Loginiai-filosofiniai tyrinėjimai / Logical–Philosophical Investigations

Wason Selection Task and a Semantics Based on State-descriptions

Miguel López-Astorga

Institute of Humanistic Studies Juan Ignacio Molina
University of Talca
Email milopez@utalca.cl
ORCID https://orcid.org/0000-0002-6004-0587

Abstract. Peter Wason provided his four-card selection task over five decades ago. It keeps causing difficulties from both the linguistic, the psychological, and the cognitive point of view. Many psychology theories have been proposed in order to remove its problems. This paper tries to offer one more possible account. That account is based on the method of extension and intension presented by Rudolf Carnap. Hence, it resorts to the concept of state-description. The basic ideas of the argumentation are two: 1) people might tend to consider state-descriptions when processing information, and 2) if conditionals are not expressed with a clear contextual framework, they might be interpreted as biconditionals.
Keywords: biconditional, conditional, semantics, state-description, Wason selection task

Wasono atrankos užduotis ir dalykų padėties aprašu grįsta semantika

Santrauka. Peteris Wasonas pasiūlė keturių kortų atrankos užduotį daugiau nei prieš penkis dešimtmečius. Ji vis kelia sunkumų tiek kalbiniu, psichologiniu, tiek ir kognityviniu požiūriu. Siekiant išspręsti šią užduotį, buvo pasiūlyta daug psichologijos teorijų. Šiame straipsnyje siekiama pasiūlyti dar vieną galimą sprendimo būdą. Šis būdas grindžiamas Rudolfo Carnapo pateiktu ekstensijos ir intensijos metodu. Todėl jis grindžiamas dalykų padėties aprašo koncepcija. Dvi pagrindinės argumentacijos idėjos yra tokios: 1) žmonės, priimdami informaciją, gali būti linkę atsižvelgti į dalykų padėties aprašus; 2) jei implikacijos neturi aiškių nuorodų į kontekstą, jos gali būti interpretuojamos kaip ekvivalencijos arba abipusio sąlygojimo teiginiai.
Pagrindiniai žodžiai: ekvivalencija, implikacija, semantika, dalykų padėties aprašas, Wasono atrankos užduotis

Introduction

Since the sixties in the last century, 'four-card selection task' or 'Wason selection task' (e.g., Wason 1966, 1968) is a cognitive, psychological, and linguistic problem. This task provided by Peter Wason is a psychological and cognitive problem because it proposes an activity to do with a very simple logical structure. However, when presented in an abstract way, it is often hard to people. On the other hand, it is also a linguistic problem because it reveals that it is not clear how individuals tend to understand conditionals such as (1).

(1)   If p, then q.

Thus, the difficulties of this task are also related to logic. It is not clear whether individuals make inferences following logical rules. Besides, it is also dark whether people interpret connectives such as the conditional in the sense logic requires.

The task continues to be a problem today; there is no consensus on it nowadays. Different psychology theories keep arguing against each other (see, e.g., Ragni et al. 2017). Nevertheless, the present paper will not address one or some of those theories. It will just try to give one more alternative account. There are at least two reasons for the presentation of this new possible explanation. First, as it can be checked below, it is not complex. Second, it is based on an approach of philosophy of language that is able to explain other similar problems from the logical point of view. That approach is the semantic method of extension and intension proposed by Rudolf Carnap (Carnap 1947). It has been useful to, for example, resolve difficulties related to other controversial task: the suppression task (for a description of the suppression task, see, e.g., Byrne 1989; for the manner Carnap's method can help to solve difficulties of the suppression task, see also López-Astorga 2020).

Thus, this paper will have three parts. It will start with a description of the general logical structure of the different versions of Wason selection task. Then, it will deal with the basic elements of the method of extension and intension necessary to give the new account. The final section will be devoted to an argumentation trying to reveal the way those elements can be taken to build the new explanation.

The logical structure of four-card selection task

As said, the structure of the task is not complicated. The participant must check whether or not a rule with the logical form of (1) is correct. The rule is presented along with a description of a scenario. It is usually indicated that there are four cards on a table. Two of them represent two facts, for example, (2) and (3).

(2)   p
(3)   q

The other two cards refer to the denials of those very facts, for instance, (4) and (5).

(4)   ¬p
(5)   ¬q

Where '¬' means negation.

But the cards have two faces. Thereby, the instructions point out that every card has information about p on one of its sides, and about q on its other side. In other words, each card has either (2) or (4) on one of its faces, and either (3) or (5) on the other one. Accordingly, the hidden face of (2) can present either (3) or (5). Either (2) or (4) can appear on the back side of (3). The other face of (4) can indicate either (3) or (5). Finally, the side of (5) that cannot be seen can show either (2) or (4).

Given this, the question of the task is: which card(s) of the set (2) to (5) need(s) to be selected to verify that (1) is valid?

This is just the logical structure of the task. In different versions of it, p and q stand for different things or beings: from numbers and letters (as in the first versions; see, e.g., Wason 1968; Ragni et al. 2017; or Appendix 1, where there is an example of this kind of version) to people from a village offering (or not) and receiving (or not) certain products, such as corn and potatoes (see, e.g., Fiddick et al. 2000; or Appendix 2, where this version is commented on). However, the structure described allows seeing the problem.

From the logical point of view, Wason selection task is not difficult to solve. In classical logic, a sentence such as (1) is false if (2) and (5) are the case at once. This means that (1) is false whenever its first clause is true and its second clause is not at the same time. Therefore, what has to be done is to be sure that combination does not happen. To do that, it is enough to choose two cards: (2) and (5). The role of (2) is to check that (5) is not on its other side. The function of (5) is to verify that (2) is not on its hidden face. However, this is not what usually occurs. The majority elections are often [I] and [II].

[I]   Selection of both (2) and (3)
[II]   Selection of only (2)

It is true that there are versions in which individuals correctly turn cards (2) and (5) (e.g., that of the potatoes and corn indicated above and presented by Fiddick et al. 2000; see Appendix 2). Nevertheless, this paper is not about those versions. This paper addresses the versions that are habitually wrongly performed (such as the one presented in Appendix 1). This is because one might think that the tasks for which people give the right answer are not a problem. From this perspective, what would have to be explained is just why there are versions with poor results.

State-descriptions, L-implication, and L-equivalence

That account can be offered with the help of some tools present in Carnap's (1947) semantic method of extension and intension. As in other works resorting to that method (e.g., López-Astorga 2020), it is not necessary to consider it as a whole. Some of the elements of the method suffice.

The first of them is the concept of 'state-description'. A state-description is akin to what in modal logic is named a 'possible world' (see also, e.g., Fitting and Mendelsohn 1998). In any state-description all the possible atomic formulae (i.e., formulae such as p and q) are included. Nevertheless, they can be affirmed or negated. In this way, in

any state-description either (2) or (4) should be present. Both of them cannot be there (state-descriptions do not admit incompatibilities), but it is also impossible that none of them is. Likewise, any state-description has to contain either (3) or (5). Both of them are not admissible. Nonetheless, the situation in which none of them is incorporated is not acceptable either.

On the other hand, another important concept is the one of 'L-implication'. In (1), (2) implies (3). However, it can be claimed that (2) L-implies (3) when (1) holds in all the state-descriptions. That circumstance would be the one in which there is no state-description in which (2) and (5) happen.

Lastly, one more relevant concept is that of 'L-equivalence'. As it is well known, in logic there is an equivalence relation when there is a biconditional relation between the two clauses. This last relation occurs when, in addition to (1), (6) is also true.

(6)   If q, then p

Under the framework of classical logic, (1) and (6) can give away (7).

(7)   (If p, then q) and (If q, then p)

Or, if preferred, (8).

(8)   (1) and (6)

And both (7) and (8) can be expressed as (9).

(9)   p IFF q

Where 'IFF' means 'if and only if' and represents biconditional relation.

According to Carnap (1947), while (9) points out that (2) and (3) are equivalent, there is a possibility that they may be L-equivalent. That would happen if (9) held in all the state-descriptions. It is also well known that a logical sentence such as (9) is true whenever (2) and (3) have the same truth value. Therefore, (2) is L-equivalent to (3) if there is no state description in which either (10) or (11) hold.

(10)   (2) and (5)
(11)   (4) and (3)

In other words, (2) and (3) are L-equivalent if in all the state-descriptions either (12) or (13) are true, and (10) and (11) are false.

(12)   (2) and (3)
(13)   (4) and (5)

Carnap's (1947) method is much wider than these three simple notions. Nevertheless, they are enough to give an account of what occurs in four-card selection task.

Processing language by means of state-descriptions

As in my earlier paper (López-Astorga 2020), it is possible to assume that people process information by considering state-descriptions. If this is accepted as a hypothesis, a problema under consideration can be clarified.. That problem is the one of [II]. As indicated, [II] is one of the most frequent responses in Wason selection task. It is an answer consistent with the idea that individuals interpret language by resorting to state-descriptions. This is because they might think that the election of card (2) implies to review all the state-descriptions in which (2) appears. Thus, in their view, that would allow checking whether in all of them (3) appears as well or, on the contrary, (5) is true in some of them. As also said, in all the state-descriptions either (3) or (5) have to be present. So, taking all the state-descriptions with (2) into account suffices to see whether (1) is true. If (5) does not hold in any of those state-descriptions, (1) is true. In fact, it would be L-true, or true in all the state-descriptions. Therefore, it could be stated that (2) L-implies (3).

Hence, the question is why [I] is another frequent answer. This is because it is necessary to explain the reasons why (3) is chosen as well; (2) would be enough.

Some approaches in the literature can help in this point. It has been claimed that the versions of Wason selection task with poor results are almost always very abstract versions (that is the case, e.g., of the task in Appendix 1). In them, it is hard to note what the actual relation between the antecedent and the consequent is in (1). This can cause the perfection of the conditional (1) (see, e.g., López-Astorga and Lagos Vargas 2016).

Conditional perfection is a phenomenon often studied in linguistics. It has been analyzed in works that can already be deemed as classical (e.g., Auwera 1997; Geis and Zwicky 1971; Horn 2000; Moldovan 2009). Basically, it refers to the case in which a conditional such as (1) is understood as a biconditional such as (7), (8), or (9).

However, the point here is about four-card selection task and the semantic method of extension and intension. In many versions of the task (e.g., the one presented in Appendix 1), the lack of details describing a context causes rule (1) to be perfected (e.g., López-Astorga and Lagos Vargas 2016). This can lead to that the selection of the pair of cards (2) and (3) is not strange anymore. In those situations, what should be demonstrated is not L-implication, but L-equivalence.

Thus, people can think that the election of (2) keeps being required to check whether there is a state-description in which (10) is true. That would make (1) false. Nevertheless, now, the second conjunct in (7) and (8), that is, (6), would also need the election of card (3): it would be necessary to verify that there is no state-description in which (11) holds either. This is important because, if a case of (11) were found, (6), (7), (8), and (9) would not be true. Ultimately, if the conditional is perfected, what would have to be shown is not just that (2) L-implies (3), but that (2) and (3) are L-equivalent as well.

Thereby, to give an account of the problem of the versions of Wason selection task with low percentages of success, it is only required to assume two ideas as hypotheses. First, when people interpret sentences, they tend to think about the state-descriptions in which those sentences can be true or false. Second, when the context is poor and there is no clear

relation between the antecedent and the consequent of a conditional, this last sentence is often perfected. The latter idea is developed, for example, in papers such as the one of Moldovan (2009). In those papers, it is shown that the antecedent of a conditional can be a necessary condition or a sufficient condition for its consequent. However, there are situations (such as that of the task in Appendix 1) in which this is not obvious. The conditional perfection tends to happen in those situations (see also, e.g., López-Astorga and Lagos Vargas 2016).

A final brief explanation in this regard can support to a greater extent this idea of conditional perfection (the explanation will follow arguments such as those in Moldovan 2009; and, for their application to Wason selection task, works such as the one of López-Astorga and Lagos Vargas 2016). In (14), the antecedent is just a sufficient condition for the consequent.

(14)   If they run, then they will go faster.

The antecedent is just a sufficient condition because they can go faster for reasons other than running. An instance can be going by car. So, (14) is a conditional. If p stands for the fact that they run, and q represents the fact that they go faster, (14) is only false in cases of (10). It is true in cases of (12) and (13). Nevertheless, it also holds in cases of (11). As indicated, it is possible that they go faster for reasons different from running (e.g., going by car).

The case of (15) is not similar.

(15)   If today is Monday, then today is the first working day in a regular week.

The antecedent of (15) is a necessary condition for its consequent, and its consequent is a necessary condition for the antecedent too. If it is Monday, it is necessarily the first working day in a regular week. Likewise, if it is the first working day in a regular week, it is necessarily Monday. Accordingly, (15) is a biconditional. If p denotes the fact that today is Monday, and q refers to the fact that today is the first working day in a regular week, there is no doubt that (15) is true only in cases of (12) and (13). (10) and (11) are impossible. It is not possible that today is Monday and today is not the first working day in a regular week. In the same way, it cannot be admitted that today is not Monday and today is the first working day in a regular week.

But there are situations in which all of this is not evident. Without further context, one may not know whether the antecedent of (16) is a sufficient or a necessary condition for its consequent.

(16)   If there is a number, then there is a letter.

The sense of (16) is not clear. It means that, whenever there is a number, there needs to be a letter. Nevertheless, there is a doubt: can a letter be without a number? To respond to this question is to indicate whether (16) is a conditional or a biconditional. If a letter can be without a number, (16) is a conditional. It is only false if (10) is true (provided that now p corresponds to the fact that there is a number, and q points out the fact that there is a letter). Nonetheless, if a letter cannot be without a number, (16) can be false in two cases: (10) and (11). Hence, it is a biconditional. The point is, again, if the antecedent is

a sufficient or a necessary condition for the consequent. The difficulty is that, in cases such as the one of (16), that cannot be known for sure.

And this is exactly what seems to occur with the versions of four-card selection task that are not carried out correctly (e.g., the one described in Appendix 1). Its conditional rule can be perfected. So, if people process information by analyzing state-descriptions, it is obvious why individuals can tend to turn cards (2) and (3) in those versions.

Conclusions and general discussion

There are still at least several points to clarify. The first of them is that there are cognitive theories that can share some communalities with the account above. That can be the case of the theory of mental models (e.g., Byrne and Johnson-Laird 2020; Johnson-Laird and Ragni 2019;Ragni and Johnson-Laird 2020). This theory also considers scenarios in which sentences are possible. Hence, it can be thought that the explanation from the theory of mental models is close to the one presented here. This point has also been mentioned with regard to the account of the suppression task that can be offered from the method of extension and intension (López-Astorga 2020). Nevertheless, a quick review of the literature shows that assuming the theory of mental models involves assuming much more than the concepts of state-description, L-implication, and L-equivalence. This theory proposes iconic models (see also, e.g., Khemlani et al. 2018) which are very different from state-descriptions. In addition, it includes many principles and theses beyond the framework used above. An example in this way is its idea that individuals habitually only represent in their minds situations in which the sentences are true (see also, e.g., Johnson-Laird 2012). This is not what has been argued here. From the perspective of the present paper, people can think about state-descriptions in which the sentence is false. This example shows one of the differences between the approaches. The review of more principles and theses of the theory of mental models can even more confirm this fact.

Of course, similar analyses could be offered regarding theories other than the one of mental models and akin in some aspects to the proposal of this paper. Nonetheless, one might think that there is at a minimum an approach that is really similar to the one above. That is Margolis' (1987) approach. Following it, people have the tendency to deem scenarios as open scenarios. This circumstance can lead to assumption that, in four-card selection task, the scenario is not just that including the four cards. The individual might consider the cards to be categories of cards. In this way, the selection of (2) can mean the review of all the possible cards that present p. Likewise, the election of (3) can imply the revision of all the possible cards with q. If a perfection of (1) is added to this idea, the reasons for [I] are clear.

It can be thought that this account is not very different from the one proposed here. However, two points can be mentioned about that. First, as in the case of the theory of mental models, the concepts coming from the semantic method of extension and intension can be hard to relate to the basic notions assumed by Margolis (1987). Carnap's (1947) method is based on modal logic; it cannot be said that logic is the essential element in

Margolis' framework. Second, an account following Carnap's philosophy of language can be preferred. That is because Carnap's (1947) theoretical tools can also offer explanations of the problems of other tasks. Wason selection task is not the only task that can be accounted for by means of those theoretical tools (as indicated, for the case of the suppression task, see López-Astorga 2020).

One more problem is that, although the explanation of the previous section is correct, it is also necessary to explain why there are versions of Wason selection task individuals answer in a correct way. As said, in principle, those versions should not be a difficulty. After all, they are versions in which the participants often give the right response. Nevertheless, that kind of version should have some characteristics that lead to different manners to process information. Those characteristics are not hard to see if examples such as that of the potatoes and corn (Fiddick et al. 2000; see also Appendix 2) mentioned above are taken into account.

Two points can be noted in those examples. On the one hand, their contexts establish a clear relation between the antecedent and the consequent of the conditional rule. In particular, those contexts usually clarify that the antecedent is a sufficient condition of the consequent. Accordingly, conditional perfection does not happen (see also, e.g., López-Astorga 2011). On the other hand, the cards generally refer to particular people in particular scenarios. Therefore, those versions indicate in an evident way that each card is related to a particular person. So, the participant knows, for example, that considering the state-descriptions in which card (2) is true does not imply to get information about the person card (4) stands for; the people in cards (2) and (4) are not the same. Thus, the intellectual strategy changes and every card is reviewed separately. As a result, if (1) is not perfected and each card is analyzed singly, the possibilities to give the expected logical answer increase (again, this explanation seems to share links to that of Margolis 1987; nevertheless, this issue has already been addressed).

Hence, the final conclusions can be akin to those given in other works resorting to the method of extension and intension (e.g., López-Astorga 2020). First, it can be said that methods such as the one of Carnap (1947) keep remaining useful nowadays. Second, to present linguistic or cognitive explanations from that method, it is not necessary to assume theses supported in other works by Carnap (e.g., Carnap 1936, 1937, 1946). In fact, it is not necessary even to accept all the assumptions, definitions, and ideas included in the book in which the semantic method of extension and intension is described (Carnap 1947). This paper can be a proof of it. To offer an explanation of the difficulties of Wason selection task, it has used just three concepts of the method: state-description, L-implication, and L-equivalence.

References

Auwera, J. van der, 1997. Pragmatics in the Last Quarter Century: The Case of Conditional Perfection. *Journal of Pragmatics* 27: 261–274. https://doi.org/10.1016/S0378-2166(96)00058-6

Byrne, R. M. J., 1989. Suppressing Valid Inferences with Conditionals. *Cognition* 31: 61–83. https://doi.org/10.1016/0010-0277(89)90018-8

Byrne, R. M. J., Johnson-Laird, P. N., 2020. *If* and *or*: Real and Counterfactual Possibilities in Their Truth and Probability. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 46(4): 760–780. https://doi.org/10.1037/xlm0000756

Carnap, R., 1936. Testability and Meaning. *Philosophy of Science* 3(4): 419-471. https://doi.org/10.1086/286432

Carnap, R., 1937. Testability and Meaning – Continued. *Philosophy of Science* 4(1): 1–40. https://doi.org/10.1086/286443

Carnap, R., 1946. Modalities and Quantification. *Journal of Symbolic Logic* 11(2): 33-64. https://doi.org/10.2307/2268610

Carnap, R., 1947. *Meaning and Necessity: A Study in Semantics and Modal Logic*. Chicago: The University of Chicago Press.

Fiddick, L., Cosmides, L., Tooby, J., 2000. No Interpretation Without Representation: The Role of Domain-Specific Representations and Inferences in the Wason Selection Task. *Cognition* 77: 1–79. https://doi.org/10.1016/s0010-0277(00)00085-8

Fitting, M., Mendelsohn, R. L., 1998. *First-Order Modal Logic*. Dordrecht: Kluwer Academic Publishers. https://doi.org/10.1007/978-94-011-5292-1

Geis, M. L., Zwicky, A. M., 1971. On Invited Inferences. *Linguistic Inquiry* 2: 561–566.

Horn, L. R., 2000. From *if* to *iff*: Conditional Perfection as Pragmatic Strengthening. *Journal of Pragmatics* 32: 289–326. https://doi.org/10.1016/S0378-2166(99)00053-3

Johnson-Laird, P. N., 2012. Inference with Mental Models. In: *The Oxford Handbook of Thinking and Reasoning*, eds. K. J. Holyoak, R. G. Morrison. New York: Oxford University Press, 134–145. https://doi.org/10.1093/oxfordhb/9780199734689.013.0009

Johnson-Laird, P. N., Ragni, M., 2019. Possibilities as the Foundation of Reasoning. *Cognition* 193. https://doi.org/10.1016/j.cognition.2019.04.019

Khemlani, S., Byrne, R. M. J., Johnson-Laird, P. N., 2018. Facts and Possibilities: A Model-based Theory of Sentential Reasoning, *Cognitive Science* 42(6): 1887–1924. https://doi.org/10.1111/cogs.12634

López-Astorga, M., 2011. ¿Existen reglas adaptativas en la mente humana? Una revisión crítica de las teorías cognitivas evolutivas por medio del enfoque de la perfección del condicional. *Cinta de Moebio* 41: 123–143. http://dx.doi.org/10.4067/S0717-554X2011000200002

López-Astorga, M., 2020. Inputs from Philosophy to Cognitive Science: The example of L-concepts and the suppression task. *Rupkatha* 12(1): 1–6. https://dx.doi.org/10.21659/rupkatha.v12n1.38

López-Astorga, M., Lagos Vargas, R., 2016. La primacía del modus ponens in la cognición humana: Tarea de selección y perfección del condicional. *Alpha* 43: 19–37. http://dx.doi.org/10.4067/S0718-22012016000200003

Margolis, H., 1987. *Patterns, Thinking, and Cognition: A Theory of Judgment.* Chicago: The University of Chicago Press.

Moldovan, A., 2009. Pragmatic Considerations in the Interpretation of Denying the Antecedent. *Informal Logic* 29(3): 309–326. https://doi.org/10.22329/il.v29i3.2846

Ragni, M., Johnson-Laird, P. N., 2020. Reasoning about Epistemic Possibilities. *Acta Psychologica* 208. DOI: https://doi.org/10.1016/j.actpsy.2020.103081

Ragni, M., Kola, I., Johnson-Laird, P. N., 2017. The Wason Selection Task: A Meta-analysis. In: *Proceedings of the 32nd Annual Conference of the Cognitive Science Society*, eds. G. Gunzelmann, A. Howes, T. Tenbrink, E. J. Davelaar. Austin: Cognitive Science Society, 980–985.

Wason, P. C., 1966. Reasoning. In: *New Horizons in Psychology*, comp. B. Foss. Harmondsworth (Middlesex): Penguin, 135–151.

Wason, P. C., 1968. Reasoning About a Rule. *Quarterly Journal of Experimental Psychology* 20(3): 273–281. https://doi.org/10.1080/14640746808400161

APPENDIX 1

An abstract version of Wason selection task

The abstract versions of four-card selection task that are difficult to carry out are to be found in many works. Those are versions in which the participants often respond with [I] or [II]. An example is presented in Ragni et al. (2017). In the latter paper, the equivalences are as follows:

(2): a card presenting D on one of its faces.
(3): a card showing 3 on one of its sides.
(4): a card having K on one of its faces.
(5): a card with 7 on one of its sides.

This means that (1) is written with this content:

"If a card has a D on one side, then it has a 3 on the other side" (Ragni et al. 2017: 980).

APPENDIX 2

A version with content of Wason selection task

There are a lot of versions of four-card selection task with a detailed context. The results are usually optimal in them; individuals habitually select cards (2) and (5). There are also many theories trying to explain this fact (e.g., Fiddick et al. (2000) claim that there are mental mechanisms natural in human beings that help to identify offenders; and most of the tasks with good results ask for discovering people that break a rule). Nevertheless, this is not the central problem of the present paper. It mainly addresses the abstract versions (see Appendix 1). Anyway, an example of task with content can be found in Fiddick et al. (2000). The equivalences in that example are these:

(2): a person from another village that received potatoes from you.
(3): a person from another village that gave you corn.
(4): a person from another village that received nothing from you.
(5): a person from another village that gave you nothing.

The task consists of finding out whether there is/are some particular person/people that cheated you. What the people from the other village told you was:

"If you give me some potatoes, then I will give you some corn" (Fiddick et all. 2000: 28).