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A CONFLICT BETWEEN SELECTING AND EVALUATING INFORMATION IN AN INFERENTIAL TASK

BY P. C. WASON AND P. N. JOHNSON-LAIRD
Psycholinguistics Research Unit, Department of Phonetics and Department of Psychology, University College London

An inferential task was investigated in which the subjects had to select which of four cards they needed to inspect in order to determine whether a rule was true or false. In one condition crucial information was concealed on the other side of the cards, and in another condition it was on the same side of the cards, but covered by a mask. A previous experiment suggested that subjects sometimes confused the notion of 'the other side of the card'. But no difference was found between these two conditions. Only two out of the 36 subjects initially made the correct selection.

An attempt was made subsequently to enable the subjects to correct their errors by asking them to *evaluate* the cards in relation to the rule. When a conflict occurred between the selection of the cards and their evaluation, some insight was gained. In other cases these two processes passed one another by, in spite of the fact that this involved self-contradiction.

In a previous experiment (Wason, 1969*a*) the subjects were presented with four cards showing a red triangle, a blue triangle, a red circle and a blue circle. They knew from previous experience that each card had a triangle (red or blue) on one side and a circle (red or blue) on the other side. They were then presented with the following rule about these four cards: *Every card which has a red triangle on one side has a blue circle on the other side.* Their task was to say which of the cards they needed to turn over in order to find out whether the rule was true or false. The subjects found this problem extremely difficult: none of them got it right initially. The correct answer is 'the red triangle and the red circle', because if these two stimuli occur on the same card, then the rule is false, but otherwise it is true.

The rule has the same logical form as the conditional sentence, 'if p then q'. Two errors were most frequently made: $\bar{q}$, i.e. not q (the red circle) was omitted, and q (the blue circle) was included. Of these two errors, the failure to select $\bar{q}$ is more important than the selection of q. This is because the selection of q would only be correct if the rule were interpreted as an equivalence: 'if p then q and if q then p'. However, $\bar{q}$ is part of the correct answer under either interpretation, and hence the present investigation is primarily concerned with its selection.

The previous experiment, however, contains a gratuitous confusing element. Half the information is referred to as being on one side of a card, and the other half on the other side of a card. It has been argued that there may have been a tendency to interpret 'the other side' of a card as being the side which is face *downwards*. One aim of the present experiment is to investigate the effect of presenting all the information so that it is potentially visible on the same side of the cards. A second aim is to attempt to induce insight into the correct solution, after the selection of cards had been made, by asking the subjects to evaluate the cards with respect to the rule. This *evaluation process* was expected to change the *selection process* (i.e. those cards which had been selected and rejected), when an inconsistency occurs between them.

WASON, P. C., *A conflict between selecting and evaluating information in an inferential task*, British Journal of Psychology, 61:4 (1970:Nov.) p.509

METHOD

Design. Three independent groups were tested. In the main experimental group (group *a*) the rule was: *Every card which has a circle on it has a border round it*, and the stimuli consisted of the following four cards (see Fig. 1): (p) a circle with a mask round the edge of the card where a curly border might be present or absent; ($\bar{p}$) no circle with a mask round the edge of the card where a curly border might be present or absent; (q) a curly border round the edge of the card with a mask over the centre where a circle might be present or absent; ($\bar{q}$) no border round the edge of the card with a mask over the centre where a circle might be present or absent. In fact, $\bar{p}$ and $\bar{q}$ are both blanks.

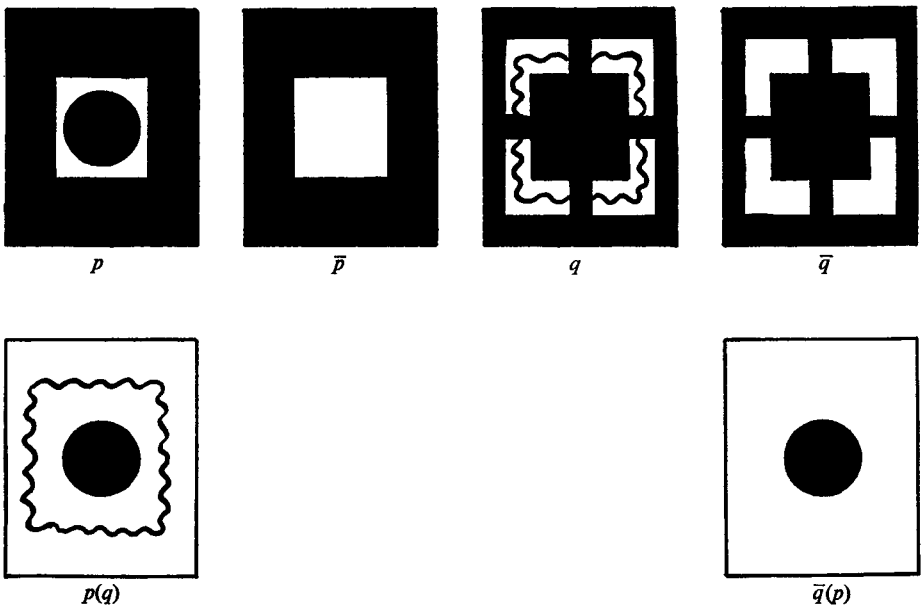

Fig. 1. The stimuli used in group *a*. The top row shows the masked cards, and the bottom row shows the two which are fully revealed.

The correct answer, to find out whether the rule is true or false, is to select (p) 'circle' and ($\bar{q}$) 'no border'. This arrangement of stimuli cannot be followed in a 'card-turning' condition because two of the cards, corresponding to $\bar{p}$ and $\bar{q}$, would have to be blank, and hence would be ambiguous between these two values. An intermediate experimental group is required. In this group (group *b*) the rule was: *Every card which has a circle on it has two borders round it*, and a triangle was substituted for $\bar{p}$, two borders for q, and one border for $\bar{q}$. In the control group (group *c*) the rule was: *Every card which has a circle on one side has two borders on the other side*, and four cards identical to those in group *b* were presented: (p) circle, ($\bar{p}$) triangle, (q) two borders and ($\bar{q}$) one border.

In groups *a* and *b* all the information is potentially visible on the same side of the card, and in groups *b* and *c* the identical values appear on the cards. It seems plausible that $\bar{q}$ can more readily be appreciated as being not q, when it consists in the absence of q, as opposed to being satisfied by another stimulus which is not q. Hence it was predicted that the frequency of correct answers would be ordered as follows: group a > group b > group c.

The experiment had three phases: (1) the initial selection of the cards; (2) the experimenter's exposure of the p and $\bar{q}$ cards, to show that p is associated with q, i.e. pq (consistent with the rule), and that $\bar{q}$ is associated with p, i.e. $\bar{q}p$ (inconsistent with the rule); (3) questions about the consequences, followed by an unstructured interview about the possible consequences of exposing the other two cards, q and $\bar{p}$. Everything was done to encourage the subjects to gain insight, and

the nature of the questions about q and $\bar{p}$ was dependent on the way in which the subjects talked about them. At the end of this interview the subjects made a final selection.

Subjects. Thirty-six paid volunteers, undergraduate students of University College London, were tested individually and assigned in rotation to the three groups ($n = 12$ in each group).

Apparatus and procedure. In groups a and b the subjects were first made familiar with the apparatus which contained the cards. This consisted of four wooden boxes ($4 \times 3 \times 0{\cdot}75$ in.), each having a hinged lid. The boxes for the p and $\bar{p}$ cards had an aperture (1·25 in. sq.) to expose p and $\bar{p}$ respectively. The boxes for the q and $\bar{q}$ cards had a slit round the edge of the lid to expose q and $\bar{q}$ respectively. In both groups it was fully explained to the subjects what they would see in each box, when the lid was closed, and the two possibilities which would remain concealed. The appropriate cards were then placed under the lids, and the rule (typed on a card, 5×3 in.) presented. The subjects were asked which of the cards they *needed* to have exposed in order to find out whether the rule was true or false. The procedure was similar in group c, except the subjects were first of all told that the cards had a circle or a triangle on one side and one or two borders on the other side.

In all three groups, after the selection of the cards, the p and $\bar{q}$ cards were simultaneously unmasked, or turned over, by the experimenter. The subjects were asked to evaluate these exposed cards: pq and $\bar{q}p$, in relation to the rule, and then asked whether they were happy with their selection of cards. The unstructured interview followed.

Quantitative results

Only two of the 36 subjects were correct initially (both in group a), and only a further nine (three in each group) corrected their selection immediately *after* they had evaluated pq and $\bar{q}p$. Presenting all the information on the same side of the cards does not evidently confer any advantage over presenting it on both sides of the cards. Hence the data from the three groups will be combined.

Table 1. *Number of subjects who were correct at their initial and final selections* ($n = 36$)

	Final selection	
Initial selection	Incorrect	Correct
Correct	0	2
Incorrect	13	21

Table 1 shows the number of subjects whose initial and final selections were correct and incorrect. It will be noted that no subjects were correct initially, and incorrect ultimately, but 21 were incorrect initially and correct ultimately. This shift was highly significant (McNemar test, $\chi^2 = 19{\cdot}05$; d.f. $= 1$; $P < 0{\cdot}001$, one-tailed). Thus the evaluation process does tend to modify the selection process, as predicted, for the subjects taken as a whole. But what is more remarkable is that 13 subjects (36 per cent) failed to get insight, even when relevant information had been exposed, and the consequences of their selections fully discussed. These individual differences merit a qualitative analysis.

Qualitative analysis

An information-processing model (Johnson-Laird & Wason, 1970*b*) has been written to explain performance in these tasks, including changes due to the effect of the evaluation process on the selection process. In the present experiment the two processes must be considered separately with respect to the two main errors: the

WASON, P. C., *A conflict between selecting and evaluating information in an inferential task* ,
British Journal of Psychology, 61:4 (1970:Nov.) p.509

failure to reject q, and the failure to select $\bar{q}$. The irrelevance of q was introduced by asking the subject to consider the effect of *hypothetical* states of affairs, e.g. the possibility of q being associated with $\bar{p}$. The relevance of $\bar{q}$, on the other hand, was introduced by a change in *reality*—the $\bar{q}$ card was exposed to reveal $\bar{q}p$ which falsifies the rule. These differences in procedure result in different kinds of effect.

There is an inconsistency between the evaluation of $\bar{q}p$ as falsifying, and the failure to have selected $\bar{q}$. When this conflict is not recognized, the evidence tends to be evaded, or resisted, in devious ways, e.g. by rationalization. Consider some examples. The first is an extreme evasion of evidence, and the only case of a denial that $\bar{q}p$ falsifies. The reasons given are of the most primitive kind.

S. 15*c*: 'This card, "circle and two borders" (pq), tells me it's true. This card, "one border with circle" ($\bar{q}p$), has nothing to do with it because I wasn't interested in "one border" ($\bar{q}$) at the beginning.'

This is the clearest demonstration of the continued influence of the selection process upon an evaluation. The next three examples are more subtle, and show how $\bar{q}$ has been dismissed, even though $\bar{q}p$ has been granted falsifying status. What matters is verification.

S. 34*a*. S: 'The only way you can verify the sentence is to look at the circle (p) and the border (q). This card, "no border with circle" ($\bar{q}p$), is totally useless, as it doesn't have a border (q) on it, so it doesn't matter.' E: 'You have seen this card ($\bar{q}p$) and that it has got a circle on it. Do you still think it doesn't matter?' S: 'Yes, I do.'

S. 16*a*. E: 'Well, you've just said this one ($\bar{q}p$) makes it false?' S: 'It hasn't got a squiggly border (q) on it, so it doesn't matter.'

S. 24*c*. S: 'That card, "one border with circle" ($\bar{q}p$), makes it false. But I'd still choose "circle" (p) and "two borders" (q).'

In contrast, consider a case of perfect insight at the inception of the task. S. 36*a*, made the following spontaneous comment *before* the p and $\bar{q}$ cards were exposed. 'This card (p) has a circle, so I must choose it to make sure it has a border (q), for the sentence to be true. However, the sentence need not be true, and this card, "no border" ($\bar{q}$), could have a circle on it, so obviously I must look at that one as well. The other two don't matter because there is no circle on this one ($\bar{p}$), and it doesn't matter whether there is a circle, or not, on this one, "border" (q).'

The inconsistency between the selection and evaluation processes for q is more surprising and revealing. Since the q and $\bar{p}$ cards were not exposed, the conflict is only hypothetical rather than actual, and hence self-contradiction may occur with relative impunity. There is no compelling need for evasion and rationalization about hypothetical events. Three cases must be distinguished.

(1) Absence of conflict between the selection and evaluation processes.

S. 30*c* (initial selection of p, q and $\bar{q}$). E: 'Can we consider "triangle" ($\bar{p}$) and "two borders" (q)?' S: '"Triangles" ($\bar{p}$) aren't mentioned, so I left that one out.' E: 'What do you expect to find on the back of "two borders" (q)?' S: 'Well, if it's a triangle ($\bar{p}$) the sentence is false.'

S. 16*a* (initial selection of p and q). S: '"No circle" ($\bar{p}$) has got nothing to do with it because there's no circle. There has to be a "circle" (p) under "border" (q) for the sentence to be true.' E: 'What if there is no circle ($\bar{p}$)?' S: 'Then the sentence would be false.'

Several more similar examples were observed, all distinguished by blatant self-contradiction. The selection process in these cases completely dominates the evaluation process. A falsifying inference is considered admissible from a selected card, but not from an unselected card. The move from x to y does not warrant the reverse operation from y to x. Exactly the same phenomenon was frequently observed in earlier experiments (Wason, 1968).

(2) Verbal resolution of the conflict without affecting the selection process.

S. 12*c* (initial selection of p, q and $\bar{q}$). E: 'What would you expect to find on the back of this card, "two borders" (q)?' S: 'A triangle ($\bar{p}$) or a circle (p).' E: 'If there's a triangle ($\bar{p}$), what would you know about the sentence?' S: (After long thought) 'It wouldn't tell you anything about the sentence.' E: 'Are you happy with your choice of cards?' S: 'It's still necessary to turn it over. I stick to my original choice of "circle" (p), "two borders" (q), and "one border" ($\bar{q}$).'

S. 27*c* (initial selection of p, q and $\bar{q}$). E: 'What do you expect to find out from "two borders" (q)?' S: 'A triangle ($\bar{p}$) would make it false. Oh no, it wouldn't—it only matters about cards with circles (p).' E: 'Are you happy with your choice of cards?' S: 'Yes. I'd need to see "two borders" (q) along with "circle" (p) and "one border" ($\bar{q}$).'

In both these examples the contradictions are eliminated at the verbal level. But the selection process in unaffected. Even though the insight is gained that $q(\bar{p})$ would not falsify, q is retained presumably because $q(p)$ is tacitly assumed to verify.

(3) Verbal resolution of the conflict, followed by gain of insight which does change the selection process.

S. 23*b* (initial selection of p and q). E: 'What does "two borders" (q) tell you?' S: 'If there's a "circle" (p) on it, then the sentence must be true. If there's a "triangle" ($\bar{p}$), then it must be false.' E: 'What does "triangle" ($\bar{p}$) tell you?' S: 'Well, if it has "one border" ($\bar{q}$) on it, the sentence is true; if "two borders" (q), the sentence is false. Ah, but of course I don't need to worry about it because the statement is about cards with circles (p). And if I don't have to worry about that "triangle" ($\bar{p}$), then a "triangle" ($\bar{p}$) underneath "two borders" (q) would make no difference either. I would only need to see two cards: "circle" (p) and "one border" ($\bar{q}$).'

This articulate subject has expressed very clearly her gain of insight as a consequence of the evaluation process. As might be expected, this case was the most frequent: six examples occurred. But no protocol was so illuminating as the one just cited.

Discussion

One explanation of the results of this experiment is that the subjects do realize their error, but are reluctant to admit it because they would feel stupid, if they were to do so. This is possible but extremely improbable because all the subjects were highly intelligent. Another argument is that the subjects become confused, and this causes them to hold on to their original selection, as being the one thing which seems certain. The subjects are indeed confused, but their confusion is not the cause of their behaviour. It is the effect of having to entertain and resolve two seemingly irreconcilable thought processes. What has to be explained is the frequent domination of the selection process over the evaluation process. One reason is obviously because it

occurs before the evaluation process, and a second is because it is a decision to act in a certain way, to have a card, or cards exposed, whereas the evaluation process is merely a passive judgement.

It is plausible, however, to suppose that, if the subject lacks insight, the selection process is equivalent to a 'self-instruction' to consult those cards which could make the rule true, rather than to the experimenter's instruction to consult those which could make it true *or false*. Previous research by Wason (1967) and Jones (1968) has demonstrated the potency of self-instruction, compared with instruction from an external source. It seems likely, in the present experiment, that such an instruction may become internalized so that it is relatively immune from modification. It may function like an autonomous *plan* (Miller *et al.*, 1960). Thus S. 34 and S. 16 do not say that $\bar{q}$ is of no avail because it only falsifies; they say it is 'totally useless' and 'it doesn't matter'. They do not reject it for wrong, but consistent reasons; they reject it because it has *already* been dismissed from their interest before they start to talk about it. Similarly, S. 12 and S. 27 admit that q would give no information, if it were to be associated with $\bar{p}$. And yet they still say it is necessary to select it. But they do not say why. The obvious reason is, if it were associated with p, it would verify the rule. This reason is no longer their concern; the selection process requires no verbal justification. When, however, such self-instruction was inhibited by an explicit instruction to select only those instances which could falsify the rule, the subjects showed a greater insight into the task (Johnson-Laird & Wason, 1970*a*).

Further knowledge about the immutability of the selection process was gained by an experiment (Wason, 1969*b*) in which it was not allowed to operate. Twenty subjects (students) were *first* given the solution, then given the task, and thirdly asked to justify the solution in words. After some initial hesitation *all* the subjects spontaneously gave the correct reasons for the solution. Thus the problem is not difficult at all. It is intrinsically easy, if the individual can be stopped from transforming it into a different problem. If he is allowed to transform it, by structuring it in the wrong way, then it may be very difficult to change it back again into the original problem.

The present experiment has shown how the selection and evaluation processes may either interact, or pass one another by, when the attempt is made to induce insight into what seems a very difficult intellectual problem. Such processes conflict in some individuals, but evidently not in others, perhaps as a function of the degree to which the individuals instruct themselves. More research needs to be done on this tendency to structure problems impulsively, and the capacity to delay and vary such structuring.

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