

# Eye Tracking as Implicit Feedback for Improving Search Results An Initial Study

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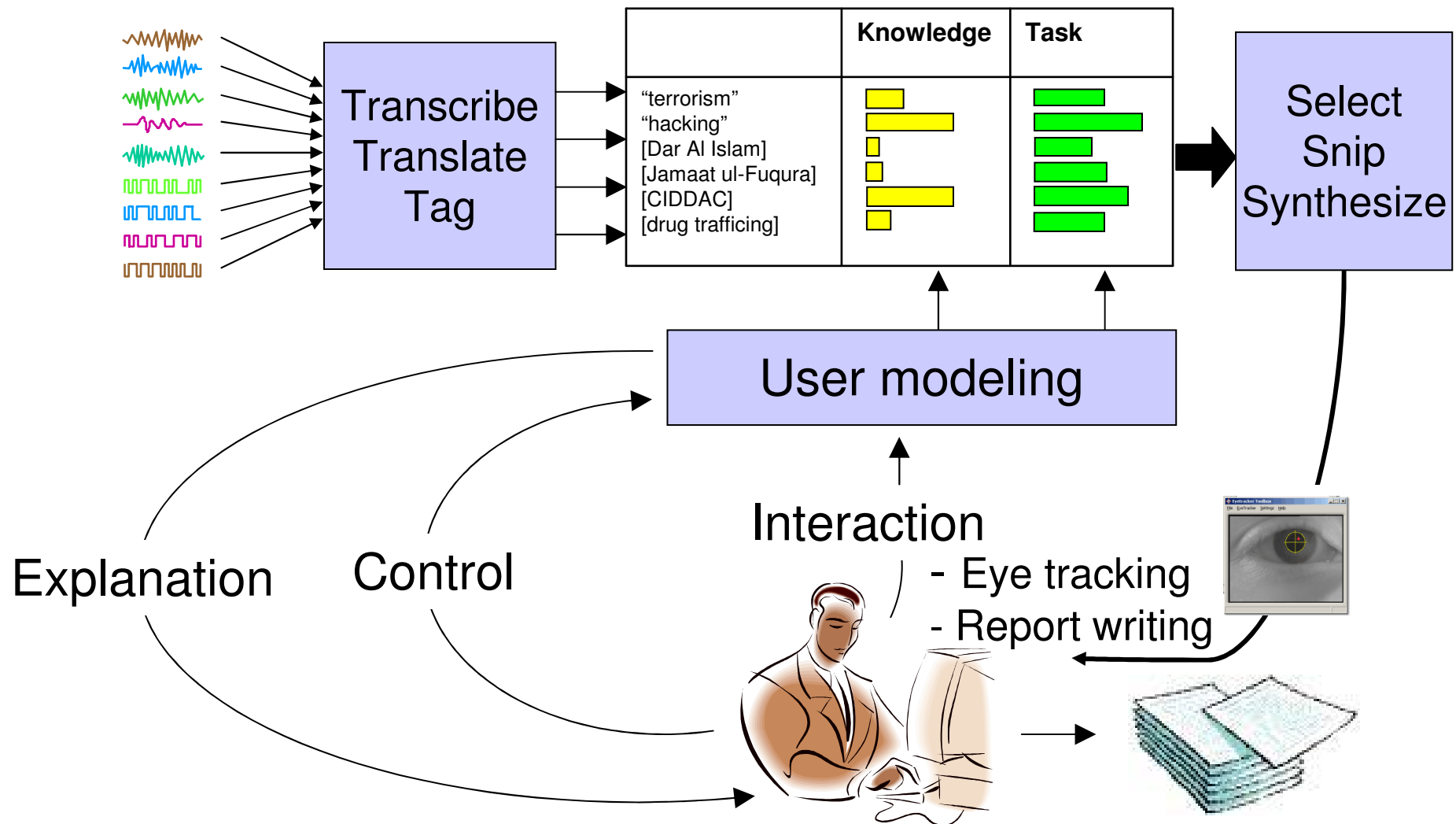
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# Adaptive User Modeling for GALE



# Research Question

- What observable behaviors indicate interest?
- Recent work on eye tracking:
  - *Inferring Relevance from Eye Movements Challenge 2005* (Salojärvi et al.)
  - *Eye-tracking on WWW search* (Granka et al. 2004)
  - *Machine learning to infer interest from eye-movement* (Puolamäki et al. 2005)

# Quantifying Interest

- Eye movement indicates **visual** interest
- Visual interest = cognitive interest<sup>?</sup>  
Reasonable for complex tasks (Rayner, K. 1998)
- Topical relevance as surrogate for interest

# Congressional Research Service, “Terrorist Capabilities for Cyberattack: Overview and Policy Issues” (18-screens)

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## Links Between Terrorism and Cybercrime

Linkages between criminal and terror groups may allow terror networks to expand and undertake large attacks internationally by leveraging criminal sources, money, and transit routes. For example, observers speculate that Aftab Ansari, a criminal suspect located in Dubai, used ransom money earned from prior kidnappings to assist with funding for the September 11, 2001 terrorist attacks. Also, London police officials believe that terrorists obtained the high-quality explosives used for the 2005 bombings on an Eastern European black market. The recent subway and bus bombings in the U.K. also indicate that terrorists may be active within other countries that have large computerized infrastructures, along with a large, highly skilled information technology workforce. A report by the Department of Homeland Security (DHS) predicts that other possible sponsors of terrorist attacks against the United States homeland may include groups such as Jamaatul-Fuqura, a Pakistani-based organization allegedly linked to Muslims of America; Jamaat al Tabligh, an Islamic missionary organization; and, the American Dar Al Islam Movement.

The proportion of cybercrime that can be directly, or indirectly attributed to terrorists is difficult to determine. For example, organized criminals use information technology for the movement of money internationally. Where criminals and terrorists work together, members of terrorist groups may be given special training in computer software, or in engineering, to facilitate communications through the Internet. In-house financial specialists and experienced advisors may also knowingly, or sometimes unknowingly, help cybercriminals evade the scrutiny of bank regulators and international investigators. These reportedly may include, accountants, bank employees in offshore zones and in major financial centers who may or may not also be terrorists or supportive of the political motives of their clients.

Officials of the U.S. Drug Enforcement Agency (DEA), reported in 2003 that 14 of the 36 groups found on the U.S. State Department’s list of foreign terrorist organizations were involved in drug trafficking. Consequently, DEA officials reportedly argued that the war on drugs and the war on terrorism are and should be linked. A 2002 report by the Library of Congress Federal Research Division, revealed a “growing involvement of Islamic terrorist and extremists groups in drug trafficking”, and limited evidence of cooperation between different terrorist groups involving both drug trafficking and trafficking in arms. State Department officials, at a Senate hearing in March 2002, also indicated that some terrorist groups may be using drug trafficking as a way to gain financing while simultaneously weakening their enemies in the West through exploiting their desire for addictive drugs. Western Europe and North America continue to be regions that have major narcotics markets, optimal infrastructure, and open commercial nodes that increasingly serve the transnational trafficking needs of both criminal and terrorist groups.

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Question:

*“What are some of the complications in linking cybercrime with terrorism?”*  
(characters. )

10 minute allotted time

Independent assessors for ground truth

# Example (ISCAN ETL-500, Dell 1280x1024 19" LCD)

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Question:











What are some of the complications in linking cybercrime with terrorism?











( You may enter up to 1000 characters. )

# Independent Variables

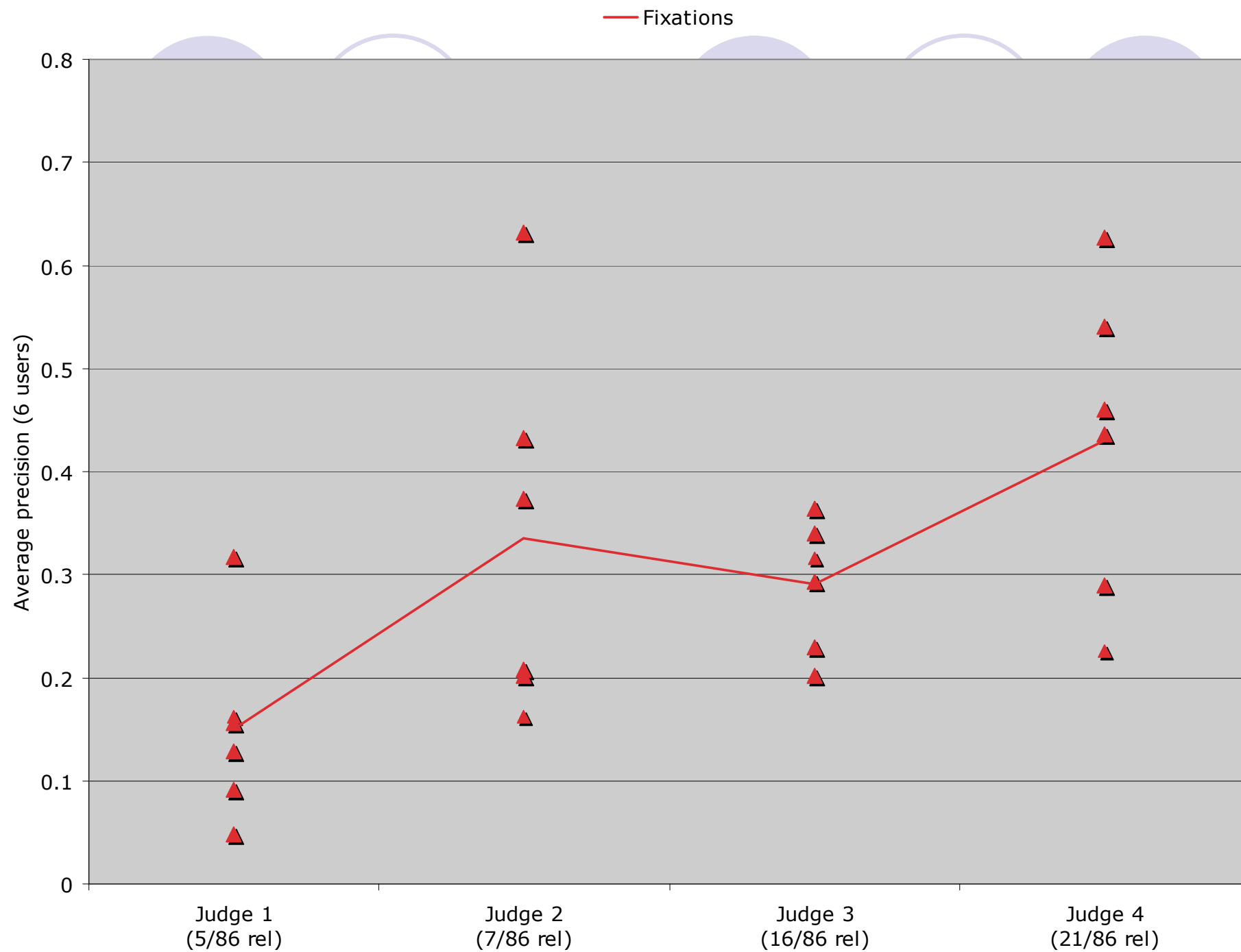
- Rank paragraphs based on eye tracking features
  - Number of fixations
  - Position-normalized number of fixations
  - Number of inter-section regressions
  - Amount of note-taking (regress from question/answer)
  - Fixation duration
  - Pupil size
- Rank based on term overlap with typed answer
  - Lucene (<http://lucene.apache.org>)

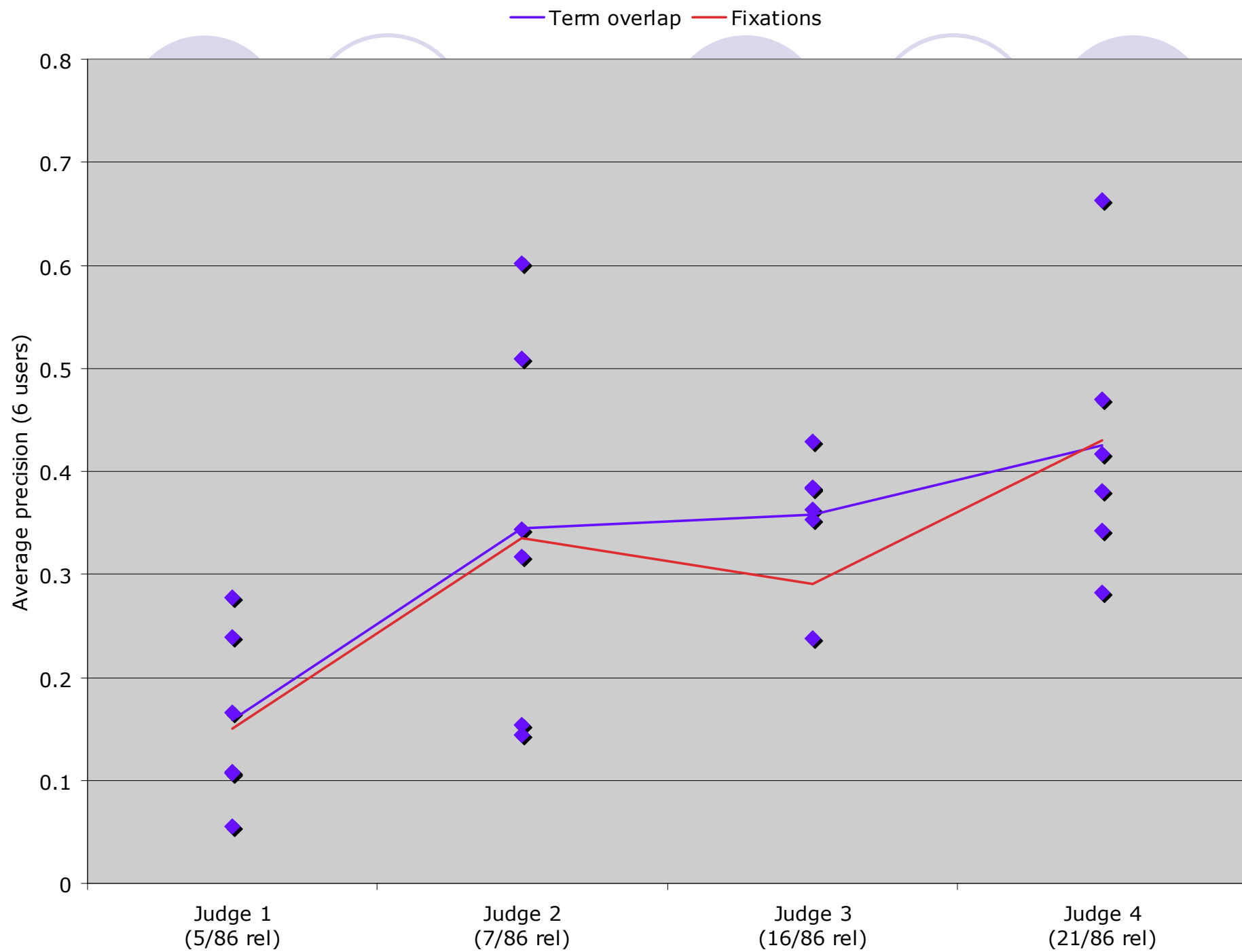
# Dependent Variable: Ranking Quality

User A			Judge 1	
Rank	ParaID	Score		Precision
1	5		✓	1.00
2	3		✓	1.00
3	2			
4	10			
5	7		✓	0.60
6	4			
7	6		✓	0.57
8	8			
9	9			
10	1		✓	0.50
Average Precision:				0.73































User A			Judge 2	
Rank	ParaID	Score		Precision
1	5		✓	1.00
2	3			
3	2			
4	10			
5	7		✓	0.40
6	4			
7	6		✓	0.43
8	8			
9	9			
10	1		✓	0.40
Average Precision:				0.55












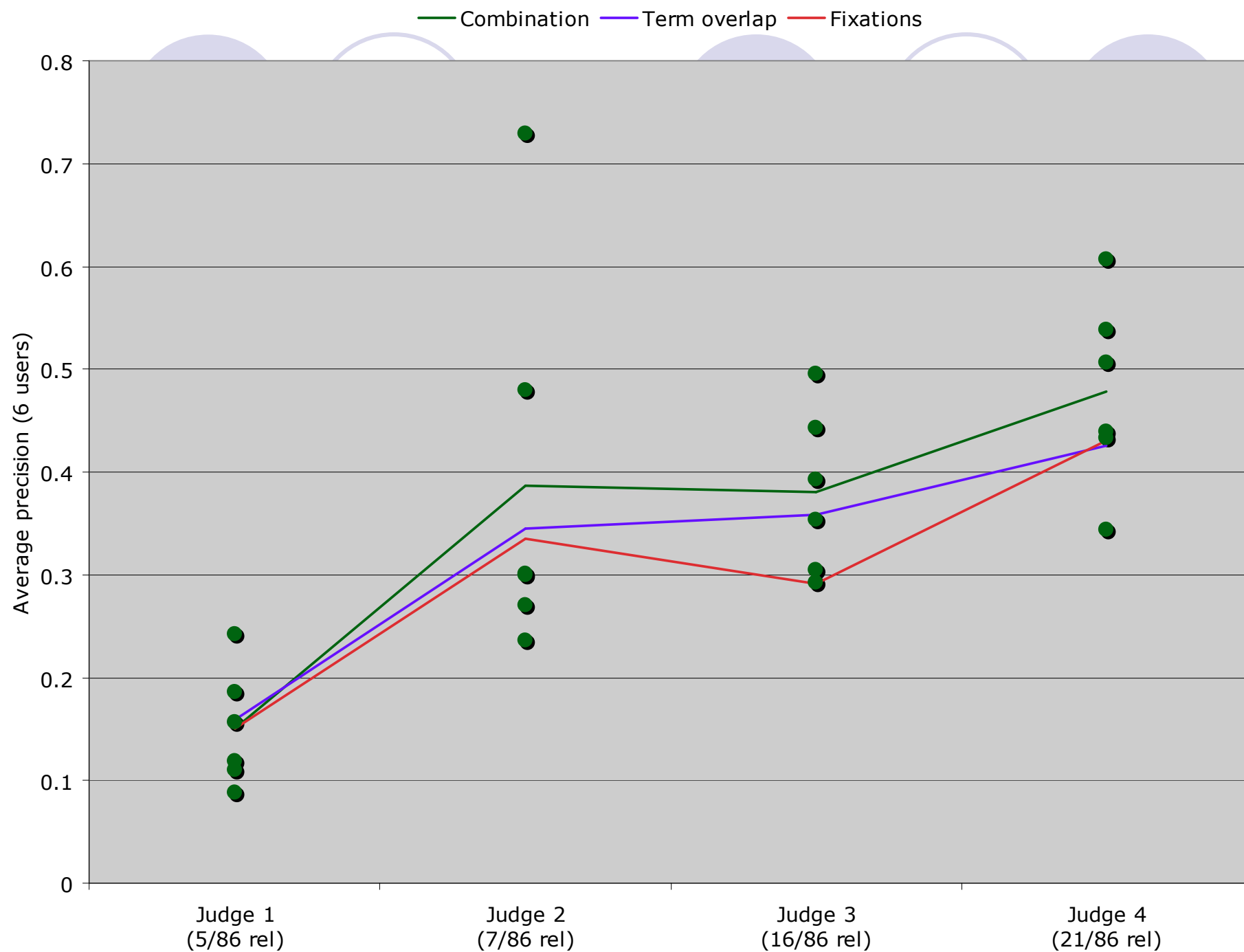




# Combination of Evidence

<u>ParaID</u>	<u>Fixations</u>	<u>Term Overlap</u>	<u>Max Score</u>
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

<u>Rank</u>	<u>ParaID</u>	<u>Max Score</u>
1	6	
2	8	
3	2	
4	3	
5	5	
6	1	
7	4	
8	10	
9	9	
10	7	





# Conclusions

- Fixations are useful indicators of interest
  - Additional measures could improve evidence combination
- Term overlap yields complementary evidence
  - Noticeable improvement for half the assessors
- Next: more documents, more question types
  - The results of this study are suggestive, not conclusive

# Future work

- Standoff eye tracking
  - Fatigue, discomfort from head-mounted eye-tracker
  - Consistent calibration is challenging/time-consuming
  - Tobii desk-mounted eye-tracker should improve this
- Additional independent variables
  - Reading speed
  - Document style
  - *A priori* interest/knowledge



A series of five circles in a horizontal row. The first circle is solid light purple and contains the text 'Questions?'. The second circle is an outline of a light purple circle. The third circle is solid light purple. The fourth circle is an outline of a light purple circle. The fifth circle is solid light purple.

# Questions?

- Thanks to our sponsors!
  - DARPA GALE (award HR0011-06-2-0001)
  - NSF (award IIS-0414699)
  - IBM T.J. Watson Research Center (GALE)