In the Hand of the Beholder: Comparing Interactive Proof Visualizations

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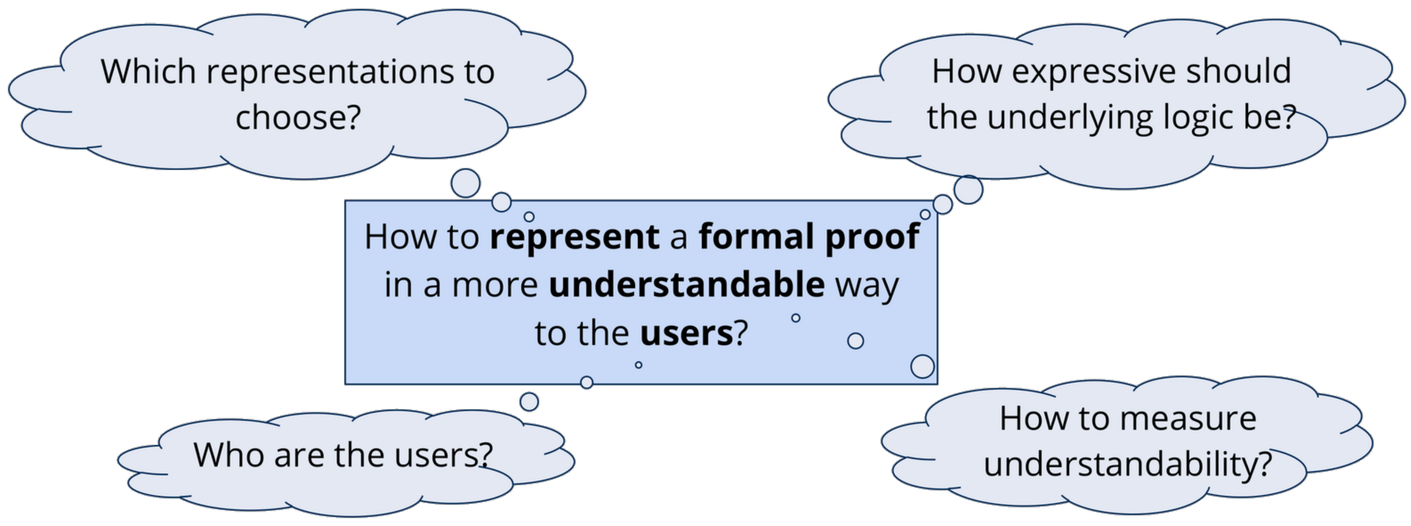
Introduction

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 intermidiate steps that users can follow. This work investigate the effect of different proof **representations** on the understanding of different **users**.

Research Question



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. } **Conditions**

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

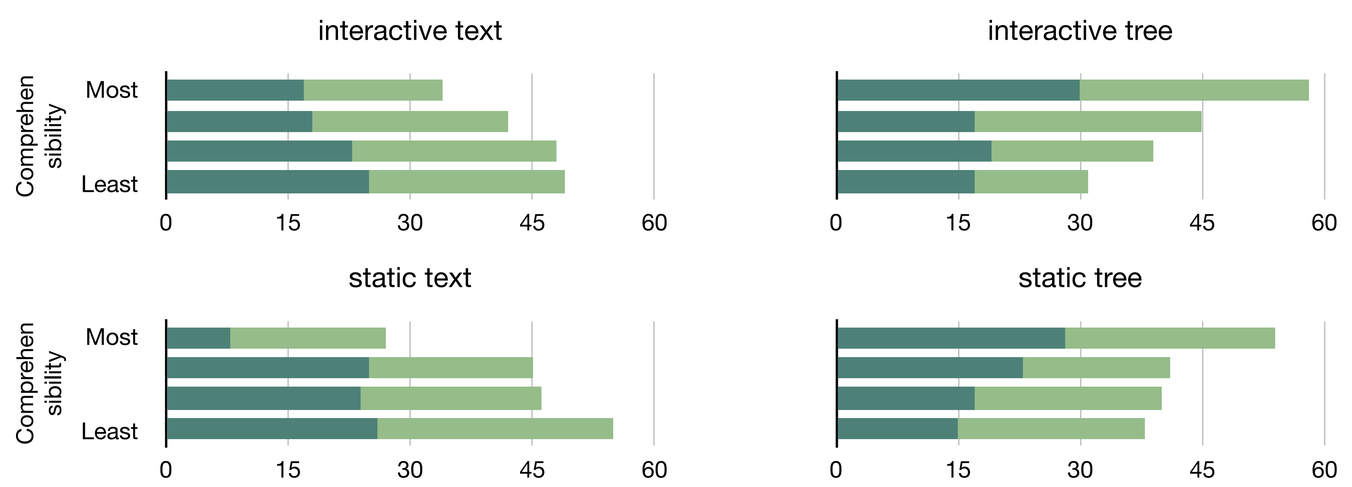
Hypotheses

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.* NOT CONFIRMED

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 goups. Side remark: **not confirmed** $\neq$ **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 perfomance.
  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.

Pre-Study: Establishing Users Groups

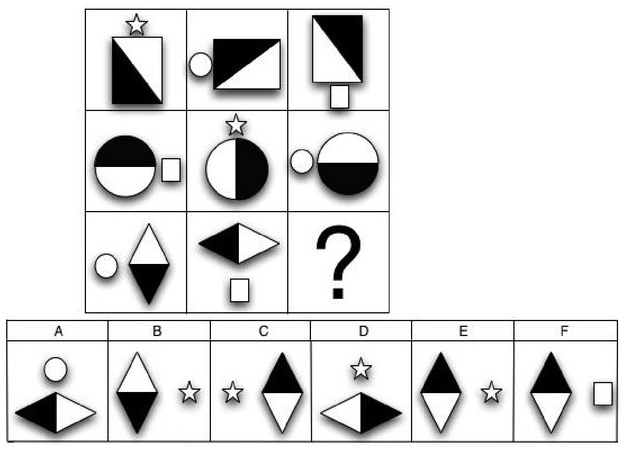
Shows the relation between users' **understanding** of proofs and their **cognitive abilities**.

Assesses cognative ability using the *International Cognative 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?

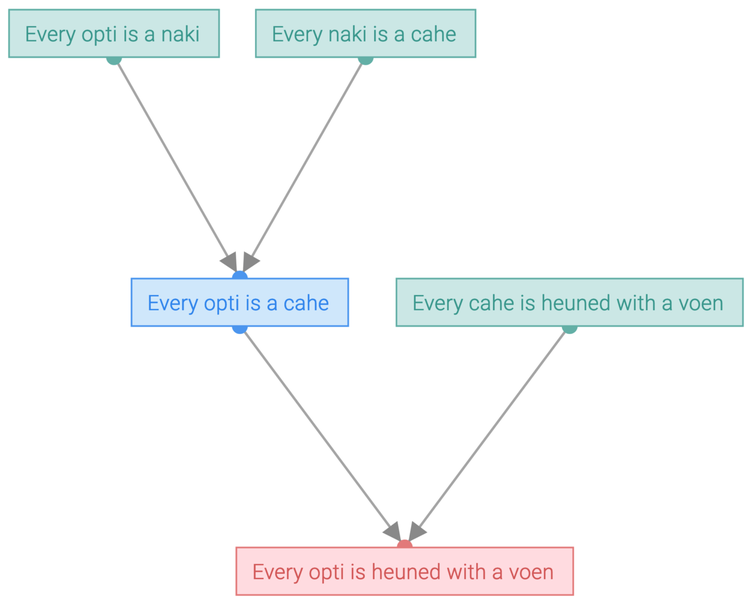


Hypothesis

The ICAR16 score predicts the users performance in logical proofs. CONFIRMED

Proofs and Axioms

- Tree-shaped proof training example



- 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.

$$\text{Opti} \sqsubseteq \exists \text{heuned}.\text{Voen}$$
$$\Updownarrow$$
Every opti is heuned with a voen

Resources

Printable version of the survey (Pre-Study): `https://cloud.perspicuous-computing.science/s/oHp9pRaoCx5SDsF`
Printable version of the survey (Main Study): `https://cloud.perspicuous-computing.science/s/dCSmbraoJ4RzDqG`
Interactive tree proof: `https://lat.inf.tu-dresden.de/evonne/example`
Interactive text proof: `https://lat.inf.tu-dresden.de/evonne/textExample`

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