Is it possible to gain new knowledge by deduction?

Abstract

In this paper I will try to defend the hypothesis that it is possible to gain new knowledge through deduction. In order to achieve that goal, I will show the main motivations to defend this hypothesis, I will propose a response to the most important objection to that hypothesis, and I will provide empirical support consistent and favorable to the hypothesis.

1. Introduction

In this paper I will defend the hypothesis that it is possible to gain new knowledge through deduction. *Grosso modo*, some piece of knowledge can be regarded as new for a subject if the propositional content of that piece of knowledge was not previously stored in her long-term memory (not even as the content of a belief). Thus, according to the hypothesis, when a subject competently deduces the logical consequences of her previous knowledge, she can gain knowledge she didn't had before, i. e., knowledge that was not stored in her long-term memory.

Prima facie, the truth of this hypothesis seems to be undeniably intuitive and even trivial; however, the fact that in deduction the content of the conclusion is already in the premises leads many philosophers and cognitive scientists to claim that it is impossible to gain new knowledge through deduction. I will defend the hypothesis from this objection by arguing that it relies on an equivocation between deductive implication and deductive inference, and then I will claim that it is possible to gain new knowledge through the latter. In order to support this last claim, I will show evidence provided by some empirical research on the cognitive process of deduction and argue that the best way to account for this evidence is to acknowledge that it is possible to gain new knowledge through deduction, understood as deductive inference. Thus, I will argue that, in light of this distinction, the hypothesis provides the best explanation for the evidence.

2. Motivations for the hypothesis

As motivation to defend that it is possible to gain new knowledge by deduction, we can appeal to what seem to be two good examples: Andrew Wiles' proof of Fermat's last theorem and Grigori Perelman's proof of the Poincaré conjecture. Wile's and Perelman's proofs provided knowledge of the truth of Fermat's last theorem and the Poincaré conjecture, respectively. Such knowledge wasn't available before their proofs, and since a mathematical proof is a deduction, it seems that those deductions provided new knowledge. Because of this kind of examples, many epistemologists are keen on the idea expressed in our hypothesis. For instance, Timothy Williamson (2009) holds that deduction is useful because it is a way to extending our knowledge: one knows more after carrying out the temporal process of carrying out the deduction than one did before. In general, according to Williamson, mathematics provides good examples of how we can gain new knowledge or extend our knowledge through deduction: "mathematics is essential to science and its main role is to extend our knowledge by deduction."

Another reason to sustain that it is possible to gain new knowledge by deduction lies in the computational complexity of some deductions. Some deductions are so computationally complex, that it seems very unlikely that the subject can have knowledge of the conclusion just by knowing and understanding the premises. Therefore, it seems that denying the possibility of gaining new knowledge through deduction comes with a high price: it involves some degree of commitment to logical omniscience and makes it very hard to explain why deduction is useful. Roughly speaking, a logically omniscient subject knows all the deductive implications of his knowledge. Some commitment to logical omniscience is involved in claiming that a subject does not gain new knowledge by deductively inferring the deductive implications of his previous knowledge because the content of what he inferred was already in the content of what he already knew. The idea of a logically omniscient human subject is highly counterintuitive due to our limitations of cognitive resources and processing capacities. Therefore, the computational complexity of some deductions and the rejection of logical omniscience constitute a motivation for the defense of our hypothesis.

3. The objection coming from the paradox of inference

Nevertheless, is hard to give up to the idea that in deduction the content of the conclusion is already in the premises because this idea accounts for the necessity of deductive validity. The clash between this fact and the intuition regarding the possibility of gaining new knowledge by deduction leads to a dilemma, according to which deduction cannot be both valid and a source of new knowledge. This dilemma was perspicuously exposed by Morris Cohen and Ernest Nagel (1934):

> *If in an inference the conclusion is not contained in the premise, it cannot be valid; and if the conclusion is not different from the premises, it is useless; but the conclusion cannot be contained in the premises and also possess novelty; hence, inferences cannot be both valid and useful.*

This dilemma has been labeled as 'the paradox of inference' because it is really paradoxical to concede that no new knowledge is gained through deduction. As a response to this paradox, I propose a way to dissolve the dilemma arguing that it relies on an equivocation between deductive implication and deductive inference.

4. Addressing the objection

Deductive implication and deductive inference are very different things: the first one is a logical relation, while the second one is a cognitive process. As a logical relation, deductive implication holds between propositions (commonly regarded as abstract entities), and it is a priori and necessary. This is validity's realm, i. e., the realm of propositions and the relations among them. Validity concerns the relation of a set of propositions that deductively implicate other proposition because the content of the latter is already in the content of the former. In contrast, deductive inference is a cognitive process carried out by human beings, who employ some specific bounded cognitive resources and capacities, through some lapse of time. Understanding deductive inference as a cognitive process would allow us to talk about gaining new knowledge by deduction. If it is true that it is possible to gain new knowledge through deductive inference, the apparent dilemma between validity and the possibility of gaining new knowledge by deduction would be explained as the result of confusing or ignoring the characteristics of deductive implication and deductive inference; acknowledgment of those distinctions would dissolve the dilemma and explain away the paradox. Since the claim that it is possible to gain new knowledge through deductive inference is an empirical claim, it is necessary to provide empirical support to state its truth.

5. Evidence for the hypothesis: Cognitive scientists have been studying deductive reasoning for decades but none of the available experiments have focused on testing if it is possible to gain new knowledge through deductive inference. However, some studies throw results which seem to provide some empirical support for the hypothesis we are defending because the best way to account for those results is to acknowledge the possibility of gaining new knowledge through deduction. Here we are going to focus on the results of two studies: one from the field of neuroscience and the other from experimental psychology.

5.1 The neural basis of the generation of conclusions in elementary deductions

The first study (Reverberi et al. 2007) searches for the neural basis of the generation of conclusions in elementary deductions through neuroimaging techniques. The importance of the experiment carried out by Reverberi et al. is that it was specifically designed to discriminate the neural basis of drawing a deductive conclusion by evaluating the brain activity at the instant of deduction, before contamination of any additional processes; in contrast, previous experiments were focused on the evaluation of the validity of a proposed conclusion to a set of premises, which may engage other processes or strategies than those specifically associated with the generation of conclusions.

As *stimuli*, participants received simple deductive problems (*Modus ponens* and disjunctive syllogisms) during fMRI scanning. In every trial, participants were asked to read each premise and, if possible, draw a conclusion as soon as they can. During the tasks, the first premise was presented to the participant, who was required to press a key as soon as she was ready to proceed to the next premise or the conclusion. A blank screen was shown for 2 seconds after the reading of the third premise, and then a question marl was presented for 1 second anticipating the presentation of four alternative conclusions. As a result of this procedure, participants were forced to generate the conclusion of the inference while processing the second or third premise.

Among the variables considered in the behavioral analysis were the reaction times required to process a specific premise (the time from presentation of a stimulus to button press), the reasoning time, and the processing time. An inferior front-parietal network in the left hemisphere (left inferior frontal gyrus BA 44 y 6 and left parietal cortex BA 40) was identified as the neural basis for generation of deductive conclusions because their average reason-related activity was greater with longer reasoning times. In contrast, the correlations between reasoning time and brain activity cannot be accounted for by a non-specific effect of overall sentences processing time because the latter, in contrast to the reasoning time, failed to correlate with brain activity in either region. The data collected by Reverberi et al. shows how brain activity in both frontal and parietal regions correlated selectively with reasoning time, but not with the overall sentence processing time.

These results, i. e., the fact that the brain regions identified as the neural basis for generation of deductive conclusions do not show activity during processing time of the premises, can be accounted for by claiming that even though the subject has processed and understood the premises, he did not know the conclusion at that time. The claim that even though the subject has processed and understood the premises he didn't have knowledge of the conclusion until he deductively inferred it from the premises, provides a very perspicuous explanation for those results, which is consistent with our hypothesis.

5.2 Understanding deductive inference as as source of knowledge.

The other study relevant to the defense of our hypothesis is composed by a set of experiments conducted by Bradford Pillow et al. (2000). Those experiments were devoted to investigate children's understanding of deductive inference as a source of knowledge. Experimenters assumed that understanding deductive inference as a source of knowledge should include the nest three abilities: a) attribute inferential knowledge to others, b) explain the origin of another person's knowledge by appealing to inferential processes, c) distinguish inferential processes from other sources of knowledge or belief, such as perception or guessing, and d) evaluate inferentially acquired beliefs (Pillow et al. 2000). Therefore, the study conducted by Pillow et al. investigated children's ability to the origins of inferential knowledge and their ability to judge the relative certainty of inferential knowledge, guesses and perceptual knowledge (Pillow et al. 2000).

In order to test those abilities, in the experiments children between 4 and 9 years old observed a puppet make a statement about the color of one of two hidden toys after the puppet a) looked directly at the toy (perception trials), b) looked at the other toy (inference trials), and c) looked at neither toy (guess trials). Those experiments should show children's ability to distinguish deductive inference form perception and guessing.

In the first experiment, children were asked to evaluate the certainty of the puppet's statements based on direct perceptual experience, deductive inference or guessing, and then they were asked to explain the origin of beliefs derived through perception, inference or guessing. Experimenters used a puppet, tow opaque plastic cans as hiding places, seven pairs of small toys of different colors, and a rating scale (a ruler attached to a cardboard stand) with a horizontal line connecting a happy face on the right end of the scale (indicating certainty) to a sad face on the left end (indicating uncertainty). Before the experiment, children began with a warm-up procedure in which they were given the opportunity to learn the color of one hidden object by direct perceptual experience and to learn the color of another hidden object by inference. Then, using the rating scale, children were asked to rate their own certainty about the color of each object. All children correctly inferred the color of the hidden object in the can they had not looked into, which means that all children were able to make a simple deductive inference.

The warm-up procedure was followed by six trials of the mains task. On each trial a different colored toy has hidden in each of the plastic cans. On the look trials, the puppet looked into one of the cans and made a statement about the color of the toy in the can. For the two inference trials, the puppet pointed to one of the cans and made a statement about the color of the toy hidden in the other can, which the puppet had not looked into. The formal or logical structure of this trial can be identified as a *Modus ponens*. For the two guess trials, the puppet pointed to one of the cans and made a statement about the color of the toy hidden inside of without looking into either of the cans. In each case, children were asked to provide explanations of the puppet's belief and to rate its certainty. The results showed that children gave significantly lower ratings on guess trials than they di on either look or inference trials. This suggested that children distinguished guess trials from look trials and inference trials. Older children's responses (5-years and 7-years-olds) gave more accurate responses than the younger ones.

The second experiment investigated children's ability to distinguish between a valid deductive inference and guess trial that was based on inconclusive premises. The materials and procedure were similar to those of the first experiments, but in addition to the look, inference and guess trials (that were identical to those in the first experiment), there was an invalid inference trial in which the puppet looked into one of three cans, each containing objects of different colors, and then stated a belief about the color of the object in one of the other two cans. Looking into only one can would not allow the puppet to deduce the color of the object in one of the other cans. It was expected that if children acknowledge this, they understand that while deductive inference is a source of knowledge, invalid inference is not. The results showed that 6 years-olds' ratings on inference trials were significantly higher than their ratings on invalid inference or guess trials. 9 years-olds' ratings on look and inference trials differed significantly from their ratings on invalid inference or guess trials.

The results of those experiments can be interpreted as showing that some children between 6 and 7 years old can understand deductive inference as a source of knowledge and rate it as more certain than guessing. Pillow et al. (2000) assert that "by 6 years, children understand that knowledge can be acquired through inference." Children's reports seem to indicate that they understand deductive inference as a source of knowledge, just as they understand perception as a source of knowledge. This result is consistent and favorable to the hypothesis that it is possible to gain new knowledge through deductive inference.

6. Concluding remarks

In addition to motivations for the hypothesis, I have proposed a response to one possible objection and empirical evidence to support this response and the hypothesis. I have claimed that the best way to account for that evidence is to acknowledge that it is possible to gain new knowledge through deductive inference. On the one hand, the fact that brain areas involved in processing the premises of a deductive argument differ from those that generate the conclusion, can be interpreted as a signal of the fact that a reasoning process is needed in order to draw the conclusion because even though the subject understands the premises, she may not know the conclusion. We can account for this by acknowledging that in such cases, the subject gains new knowledge through the deductive inference process: since she comes to know the conclusion only after deducting it, her knowledge of it can be regarded as new. On the other hand, the fact that children report they gained new knowledge after the inferential process they carried out, is consistent and favorable to our hypothesis, specially because due to their ages, the propositional content of the children's beliefs acquired through the inferences could not be stored in their long term memory, so those beliefs can be regarded as new beliefs, belief they previously hadn't.

I acknowledge that in order to provide stronger empirical support for the hypothesis, further research needs to be done to show that there are inferred conclusions not previously present in the subjects' long-term memory. For example, it would be necessary to design an experiment specifically designed to investigate if the conclusions deductively inferred from a set of premises were previously among the contents stored in the long-term memory.

References

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