Visualization is Better!
A Comparative Evaluation

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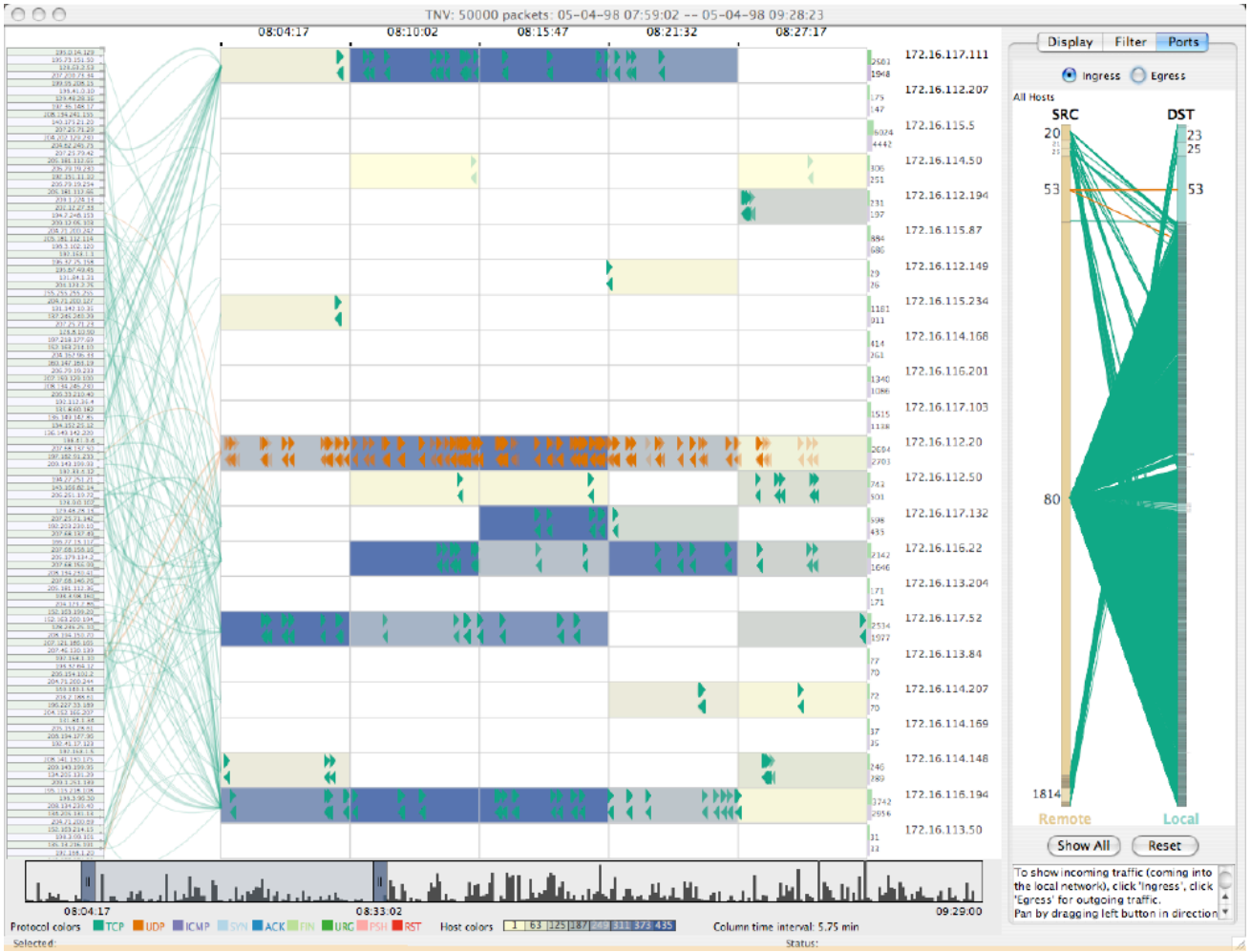
APPLIED VISIONS

SecureDecisions DIVISION

Context

- This work was part of larger research study
- Field study, interviews with security analysts, and survey to understand intrusion detection work practice
- Development of vis tool for analysis
  - Iterative heuristic reviews and usability testing
- Summative comparative evaluation

tnv



http://tnv.sourceforge.net/

User Testing

- *Controlled experiments comparing design elements*: a comparison of specific widgets
- *Usability evaluation of a tool*: an evaluation of problems users encounter when using a tool as part of the design process
- *Controlled experiments comparing two or more tools*: a comparison of multiple visualizations or the state of the art with a novel visualization
- *Case studies of tools in realistic settings*: an evaluation of a visualization tool in a natural setting with users using the tool to accomplish real tasks

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Study Design

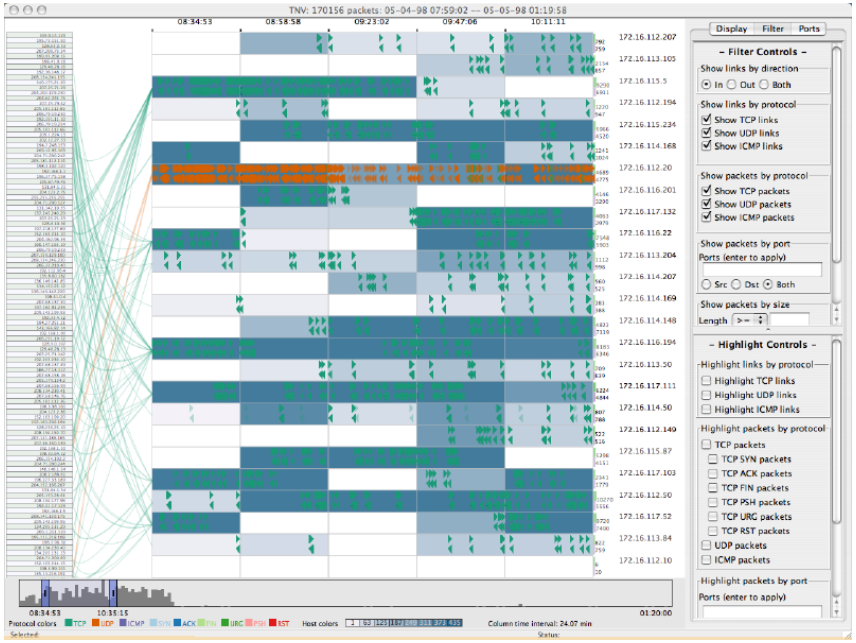
- Goal: Compare tnv and the standard tool for network packet analysis
- Design: Repeated measure within subject
- Participants: 8 IS undergrad/grad students
- Tools: tnv & Ethereal
- Data: small (200 packets) & large (750 packets)
- Tasks: well-defined & exploratory

Why Novice Users?

- Learning: research showed that novices ‘play’ with tools to learn; tnv was designed to facilitate learning
- Background: domain experts would have lots of experience with Ethereal, which could skew the results
- Accessibility: domain experts are hard to come by

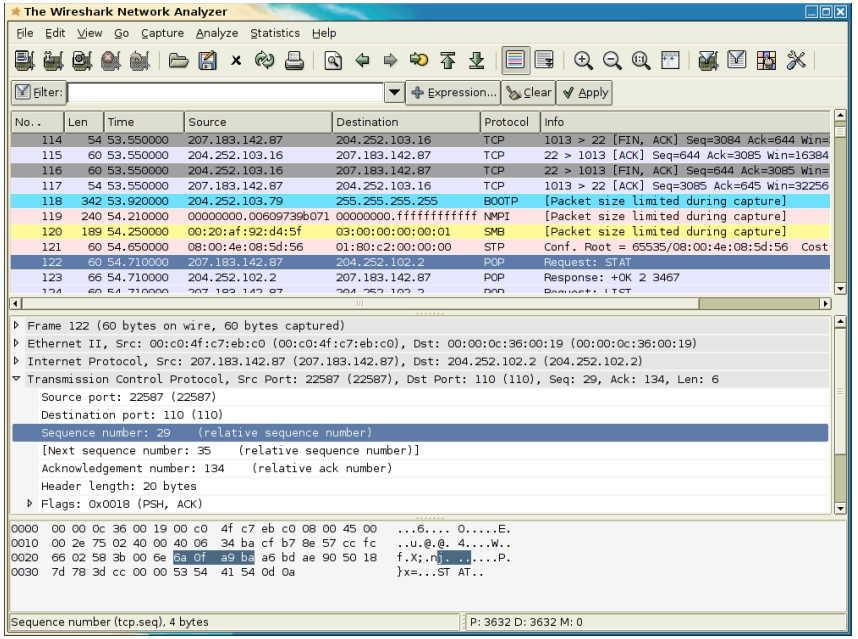
Tools

tnv



Designed to facilitate high-level and detailed understanding of network traffic

Wireshark



De facto standard for packet analysis: 88% of survey respondents used Ethereal at least occasionally (62% frequently)

Tasks

- Well-defined
  - Representative of ‘typical’ tasks; 1 correct answer
  - Task categories: comparison & identification
  - 16 tasks for each tool
- Exploratory
  - Asked participants to draw open ended conclusions from the data; no correct answer
  - Predefined time limit
  - 1 exploratory task for each tool

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Procedure

- Introduction to the study and each of the tools
- Training using either tnv or Ethereal
- Timed tasks using that tool
- Exploratory task using that tool
- Training using the second tool
- Timed tasks using the second tool
- Exploratory task using the second tool
- A satisfaction questionnaire on both tools

Variables

- Independent Variables
  - Tool: tnv, Ethereal
  - Task Type: Comparison, Identification
- Dependent Variables
  - Accuracy
  - Completion Time
  - User Perceptions

Expected Results

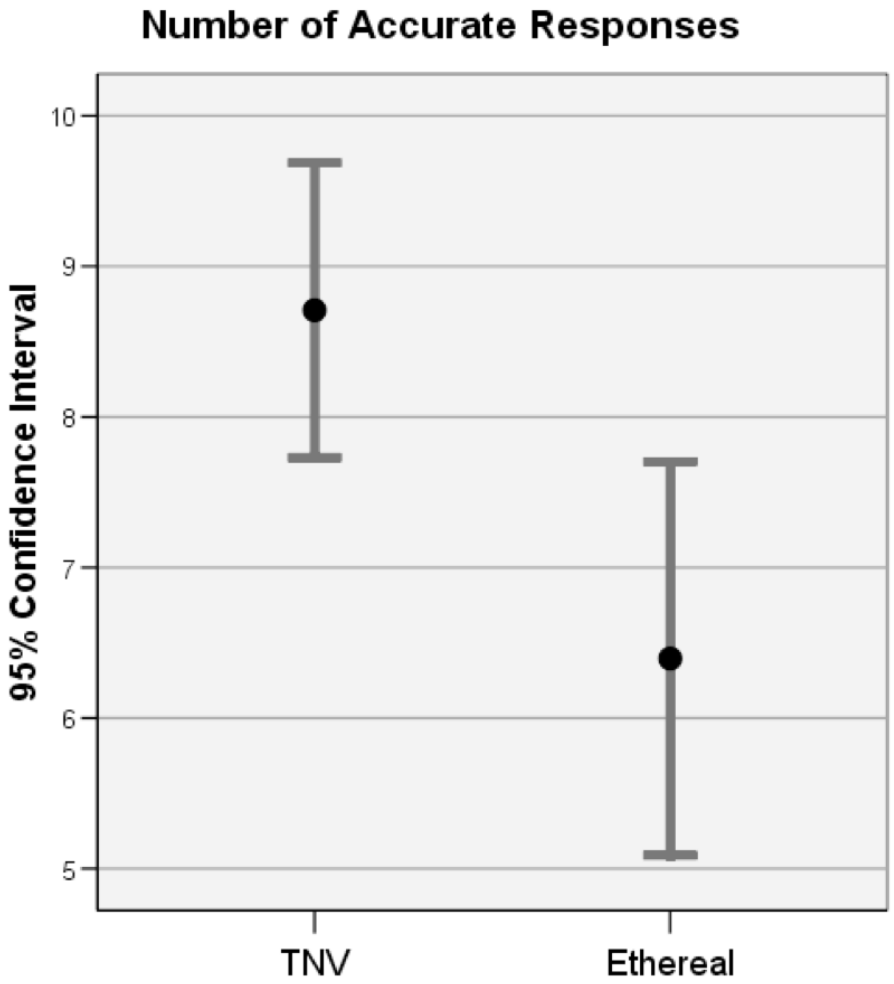
Expect users to perform better with tnv…

- …Especially for comparison tasks, since tnv shows much more data at once
- …But identification tasks will be closer, since Ethereal has easy to use search capability

Analysis

- A repeated measures analysis of variance (RMANOVA) with repeated measures for tool (tnv, Ethereal) and task type (Comparison, Identification)
- To ensure that counterbalancing the tool order usage had no effect on performance, order was treated as a between subject variable
- The between subject variable of tool order was not significant in any of the tests

Accuracy

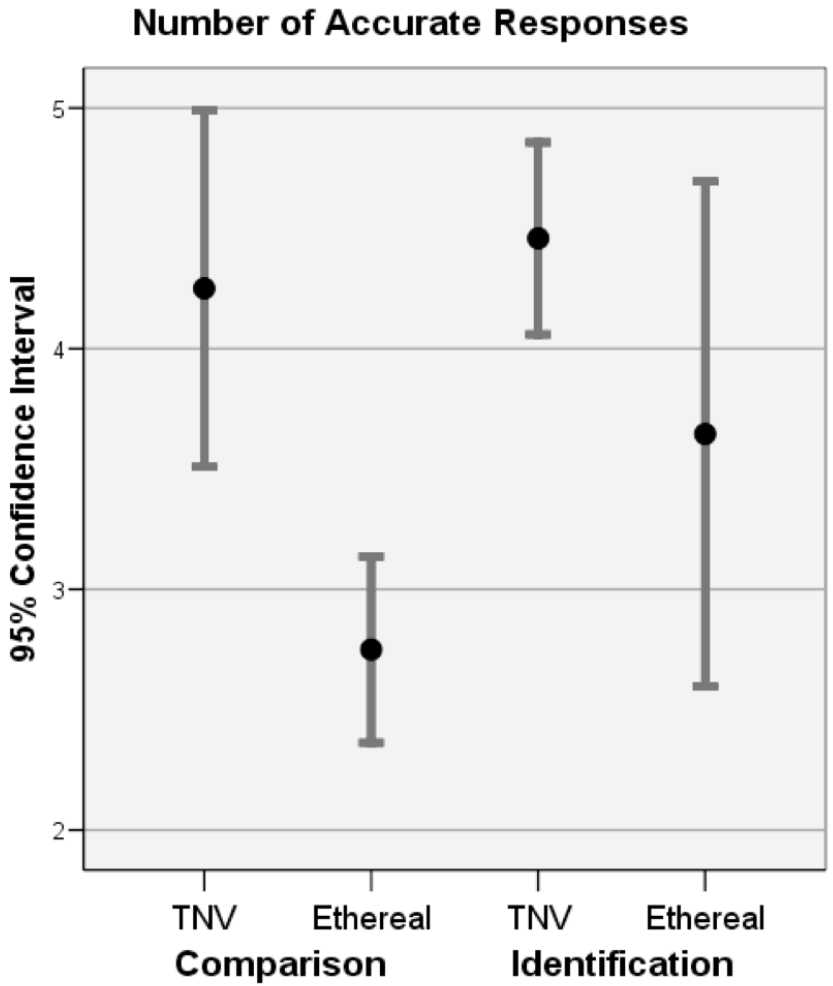


Mean and 95% confidence interval of accurate responses by tool. (maximum = 10)

Interaction effect of tool:
$F(1,6) = 14.72$, $p = 0.009$

Participants had significantly fewer errors using tnv than using Ethereal

Accuracy



Mean and 95% confidence interval of accurate responses by tool and task type. (max. = 5)

Interaction effect between tool and task type:
$F(1,6) = 2.139$, $p = 0.194$

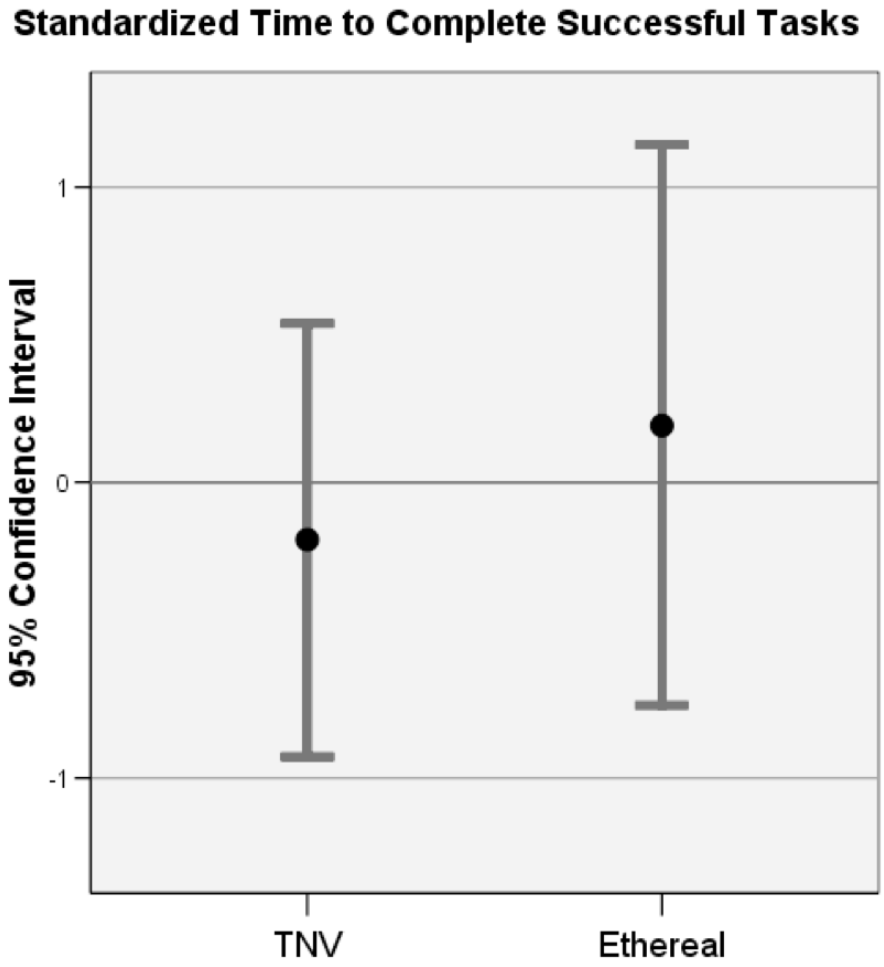
But, looking at comparison tasks for each tool, there is an effect
$t = 5.612$, $p = 0.001$

Time

- Time to completion for *successful* tasks
  - Not partially successful tasks or timed out tasks
  - Incorrect responses could have been guesses
- Standardized time
  - Tasks were of varying levels of difficulty
  - Average time for each task varied greatly
  - Negative number means faster than average

StandardizedTime = (ParticipantTime – TaskMeanTime) / TaskStandardDeviation

Time

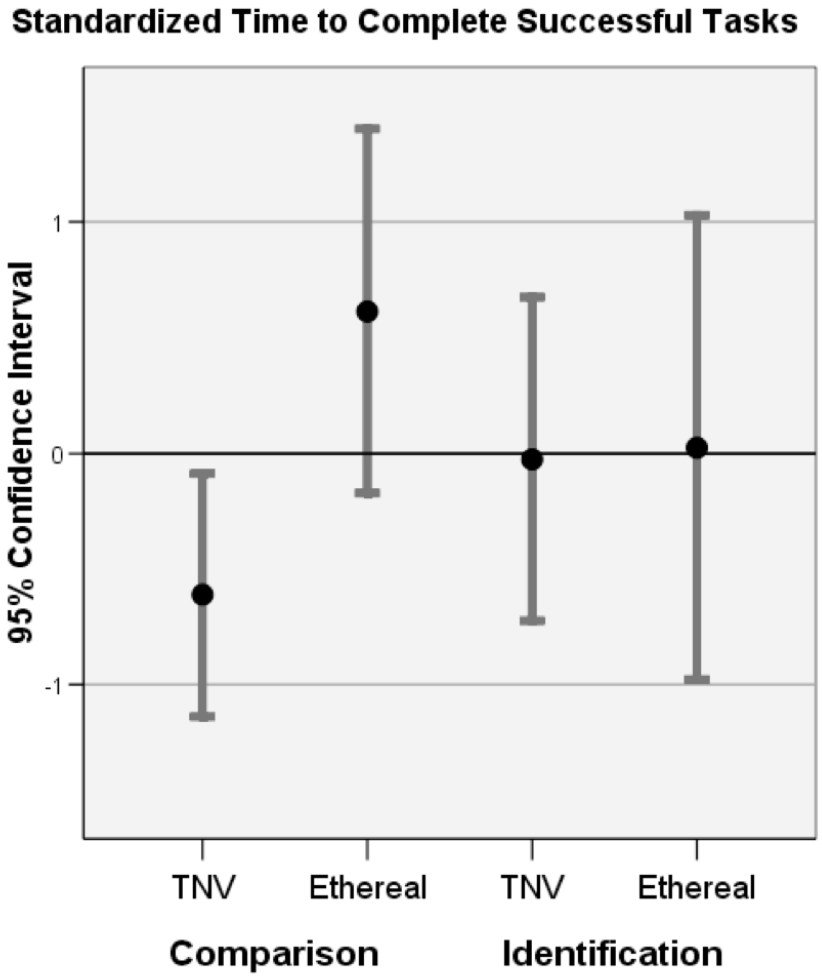


Mean and 95% confidence interval of standardized time to successful tasks by tool

Interaction effect of tool:
$F(1,6) = 5.581$, $p = 0.056$

Trend suggests faster performance, but not significant

Time



Mean and 95% confidence interval of standardized time to successful tasks by tool and task type

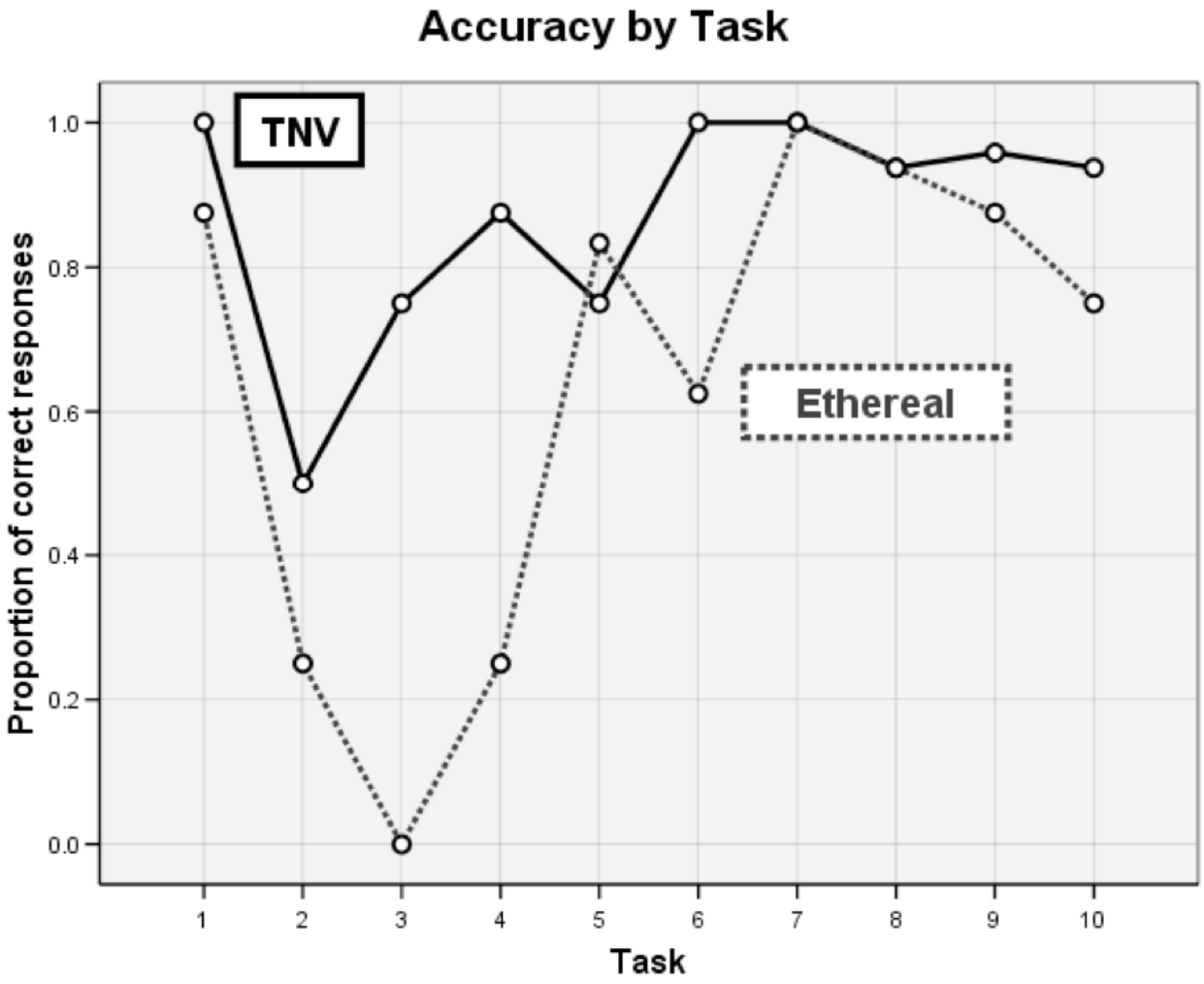
Interaction effect between tool and task type
$F(1,6) = 2.558$, $p = 0.161$

But, looking at comparison tasks for each tool, there is an effect
$t = -4.615$, $p = 0.002$

Discussion: Task Type

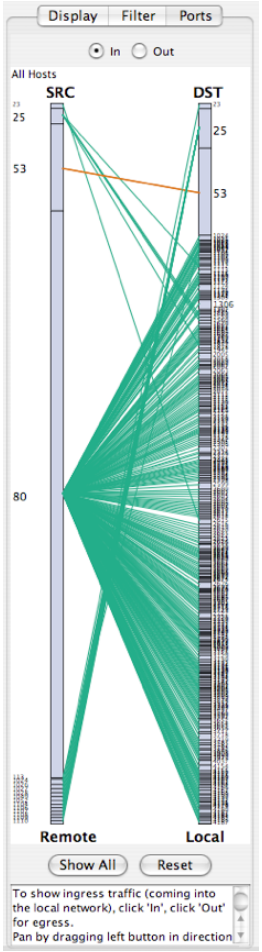
- Larger difference in comparison tasks
  - Ethereal: Statistics were underused; comparisons were done by sorting and mental addition
  - tnv: Comparisons could be seen at a glance
- Less of a difference in identification tasks
  - Ethereal: Search on small data sets removed all but the relevant information
  - tnv: Search highlighted relevant information, but kept all data on the screen, so participants didn't always see where it was

Discussion: Tasks



Port Related Tasks

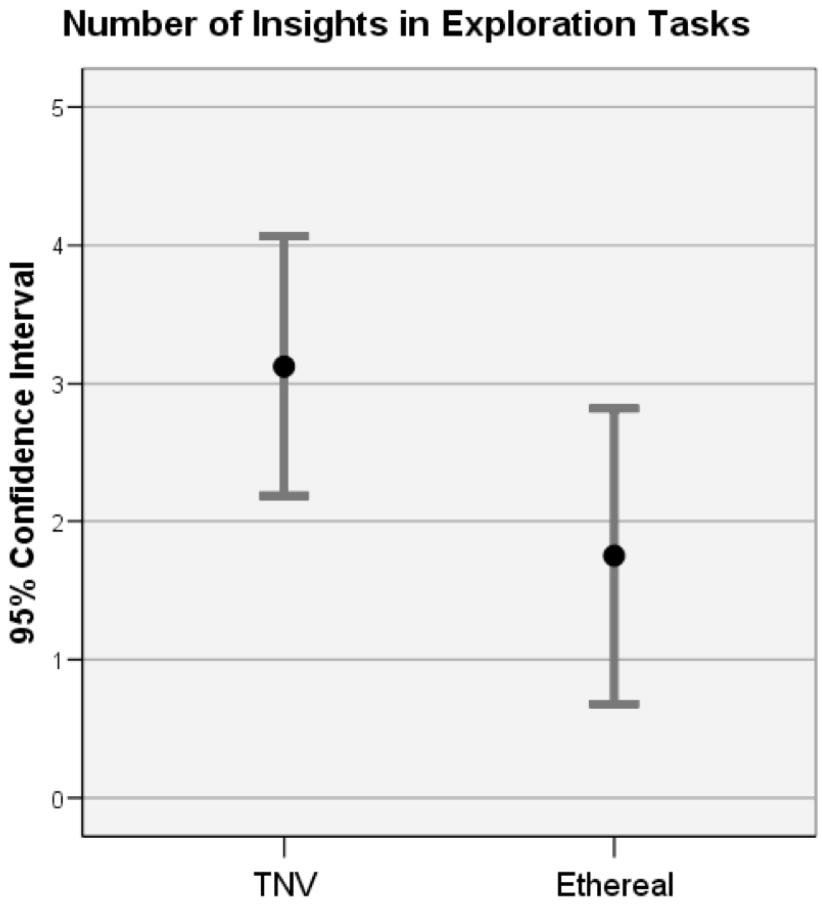
- Tasks 2, 3: compare port activity
- tnv port visualization is hidden by default
- Participants couldn't answer by looking at main display
- Participants learned in task 2, so task 3 was much faster (81 s -> 22 s)



Exploratory Tasks

- Measured number of ‘insights’ that were not mentioned in timed tasks and not incorrect
- Results: participants often started out talking about the **tools**, not the **data**
- Several simply gave up (especially for Ethereal)

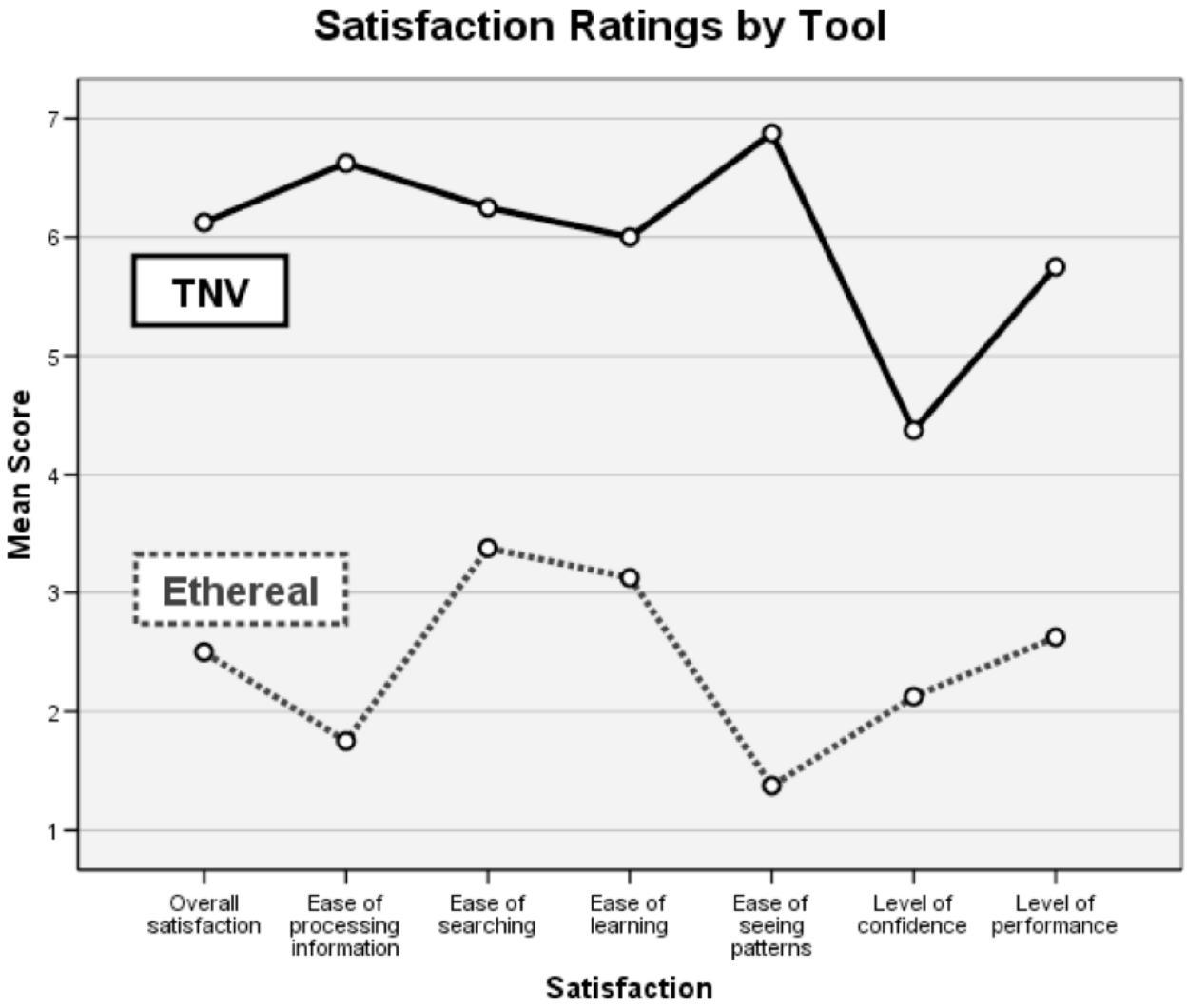
Results: Exploration



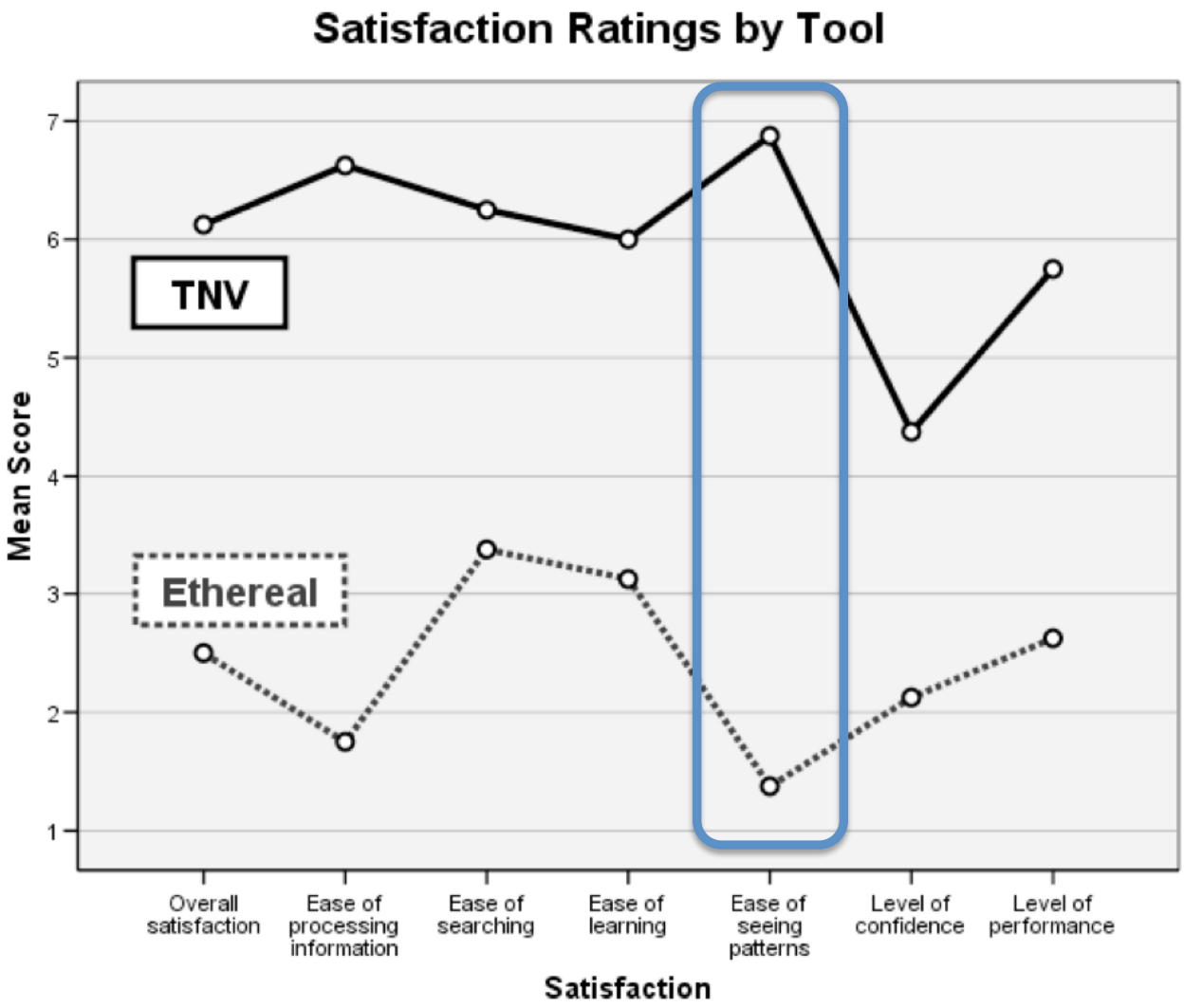
Mean and 95% confidence interval of the number of insights discovered

- tnv: higher-level
  - Gap in activity
- Ethereal: packet-level details
  - Unencrypted passwords

User Perceptions



Ease of Seeing Patterns



Lessons

- Domain experts are difficult to recruit
  - Include them in the design process
- Training can take a lot of test time
  - Self-directed training matches how analysts learn
- Data sets are problematic and unlabeled
  - http://vizsec.org/datasets/
- 'Realistic' tasks that can be answered quickly with both tools are hard to define
  - ???

Questions?

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