement and cards.

All the participants assessed the statement correctly according to the outcomes of information represented on the underside of the P card. The majority of participants reported that each outcome from turning the ´P card was irrelevant and had no consequences for the statement, which is an incorrect assumption. With the exception of one, the remainder believed that turning the Q card to reveal a P would imply that the statement was true, which is also a commonly held misconception. Approximately half correctly assumed that discovering a P on the underside of the ´Q card would suggest the statement was false.

In sum, participants have a correct understanding of the P card, and they also appreciate that the ´Q card can falsify the statement, but misunderstand its relevance, evidenced in its absence from most participants card choices prior to tutoring. The Q card was the most misunderstood, and directly related to participants difficulty in appreciating that a bi-conditional interpretation (e.g., if and only if there is a vowel, then there is an even number, which also implies that if there is an even number, then there is a vowel) could not be assumed for the conditional statement.

The data from the tutoring sessions also suggest that participants misunderstandings of the cards did not correspond to previous responses in the booklet (Tasks 2-4). To illustrate, approximately 75% of participants selected the PQ card combination in the booklet, the corresponding misconception entails assuming that turning a Q card and discovering a P would also verify the statement, and that turning the same card over to reveal a ´P would in turn suggest the statement was false. However, comparing participants prior card selections revealed that they displayed a variety of misconceptions, and there was no significant relationship between particular card choices (i.e., P and Q) and its corresponding misinterpretation.

Discussion

The present study investigated unconscious deductive processes based on the claims made by the three theories, and the findings strongly imply that the characterisation of unconscious processes is inaccurate. The findings also challenge the extent to which unconscious and conscious processes can be considered as dissociated. However, it could be argued that the present study did not adequately demonstrate unconscious reasoning processes, and this is the reason

why the claims were not supported. Certainly there is some doubt over what the methods used presently actually demonstrate, but it was thought that the most appropriate method of examining the proposals of dual process theories was to use similar types of task designs, the findings of which the theories have used to support their claims.

Card Selections in the Rapid Response Tasks
The RRT tasks were designed to separate out attentional processes from decision making processes. Thus, the brief exposure of the cards did not allow participants to think about selecting cards while viewing them. The less restricted interval for choosing enabled participants to reflect on their choices under some degree of uncertainty as to what cards they saw.

The analyses suggested that participants differed in their card selections during RRTs. If unconscious processes are inflexible, then there should be a correspondence between the cards selected in both RRTs, and tutoring should have no effect, however this was not found in the present study. Instead, the findings suggest that tutoring influenced reasoning processes employed in restricted as well as in free time tasks, implying that unconscious processes are not inflexible.

Comparisons between card choices in the first RRT and its proceeding task, which was a free time version presented in the booklet, revealed significant differences. Furthermore, 17/48 participants selected matched card selections under restricted time conditions, compared to 34/48 in the first booklet task. If matched card selections are indicative of unconscious reasoning processes then the proportion of matched card selections should be the same for both tasks. 17/48 participants selected the same card combinations in the first RRT and the first booklet task, (compared with 24/48 consistent card selections between the second RRT and the generation task), however, 13/17 participants selected matched cards in these tasks. While the later result lends some support to dual process theorists view of matched card selections, the other findings reported here provide a stronger case against their proposals.

Decision Latencies
Attentional bias has been proposed as an explanation for the longer latencies found for cards selected than rejected in inspection time studies (e.g., Evans, 1996; Evans, Ball, & Brook, 1987). The present findings suggest that participants decision times were not markedly different for different types of card selecting decisions. There were, however, differences between overall responses latencies in the RRTs. Participants made quicker decisions during the second RRT compared to the first. The tutoring participants received before the second RRT may have influenced this result,

because they were better informed about the task requirements. Furthermore, there were no differences between the two RRTs based on confidence ratings. However, the only significant difference was found for ratings of the Q card, participants were more confident of their decisions during the second RRT compared to the first. One reason for this may have been the tutoring received prior to the second RRT, suggesting that an increase in understanding also results in an increase in confidence.

Tutoring
There have been many examples of unsuccessful attempts to tutor participants on conditional reasoning (e.g., Wason, 1968; Wason & Johnson-Laird, 1970; Wason & Shapiro, 1971). Wason (1968) first introduced remedial procedures or 'therapies' to invoke insight into the task. Johnson-Laird and Wason (1970) proposed that participants failed to solve the task correctly because there was a disassociation between participants selection and evaluation processes. Wason and Johnson-Laird (1970) suggested that selecting is an active process and occurs immediately before evaluation because the evaluation process is effortful and more cognitively demanding.

The lack of transfer reported in tutoring studies has been used to demonstrate dissociations between conscious and unconscious reasoning processes. Participants inability to adopt new concepts, taken together with the fact that they revert to previous card choices, typically P and Q, suggest that either the methods of tutoring are inadequate, or the processes guiding card selections in the abstract task are inflexible. The results from the present experiment challenge both views.

A reduction in the proportion of matched card choices (i.e., P Q) following tutoring, and an increase in correct card selections (i.e., P~Q) suggest that tutoring was effective, and that participants reasoning processes are not inflexible. Also, individual differences were revealed in the tutoring session, indicating that participants held a variety of misconceptions of the statement and the cards, which were corrected following tutoring. Moreover, many participants did not share the same misconceptions despite having selected the same card combinations in previous tasks. Thus, the selection of P and Q cards does not imply that participants have the same understanding of the cards, or that they are employing the same underlying reasoning process.

Conclusions
The findings from this study do not support the claims made by dual process theories of reasoning. However, it is not possible to rule out the possibility that

unconscious processes are involved in reasoning. This cautionary approach is based on problems concerning methodology. The techniques used to expose unconscious reasoning processes are not sufficiently refined to decide whether the description of the processes is inaccurate and that unconscious processes are still present, or whether there are actually no unconscious processes in reasoning.

Acknowledgments

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