Comparing Interactive Proof Visualizations

Explaining logical inferences to users is a challenging task. Sometimes, it is enough to point out the axioms that lead to the consequence, but not always. Complex inferences require proofs, which provide intermediate steps that users can follow. This work investigates the effect of different proof representations on the understanding of different users.

Research Question

Which representations to choose?

How expressive should the underlying logic be?

How to represent a formal proof in a more understandable way to the users?

Who are the users?

How to measure understandability?

Main Study: Logical Abilities & Proof Representation Preferences

The study attempts to find a difference in the preferences and performance with each proof representation, depending on the user's level of logical reasoning ability.

Each proof is formatted as either: A (linear) text or tree-shaped proof. A static or interactive proof.

Participant total = 173 (female=71, male=102). Age range = [18, 65].

Hypotheses

Hypothesis 1: It is easier to understand interactive proofs than static proofs.

Hypothesis 2: The relative level of comprehensibility of a tree-shaped vs. a textual proof depends on cognitive ability.

No significant difference detected in the comprehensibility ratings as well as the performance between the various representations in each cognitive ability group, and across the two groups. Side remark: not confirmed ≠ wrong.

Representations Ranking

Ranking of all 173 participants (light bar) and of the 83 participants with a high ICAR score (dark bars) for each condition combination.

• There are significant differences in the ranking across both ICAR groups, interactive tree > interactive text > static text, static tree > static text.

• and in the group with a high ICAR performance, static tree > static text, interactive tree > interactive text.

The observed subjective preference for tree-shaped proofs was not reflected by an increase in the performance in our study.

Resources

Printable version of the survey (Pre-Study):
https://cloud.perspicuous-computing.science/s/olp9r9aoC5sSDDaF

Printable version of the survey (Main Study):
Interactive text proof:
https://lat.inf.tu-dresden.de/evonne/example
Interactive tree proof:
https://lat.inf.tu-dresden.de/evonne/textExample

Pre-Study: Establishing Users Groups

Shows the relation between users’ understanding of proofs and their cognitive abilities.

Assesses cognitive ability using the International Cognitive Resource (ICAR16) questionnaire.

Participants total = 101 (female=45, male=56). Age range = [18, 48].

ICAR16 Question Example

Please indicate which is the best answer to complete the figure below?

Hypothesis

The ICAR score predicts the users performance in logical proofs.

CONFIRMED

Proofs and Axioms

• Tree-shaped proof training example

Every opti is heuned with a voen

• Text proof training example

Since every opti is a naki and every naki is a cahe, every opti is a cahe.

Furthermore, since every cahe is heuned with a voen, we can conclude that every opti is heuned with a voen.

To open the experiments to a larger population, axioms in formal DL syntax were replaced by hand-crafted textual representation.

Opti heuned Voen

Every opti is heuned with a voen