

SIMPLE ARGUMENTS ARE NOT THAT SIMPLE

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Scientific problem

This study is concerned with the problem of distinguishing fast, automatic, embedded modes of reasoning from slow, deliberative, reflexive ones and finding a cognitive basis for classification of reasoning (and arguments).

Theoretical basis

Our research on reasoning process stemmed from two main sources:

1. Dual process theory;
2. Logically approved distinction between simple and complex arguments, where the former serve as building blocks (rules of inference) for the latter.

In logic, such initial primitive inferences include in particular the principles of implication elimination (Modus Ponens and Modus Tollens), as well as disjunction elimination (Modus Tollendo Ponens and Modus Ponendo Tollens).

Hypothesis

Some of the simple, atomic arguments are carried out by means of an embedded quick system 1, while the other though considered as logically simple are conducted with the help of slow and thoughtful system 2.



Participants

15 healthy native Russian students were recruited to participate in argument verification research.

Apparatus

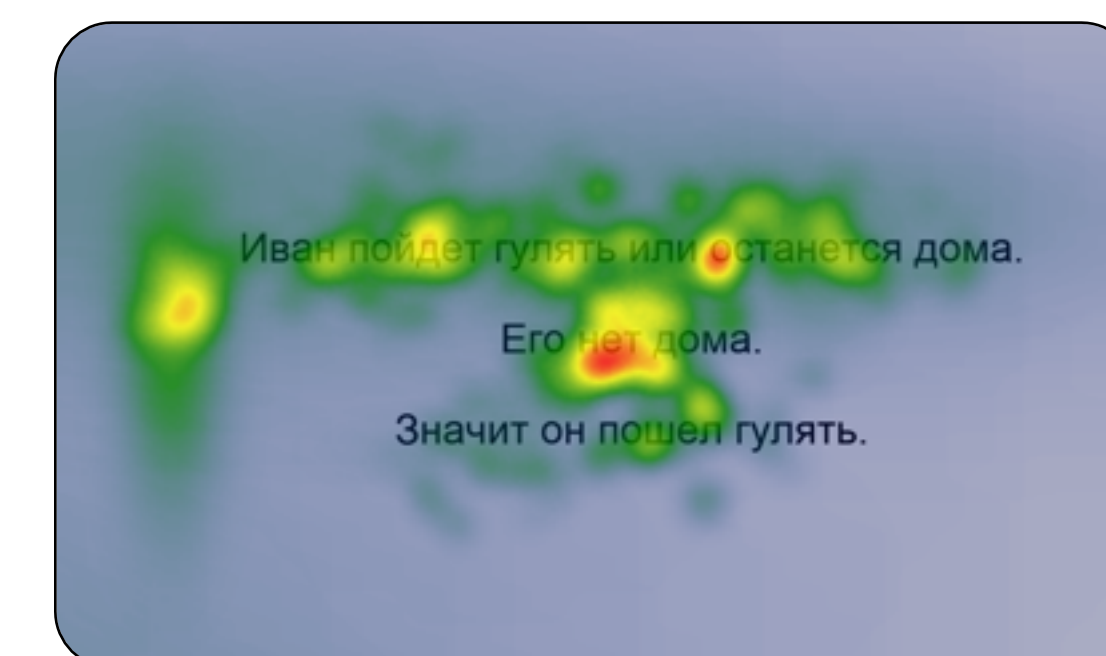
The experiment was conducted using SMI iView X Hi-Speed 1250 eye tracker.

Procedure

Stimulus presentation time was unlimited, the participant used the keyboard to go to the answer, and then using the computer mouse gave an answer to the question of whether the inference was correct or not. Each of the 80 stimuli was presented once and in a pseudorandom order.

Registered parameters

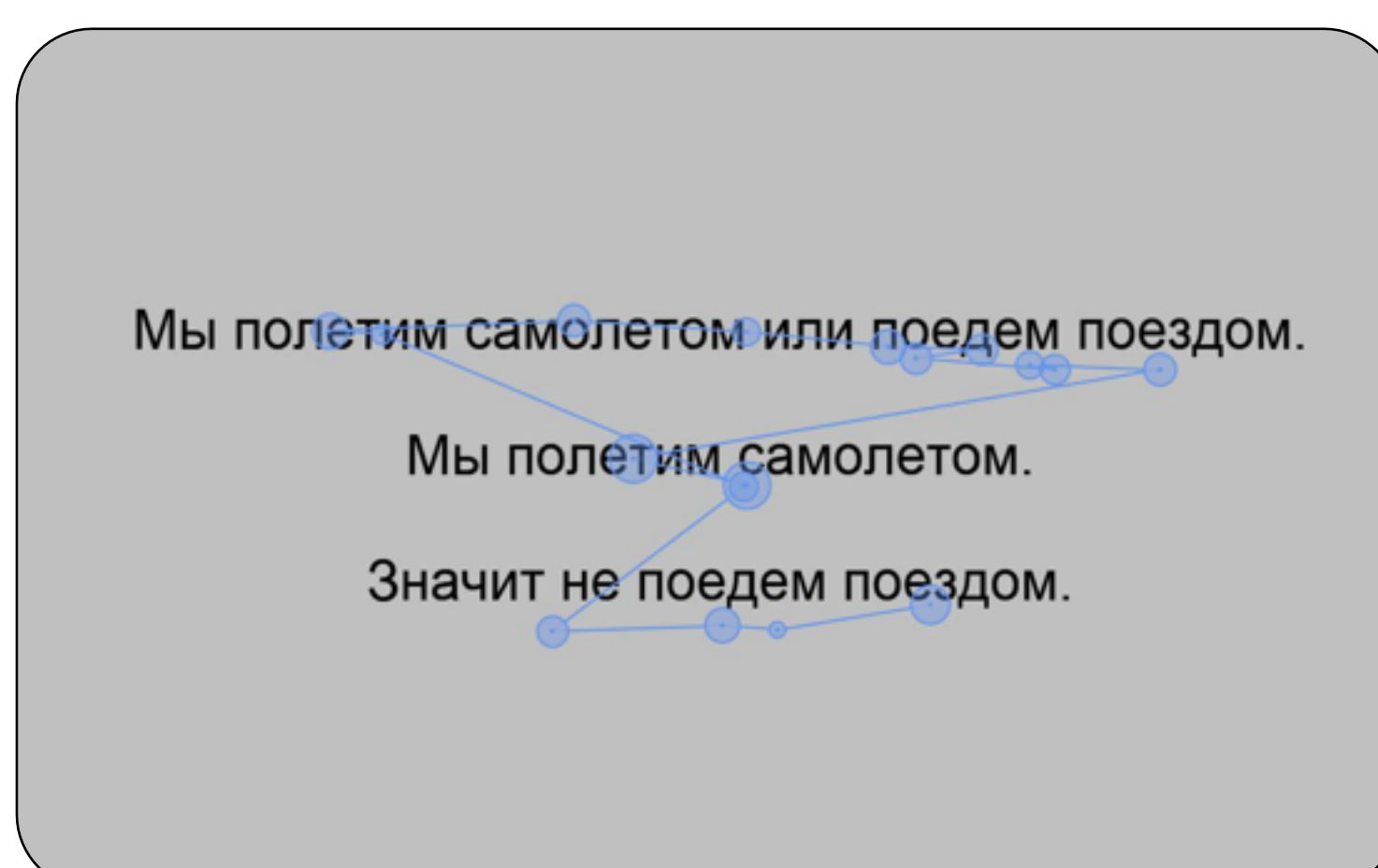
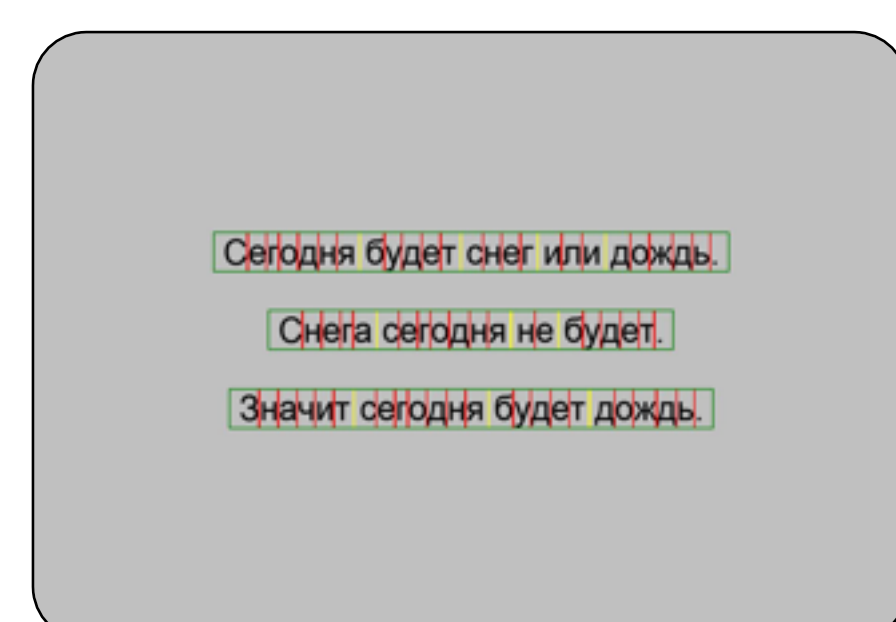
The response time, the answer, the fixation count, the duration of fixations, the saccade count, the amplitude and velocity of saccades, the scanpath length were registered.



Stimuli

| | Valid | Invalid |
|-------------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------|
| Modus Ponens [MP] | MP_p If A, then B A Therefore, B | MP_n If A, then B B Therefore, A |
| The amount of stimuli: | 10 | 10 |
| Modus Tollens [MT] | MT_p If A, then B Not B Therefore, Not A | MT_n If A, then B Not A Therefore, Not B |
| The amount of stimuli: | 10 | 10 |
| Modus Ponendo Tollens with exclusive and non-exclusive "or" [MPT] | MPT_sp A or (= "excl. or") B A Therefore, Not B | MPT_n A or B A Therefore, Not B |
| The amount of stimuli: | 10 | 10 |
| Modus Tollendo Ponens with non-exclusive "or" [MTP] | MTP_p A or B Not A Therefore, B | |
| The amount of stimuli: | 10 | |
| Modus Tollendo Ponens with exclusive "or" [MTP] | MTP_sp A or (= "excl. or") B Not A Therefore, B | |
| The amount of stimuli: | 10 | |

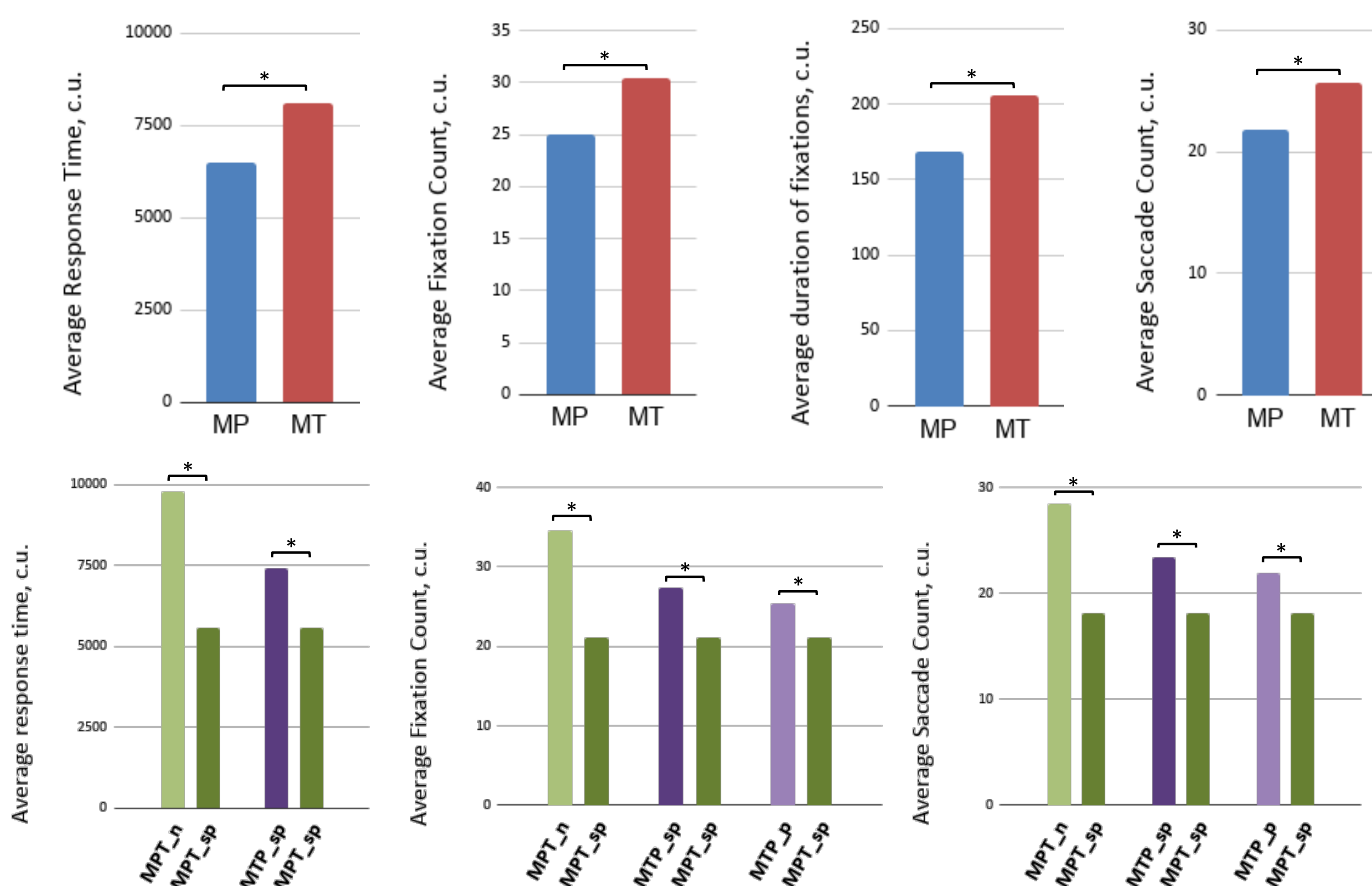
Stimuli (three-term inferences) in Russian were displayed on a monitor.



Results

Significant differences (*p<0.05) between different types of inference were detected for MP and MT: the response time, the fixations count, the fixation durations and the saccades count.

Significant differences between different variants of MTP and MPT were detected in the response time, the fixations count, the fixation durations, the saccades count and the scanpath length.



These results confirm the existence of fundamental differences in cognitive processing of Modus Ponens and Modus Tollens. Modus Ponens arguments are processed relatively quickly, requires less amount of fixations and saccades and also shorter fixation duration. All these significant advantages in the cognitive processing of MP and the absence of negation in its premises and conclusion suggests that MP can be considered as an atomic built-in scheme of inference.

| Designation | MP_p | MP_n | MT_p | MT_n | MTP_p | MTP_sp | MPT_n | MPT_sp |
|--------------------------------------------------|-----------------------------------|-----------------------------------|-------------------------------------------|-------------------------------------------|---------------------------------|------------------------------------------------|---------------------------------|------------------------------------------------|
| Logical Inference Formula | If A, then B A Therefore, B | If A, then B B Therefore, A | If A, then B Not B Therefore, not A | If A, then B Not A Therefore, not B | A or B Not A Therefore, B | A or (= "excl. or") B Not A Therefore, B | A or B A Therefore, Not B | A or (= "excl. or") B A Therefore, Not B |
| Average response time, c.u. (conditional units) | 6157.1 | 6809.5 | 8166.4 | 8010.5 | 6658.2 | 7427.8 | 9773.9 | 5570.4 |
| Average fixation count, c.u. | 23.7 | 26.2 | 30.7 | 30.1 | 25.3 | 27.4 | 34.5 | 21.2 |
| Average duration of fixations, c.u. | 163.9 | 173.6 | 195.7 | 216.0 | 203.8 | 181.6 | 244.8 | 186.1 |
| Average saccade count, c.u. | 20.7 | 22.9 | 25.5 | 25.8 | 21.9 | 23.4 | 28.4 | 18.1 |
| Average amplitude of saccades, c.u. | 5.0 | 4.3 | 3.9 | 4.7 | 4.4 | 4.1 | 4.6 | 5.1 |
| Average velocity of saccades, c.u. | 110.4 | 99.7 | 97.1 | 111.1 | 108.5 | 99.6 | 115.1 | 109.5 |
| Average scanpath length, c.u. | 4133.3 | 4567.9 | 5052.9 | 4632.8 | 3846.5 | 4520.0 | 5398.2 | 3258.9 |
| Response rate "Yes, the inference is correct", % | 74.0 | 81.4 | 72.7 | 79.3 | 70.7 | 80.0 | 76.0 | 82.0 |