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Cognitive Transfer Via Analogical Reasoning; Applying Lessons to the Wason Selection Task

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Abstract

The goal of this study is to discover a relationship between performance on a specific repeated task and multiple attention shifts over a specified number of task trials. In 1966, P. C. Wason published the results of what he called "a small study."[1] The study was simple enough: four cards were presented to each participant, with numbers on one side and letters on the reverse; two cards were number-side up while two cards were letter-side up. The participants were then asked to select which cards would need to be turned over to "determine whether the experimenter was lying in uttering" a particular conditional statement; the performance of the participants proved the task "to be particularly difficult."[2] The logic involved in the task seems to be the root of the difficulty. In order to disprove a conditional statement, the antecedent must be true and the consequent false. Being tutored in conditional logic improves performance on a task involving conditional statements, such as Wason's selection task.[3] Another factor may be at work, however. Being primed in a tutoring setting may be enough to improve performance on a test-taking task.[4] In my study, participants were randomly assigned to one of four conditions: control, block scheduling, variable scheduling, or variable-block scheduling. Each condition involved the same Wason selection tasks and the same distracter worksheets (except the control group, which did not involve distracters). Performance on the Wason sheets were tallied within each group, and performance improvement on the task sheets were evaluated across groups. The results suggest benefits and disadvantages of distracter tasks between repeated tasks-at-hand.
Keywords: transfer, lessons, Wason

1. Introduction

In 1966, P. C. Wason published the results of what he called "a small study."[5] Writing the "Reasoning" chapter for a book called *New Horizons in Psychology*, Dr. Wason presented participants with a simple logic task. The task, as presented by Wason, involved a deck of cards with numbers on one side and letters on the reverse. To each participant, four cards were presented. Two cards were presented number-side up, and the other two cards were presented letter-side up. Participants were asked to flip over exactly the necessary cards to "determine whether the experimenter was lying in uttering" a particular conditional statement; participants found the task "to be particularly difficult."[6] The logic involved in the task seems to be the root of the difficulty.

A conditional statement is an "if-then" statement. The "if" portion of the statement is called the *antecedent* (represented here as a capital P), and the "then" portion of the statement is called the *consequent* (represented here as a capital Q). In order to disprove a conditional statement, the antecedent must be true and the consequent false (P & ~Q {the tilde (~) represents negation}). For example, to disprove the statement, "If there is a vowel on one side, there is an odd number on the other side," a card would need a vowel on one side and an even number on the other side. Most of the participants in Wason's study correctly identified the true antecedent card (P, a vowel), but most participants chose the true consequent (Q, an odd number) card as well. A false antecedent paired with a true consequent (~P & Q, a consonant and an odd number) demonstrates vacuous truth of the conditional statement, i.e.,

a card with a consonant on one side and an odd number on the other is irrelevant to the given conditional statement. A true antecedent with a true consequent (P & Q, a vowel and an odd number) demonstrates an instance of truth of the conditional statement, i.e., a card with a vowel on one side and an odd number on the reverse is consistent with the given conditional statement; in other words, a true consequent (in this case an odd number) cannot indicate a false conditional statement.

Researchers after Wason have put forward and investigated several explanations for the lack of logic displayed by participants in the Wason selection task. For instance, participants may be subject to a "matching bias,"[7] such that participants are apt to choose whatever is explicitly mentioned in the conditional statement instead of logically reasoning to choose a false consequent. In other words, participants tend to choose cards that have features that are specifically mentioned over cards with other features. Further studies have supported this hypothesis.[8] Variations of the Wason selection task have shown that performance is significantly better when deontic (i.e., socially relevant) conditional statements are used in place of the abstract conditional statement used by Wason.[9] This information suggests that perhaps the matching bias is not just a bias, but a catalyst to misunderstanding the task.[10]

Wason suggested that participants are likely to choose a true consequent because, despite the experimenter's instructions, many participants attempt to demonstrate the truth of the conditional statement rather than its falsity.[11] In other words, even though they are asked to determine if a conditional statement is false, participants tend to try to demonstrate explicitly true instances of the conditional statement instead of false instances. For example, given the conditional statement, "If there is a vowel on one side, there is an odd number on the other side," most participants choose the card with a vowel showing and the card with an odd number showing. Along these lines, some researchers have attempted to show that participants are using heuristic, economic, or deontic reasoning instead of logical reasoning when confronting a selection task like Wason's.[12] In other words, people may be using some practical, rather than logical reasoning; to many people demonstrable truths are more relevant than demonstrable falsities. This explanation, like many explanations of the many-times replicated Wason selection task, has been hotly contested.[13] For example, A. Almor and S. A. Sloman experimentally demonstrated that familiar, concrete, non-deontic conditional statements provoked better performance than abstract conditional statements; Almor and Sloman claim that this result is inexplicable via Oaksford's and Chater's model of deontic reasoning.[14]

Simple misinterpretation is yet another explanation for demonstrated poor performance on the task.[15] One possibility is that participants confusedly interpret "if" as "iff" (if and only if), and thus misinterpret the conditional as a biconditional (P implies Q and Q implies P). For example, if the given conditional statement is, "If there is a vowel on one side, there is an odd number on the other side," participants may misinterpret that statement to be biconditional, which would imply that "if there is an odd number on one side, there is a vowel on the other side." In a biconditional, a true consequent (an odd number) is also a true antecedent; likewise, a false consequent (an even number) is also a false antecedent. True antecedents (a vowel in the original statement) can be indicative of false conditional statements, while false antecedents (a consonant in the original statement) cannot.

In support of the misinterpretation hypothesis, experiments have shown that tutoring on the subject of conditional logic does improve performance on the Wason selection task.[16] Regardless of the reason(s) for typical poor performance on the Wason selection task, relevant tutoring evidently can improve a participant's performance on the task.

One potential explanation of the positive effects of tutoring on a logic task such as this one is the idea that abstract mathematical (and logical) reasoning is necessarily associated with formal, spatial representations.[17] Thus, tutoring may not simply aid in performance of the task, tutoring may provide the means for abstractly understanding the conditional statement involved in the task.

Being tutored specifically in conditional logic improves performance on a task involving conditional statements. However, another factor may be at work in addition to the explicit conditional tutoring. Being primed in a tutoring setting may be enough to improve performance on a test-taking task.[18] If a priming task that is irrelevant to a testing task can improve performance on that testing task, school scheduling may be less important than it seems. If formal structure is the dominant similarity between the priming task and the testing task, simply being in a school environment may be similar enough to taking a test that test-taking performance could be improved simply by being cognitively primed by the environment.

The author of this study set out in search of a relationship between the amount of time spent on one school-setting task and performance on a largely unrelated school-setting task. If such a link could be established, school administrators could use this information to implement efficient scheduling paradigms. The three experimental conditions in this study are defined analogously to school scheduling paradigms. With the term *block of time* defined, a school can be scheduled such that one subject is presented per block of time (i.e., block scheduling), such that multiple topics are presented per block of time (i.e., variable scheduling), or such that blocks of time are subdivided, meaning multiple topics are presented per block of time as defined but a single topic is presented per

sub-block of time (this scheduling system is referred to here as variable-block scheduling). This list of scheduling paradigms is by no means exhaustive, but the paradigms mentioned are those investigated here.

1.1 hypothesis

Since the Wason task is notorious for poor performance on first attempts, an assumption is made that the participants did not previously know the single correct solution to the task. This way, an improvement over four repetitions of the task should be indicative of benefits or disadvantages regarding the presentation of the task, i.e. block scheduled, variable scheduled, or variable-block scheduled.

Hypothetically, the participants with the most blocked scheduling will improve the most over the course of four Wason selection tasks, while the control group will improve the least. The block group will spend a prolonged continuous period of time on both a preparatory, lesson-based task, as well as spending a prolonged continuous period of time on the selection task. The other two experimental groups will spend the same amount of time with the material as the block-scheduling group, but these groups will see the different tasks in a discrete, piecemeal fashion. The control group will not encounter the preparatory, lesson-based task.

2. Methodology

In preparation for the study, eight worksheets, four lesson-based worksheets on the subject of comma usage (Figure 1-A) and four Wason selection task worksheets (Figure 1-B), were prepared. The lesson sheets were labeled worksheets B, C, D, and E, and the Wason sheets were labeled worksheets F, G, H, and I. The sheets were grouped into packets, which were paper-clipped together, in advance. The sheets were put into a particular order, according to which condition the packet was a part of: control, block scheduling, variable scheduling, or variable-block scheduling. The control packets contained four consecutive Wason sheets and no lesson sheets. The block scheduling packets contained four consecutive lesson sheets followed by four consecutive Wason sheets. The variable scheduling group contained sheets ordered lesson, Wason, lesson, Wason, lesson, Wason, lesson, Wason. The variable-block scheduling group contained sheets ordered lesson, lesson, Wason, Wason, lesson, lesson, Wason, Wason. For each condition, four different packets were prepared; within each of these packets, the order in which the lesson sheets (B-E) were ordered, and the order in which the Wason sheets were ordered (F-I) were determined at random by a computer. Each of the sheets in each of the packets was then labeled on the back with a letter J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, or Y; a master record was kept to keep track of the labels on the sheets with respect to both order and condition. For example, the R packets were designated control packets, so these packets contained only worksheets F-I. In the R packets, sheet H was presented first, followed by F, G, and I, in that order. The V packets were also control packets, but in these packets the order of the sheets was I, G, H, F.

A phrase is a group of words. An independent clause is a phrase containing a subject (noun or noun phrase) and a predicate (verb or verb phrase) that can stand alone as a sentence. A dependent clause is a phrase containing a subject and a predicate that cannot stand alone as a sentence.

"For example" is a phrase.

"This is an independent clause" is an independent clause.

"While this is a clause" is a dependent clause.

Commas are necessary when a phrase or dependent clause precedes an independent clause. Commas should not be used when an independent clause precedes a phrase or dependent clause. A sentence typically must have exactly one independent clause to be a complete sentence. These rules hold except when contradicted by other grammatical rules.

Please use the above rules to insert commas in the appropriate place(s) in the following sentences by Roald Dahl; do not add a comma if none is needed:

1. No other factory in the world mixes its chocolate by waterfall.

2. For those idiots out there who don't know how to play here's how it goes.

3. When a person is bad that person has to be taught a lesson.

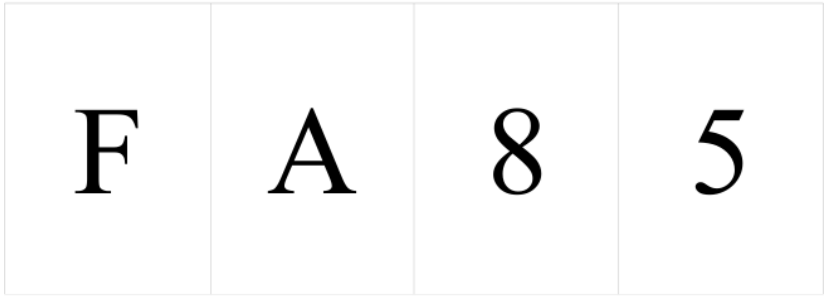
4. I can't go on forever and I don't really want to try.

Worksheet B

The following four cards are from a deck of cards that have numbers on one side and letters on the other side. Either side may be facing upwards.

Dr. Wason says, "If there is a vowel on one side of a card, there is an even number on the other side of that card."

Dr. Wason might be a liar. Turning over too many cards is an incorrect answer. Turning over too few cards is an incorrect answer. Turning over the wrong cards is an incorrect answer. Please circle the cards you would need to turn over to determine if Dr. Wason is a liar:



Worksheet F

Figure 1. A lesson sheet (1-A, left) and a Wason sheet (1-B, right).

Figure 1 (1-A) Each lesson sheet provides a four-line paragraph regarding comma usage, followed by three examples, followed by another four-line paragraph. Each worksheet then instructs the participant to "Please use the above rules to insert commas in the appropriate place(s) in the following sentences by [an English author]; do not add a comma if none is needed." Four quotations from one English author per sheet follow, with the commas omitted. The authors used are Roald Dahl, Rudyard Kipling, William Shakespeare, and Lewis Carroll. (1-B) Each Wason sheet begins with the following text: "The following four cards are from a deck of cards that have [antecedent category] on one side and [consequent category] on the other side. Either side may be facing upwards. Dr. Wason says, 'If there is [true antecedent] on one side of a card, there is [true consequent] on the other side of that card.' Dr. Wason might be a liar. Turning over too many cards is an incorrect answer. Turning over too few cards is an incorrect answer. Turning over the wrong cards is an incorrect answer. Please circle the cards you would need to turn over to determine if Dr. Wason is a liar." Each sheet then presents a true antecedent, a true consequent, a false antecedent, and a false consequent, in a computer-generated random order. In the pictured sheet, Worksheet F, "a vowel" (A) is the true antecedent and "an even number" (8) is the true consequent; thus, on this sheet, the correct answer is A and 5.

Over ten non-consecutive days, a total of 120 students at the University of Evansville volunteered to participate in this study. Each participant was offered extra credit in certain specific courses, but not all participants accepted compensation. Prior to participation, participants were offered the incentive and reminded that their participation was voluntary and could be self-terminated at any time and for any reason. Participants were also reminded that participation was anonymous. Each participant was then randomly assigned to one of the four prepared conditions. The assignment selection was made by retrieving a packet at random from a computer carrying case. To begin the experiment, each participant was given the first sheet of his or her respective packet, and asked to turn the sheet over when he or she had completed that sheet. When a participant would turn over a worksheet, a researcher would collect that worksheet and give the participant the next worksheet from the appropriate packet. Once a participant had completed all of the worksheets in a packet, he or she was presented with a receipt to present if questioned about participating and was thanked for participating. The completed worksheets were stored together until all 120 packets had been completed, at which time, the Wason sheets were scored.

3. Data

120 volunteers participated in this study by completing one packet from one of the four conditions, i.e. for any one of the four conditions, 30 volunteers participated by completing a packet. As usual with the Wason selection task, participants tended to perform poorly. Figure 2 shows the average percentage of correct responses for each condition. Figure 3 shows the total percentage of correct responses for each sheet, separated into conditions.

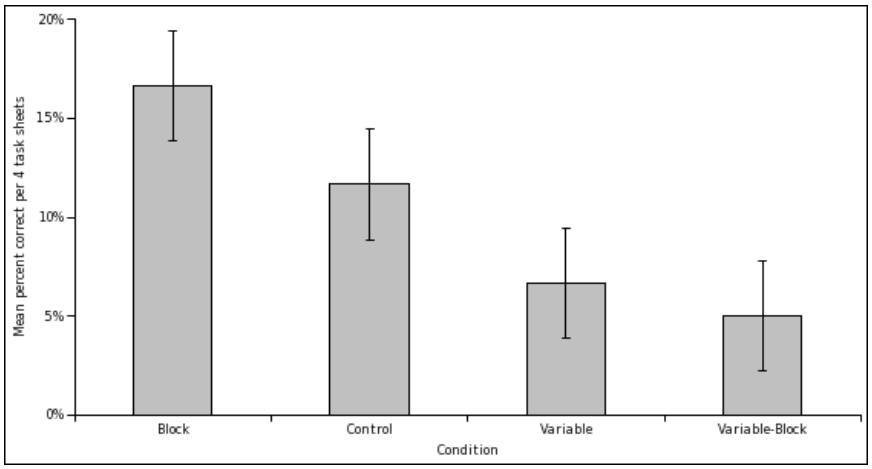


Figure 2. Average performance on Wason selection task sheets

Figure 2 The error bars in the figure represent the standard deviation, which, in this case, is the most conservative estimate of error, i.e., the longest error bars.

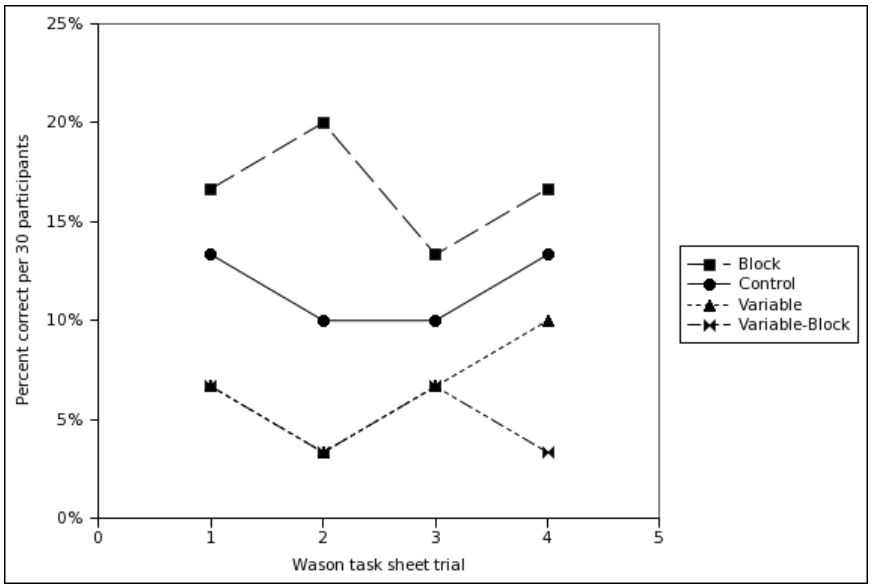


Figure 3. Total percentage correct per Wason selection task sheet

In P. C. Wason's original study, the response "P & Q" was the most common, followed by "P" alone, with the correct answer "P & ~Q" taking third place[19]. These results were echoed here, as illustrated in Figure 4.

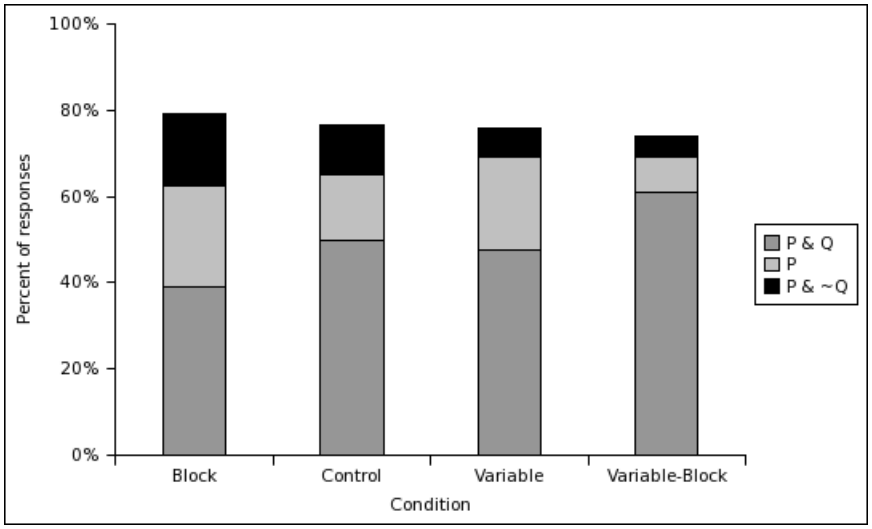


Figure 4. Top three responses on Wason task sheets

Figure 4 There are 16 possible responses to the Wason selection task; the quantity of the other 13 responses brings each of the bars in the figure to 100%. The top three responses that Wason found were the same as the top three overall responses in this study, as well as the top three responses in the control, block, and variable conditions. For the variable-block condition, "P & Q" and "P" were the top two responses, but "~P & ~Q" and "P & ~P & Q & ~Q" were both selected more frequently than the correct response, "P & ~Q".

4. Conclusions

The data collected in this study are inconsistent with the hypothesis, but the data show interesting trends. Contrary to the hypothesis, none of the groups showed improvement over the four Wason tasks. However, while the variable and variable-block groups performed comparably to one another, the block group performed significantly better, with the control group falling in the middle. Since each of the experimental conditions was exposed to the same

lesson sheets and task sheets, the amount of tutoring is irrelevant; only the presentation differed between the groups.

The data seem to indicate that off-topic distracter tasks that are presented in one form (viz. worksheets), in small doses, hinder performance on logic tasks presented in the same form, while prolonged exposure to the same off-topic distracter task encourages performance on the same logic task. Since the "distracter task" was helpful to the block group, the same task in this situation could instead be called the "priming task". As Michael Atherton suggests[20], participants seem to become cognitively primed by the rule-governed test-taking setting in the block condition of this study, with this cognitive setting being primed by the lesson sheets and continuing into the task of the Wason sheets. One or two worksheets do not seem to be enough to cognitively prime a participant; in fact, one or two worksheets seem to be distracting. In this case, four worksheets was enough to produce an effect. Some number of worksheets could be the maximum number necessary to produce this effect; moreover, a number beyond this number could return the worksheets to the category of "distracting". A study over a much longer period of time will be necessary to really apply this information to school scheduling; if there is an upper limit to the effect, school scheduling will be relevant. However, since four worksheets is sufficient to show an effect, and schools are not likely to have courses that meet for fewer than ten minutes, scheduling may be irrelevant, at least with regard to the duration of classes in a variable scheduling setting.

One reason small numbers of irrelevant worksheets could be distracting is lack of continuity. In the block condition, participants completed a set of four similar worksheets before switching to a set of four worksheets, similar to each other but different from the first set; these participants only needed to change topics once. In the other experimental conditions, participants needed to change topics seven times (in the variable condition) or three times (in the variable-block condition). Presumably, these attention shifts contributed to the below-average performance of these groups.

An extension of this study with increasing levels of repetition could yield interesting results; the results of a condition in which participants are exposed to four lesson sheets followed by four task sheet followed by four lesson sheets followed by four task sheets would be of particular interest to the conclusions presented here. Since the Wason tasks is so difficult, replicating this study with an easier logic task may be an alternative appropriate next step. A further study could be conducted using distracter tasks with different levels of relevance.

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