Speech Transcription with Crowdsourcing

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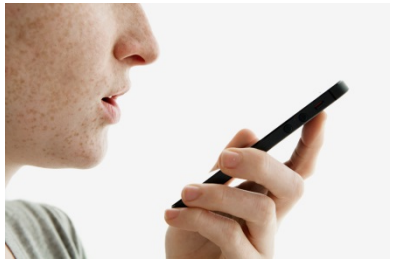
11/20/13

Why I'm here

1. Get more data, not better data
2. Use other Turkers to do QC for you
3. Non-English crowdsourcing is not easy

Siri in Five Minutes



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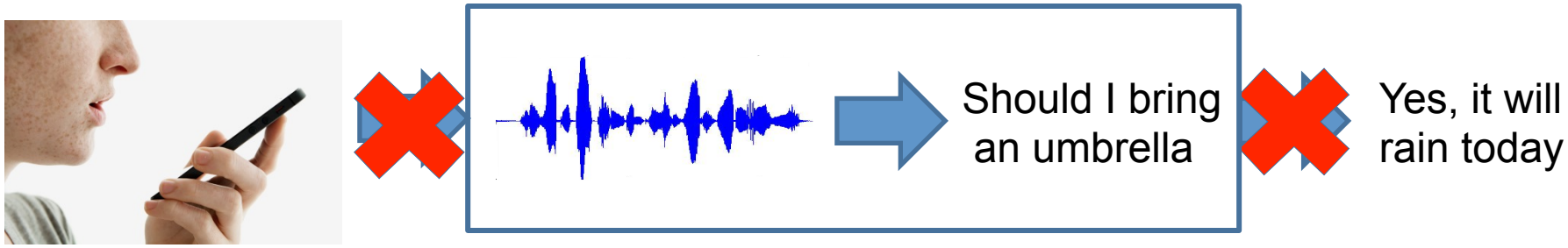

Automatic Speech Recognition

Digit Recognition

Digit Recognition

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P(one| ) =

Digit Recognition

$$P(\text{one}|\ ) = \frac{P(\ |\text{one})\ P(\text{one})}{P(\ )}$$

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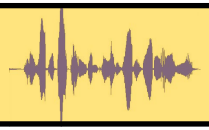
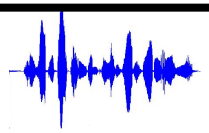
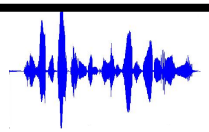
P(one| ) = P( |one) P(one)

Acoustic Model **Language Model**

Digit Recognition

$$P(\text{one}|\ \text{  }\ ) = \frac{P(\ \text{  }\ |\text{one})\ P(\text{one})}{P(\ \text{  }\ )}$$

$$P(\text{two}|\ \text{  }\ ) = \frac{P(\ \text{  }\ |\text{two})\ P(\text{two})}{P(\ \text{  }\ )}$$

Digit Recognition

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$$P(\text{zero}|\ ) = \frac{P(\ |\text{zero})\ P(\text{zero})}{P(\ )}$$

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Evaluating Performance

Reference THIS IS AN EXAMPLE SENTENCE

Evaluating Performance

Reference	THIS	IS	AN	EXAMPLE	SENTENCE	
Hypothesis	THIS	IS		EXAMPLE	CENT	TENSE

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$$WER = \frac{\#sub + \#ins + \#del}{\#ref} = \frac{1+1+1}{5} = 60\%$$

Evaluating Performance

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Hypothesis	THIS	IS		EXAMPLE	CENT	TENSE
Score			*Del.*		*Subs.*	*Insert.*

$$WER = \frac{\#sub + \#ins + \#del}{\#ref} = \frac{1+1+1}{5} = 60\%$$

- **Some Examples (lower is better)**
  - Youtube: ~50%
  - Automatic closed captions for news: ~12%
  - Siri/Google voice: ~5%

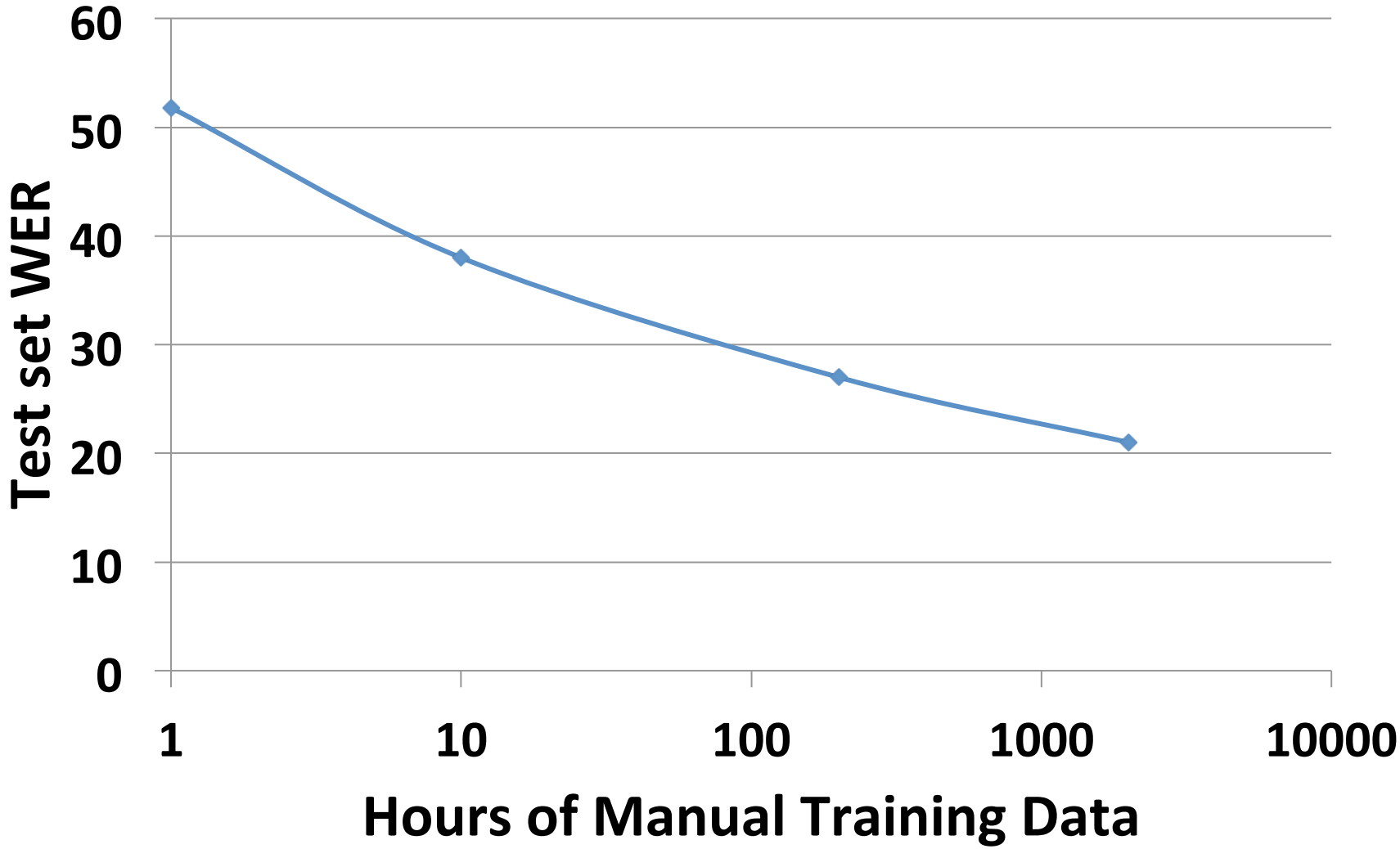
Probabilistic Modeling

$$\arg\max_{\mathbf{W}} \; P(\text{audio}\,|\mathbf{W})\; P(\mathbf{W})$$

Acoustic Model **Language Model**

- **Both models are <u>statistical</u>**
  - I'm going to completely skip over how they work
- **Need training data**
  - Audio of people saying "one three zero four"
  - Matching transcript "one three zero four"

Why do we need data?



Motivation

- **Speech recognition models hunger for data**
  - ASR requires thousands of hours of transcribed audio
  - In-domain data needed to overcome mismatches like language, speaking style, acoustic channel, noise, etc…
- **Conversational telephone speech transcription is difficult**
  - Spontaneous speech between intimates
  - Rapid speech, phonetic reductions and varied speaking style
  - Expensive and time consuming
    - $150 / hour of transcription
    - 50 hours of effort / hour of transcription
- **Deploying to new domains is slow and expensive**

Evaluating Mechanical Turk

- **Prior work judged quality by comparing Turkers to experts**
  - 10 Turkers match expert for many NLP tasks (*Snow et al 2008*)
- **Other Mechanical Turk speech transcription had low WER**
  - Robot Instructions ~3% WER *(Marge 2010)*
  - Street addresses, travel dialogue ~6% WER *(McGraw 2010)*
- **Right metric depends on the data consumer**
  - Humans: *WER on **transcribed** data*
  - Systems: *WER on **test** data decoded with a trained system*

English Speech Corpus

- **English Switchboard corpus**
  - Ten minute conversations about an assigned topic
  - Two existing transcriptions for a twenty hour subset:
    - LDC – high quality, ~50xRT transcription time
    - Fisher 'QuickTrans' effort – 6xRT transcription time

- **Callfriend language-identification corpora**
  - Korean, Hindi,Tamil, Farsi, and Vietnamese
  - Conversations from U.S. to home country between friends
  - Mixture of English and native language
  - Only Korean has existing LDC transcriptions

Transcription Task

Transcribe English phone conversations

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Thanks so much for your help!

Pay:

OH WELL I GUESS RETIREMENT THAT KIND OF THING WHICH I DON'T WORRY MUCH ABOUT

UH AND WE HAVE A SOCCER TEAM THAT COMES AND GOES WE DON'T EVEN HAVE THAT PRETTY

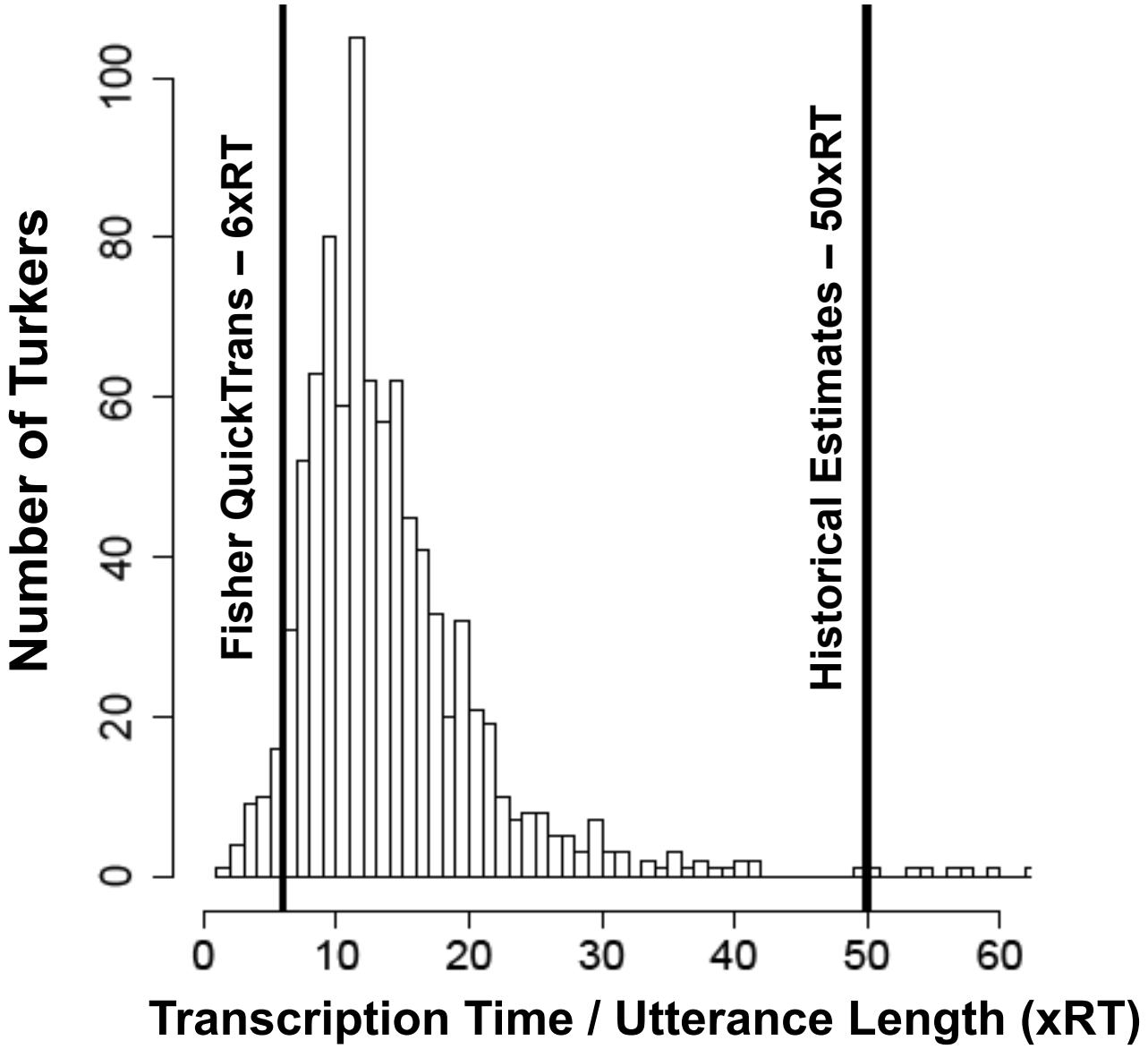
Speech Transcription for $5/hour

- **Paid $300 to transcribe 20 hours of Switchboard three times**
  - $5 per hour of transcription ($0.05 per utterance)
  - 1089 Turkers completed the task in six days
  - 30 utterances transcribed on average (earning 15 cents)
  - 63 Turkers completed more than 100 utterances

- **Some people complained about the cost**
  - *"wow that's a lot of dialogue for $.05"*
  - *"this stuff is really hard. pay per hit should be higher"*

- **Many enjoyed the task and found it interesting**
  - *"Very interesting exercise. would welcome more hits."*
  - *"You don't grow pickles they are cucumbers!!!!"*

Turker Transcription Rate



Dealing with Real World Data

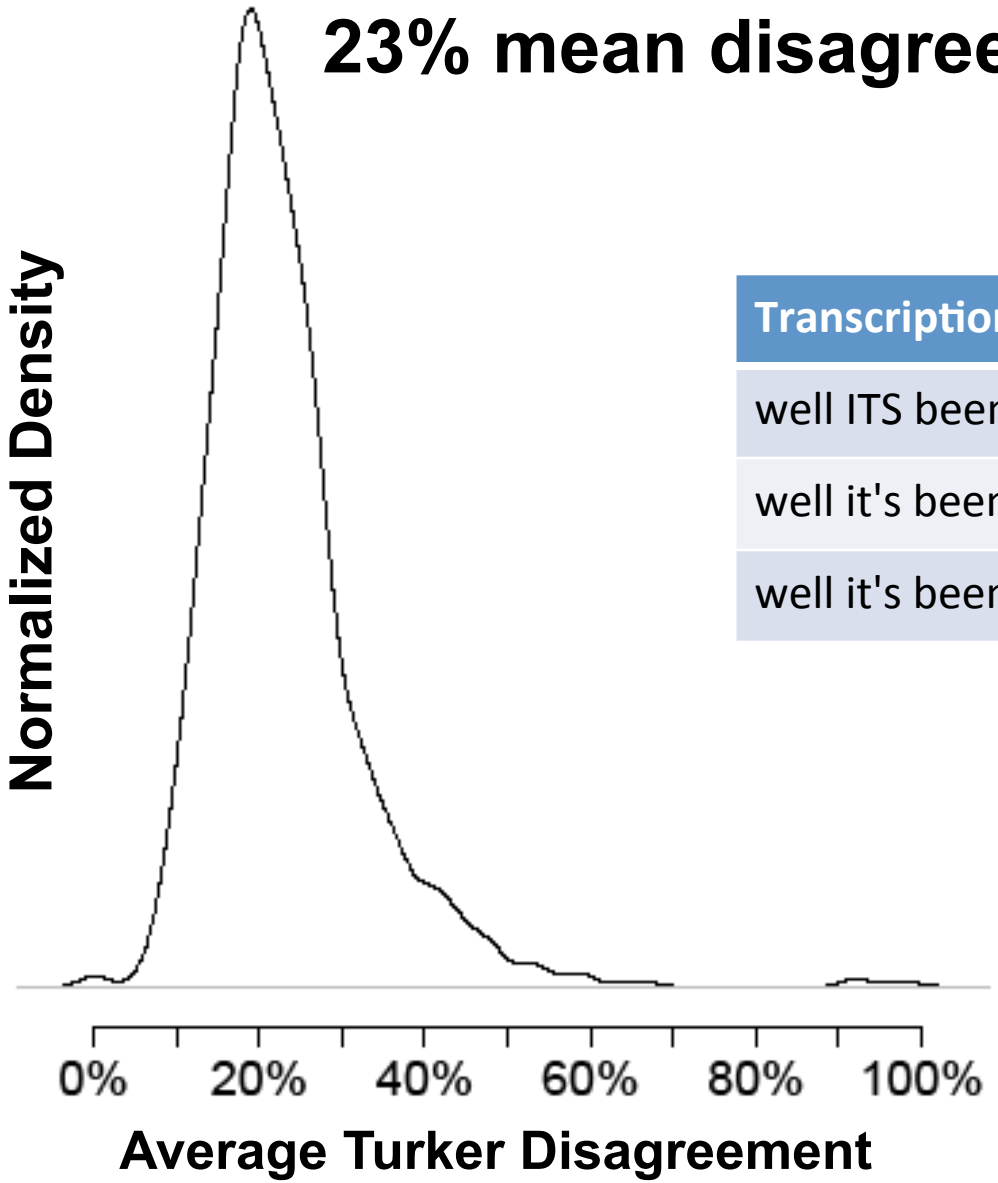
- **Every word in the transcripts needs a pronunciation**
  - Misspellings, new proper name spellings, jeez vs. geez
  - Inconsistent hesitation markings, myriad of ‘uh-huh’ spellings
  - 26% of utterances contained OOVs (10% of the vocabulary)

- **Lots of elbow grease to prepare phonetic dictionary**

- **Turkers found creative ways not to follow instructions**
  - Comments like “hard to hear” or “did the best I could :)”
  - Enter transcriptions into wrong text box
  - But very few typed in gibberish

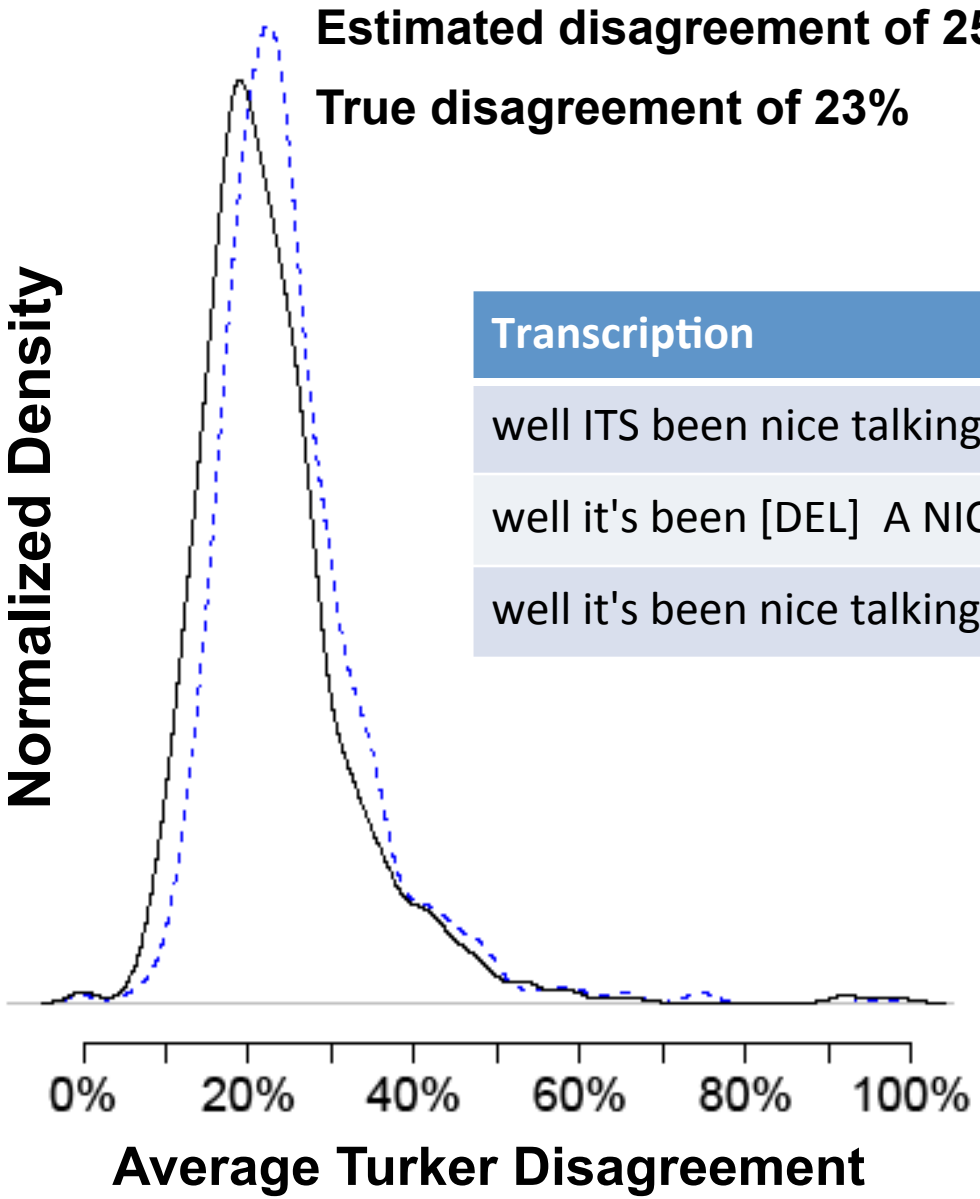
- **We did not explicitly filter comments, etc…**

Disagreement with Experts



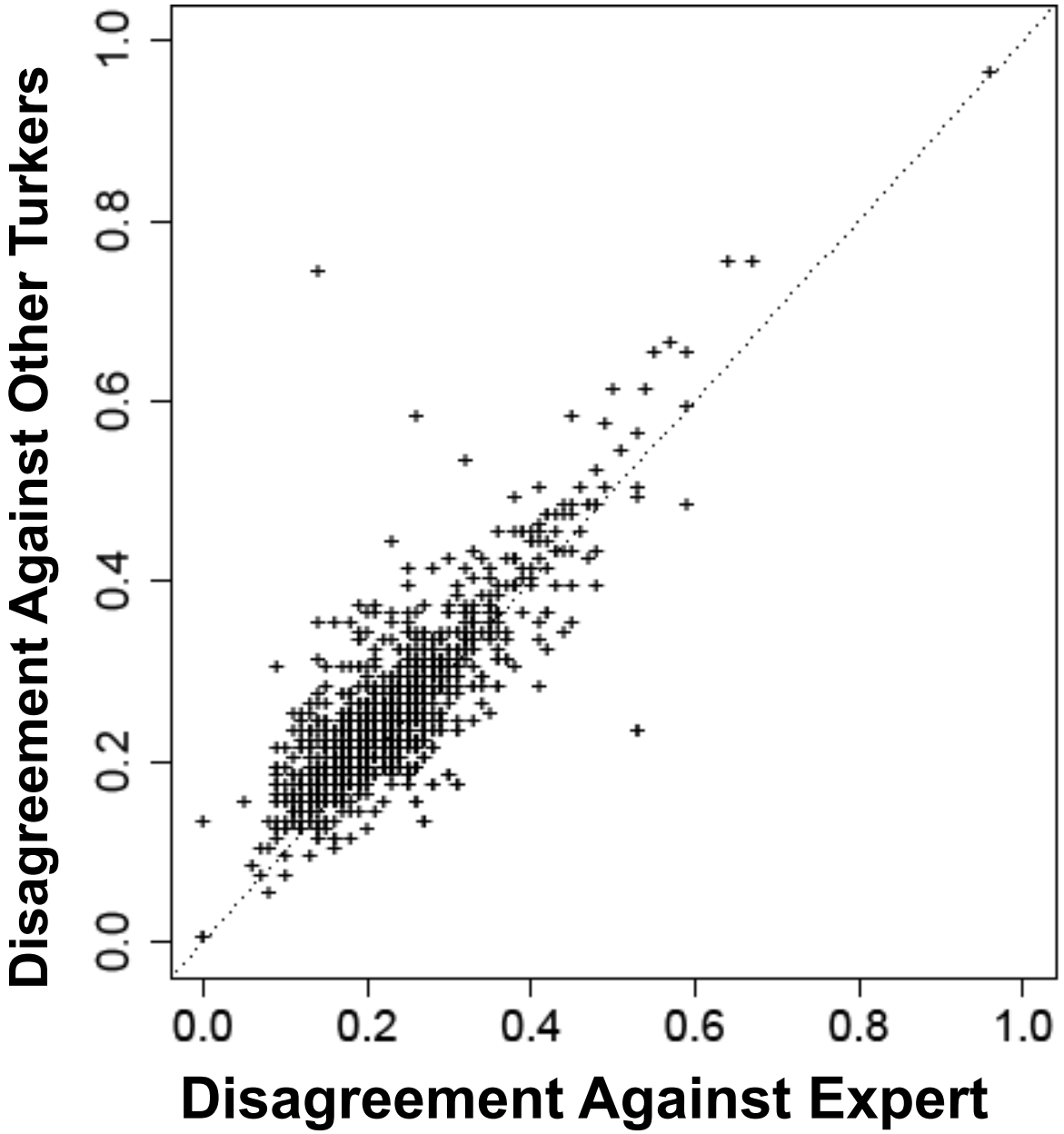
Transcription	WER
well ITS been nice talking to you again	**12%**
well it's been [DEL] A NICE PARTY JENGA	**71%**
well it's been nice talking to you again	**0%**

Estimation of Turker Skill

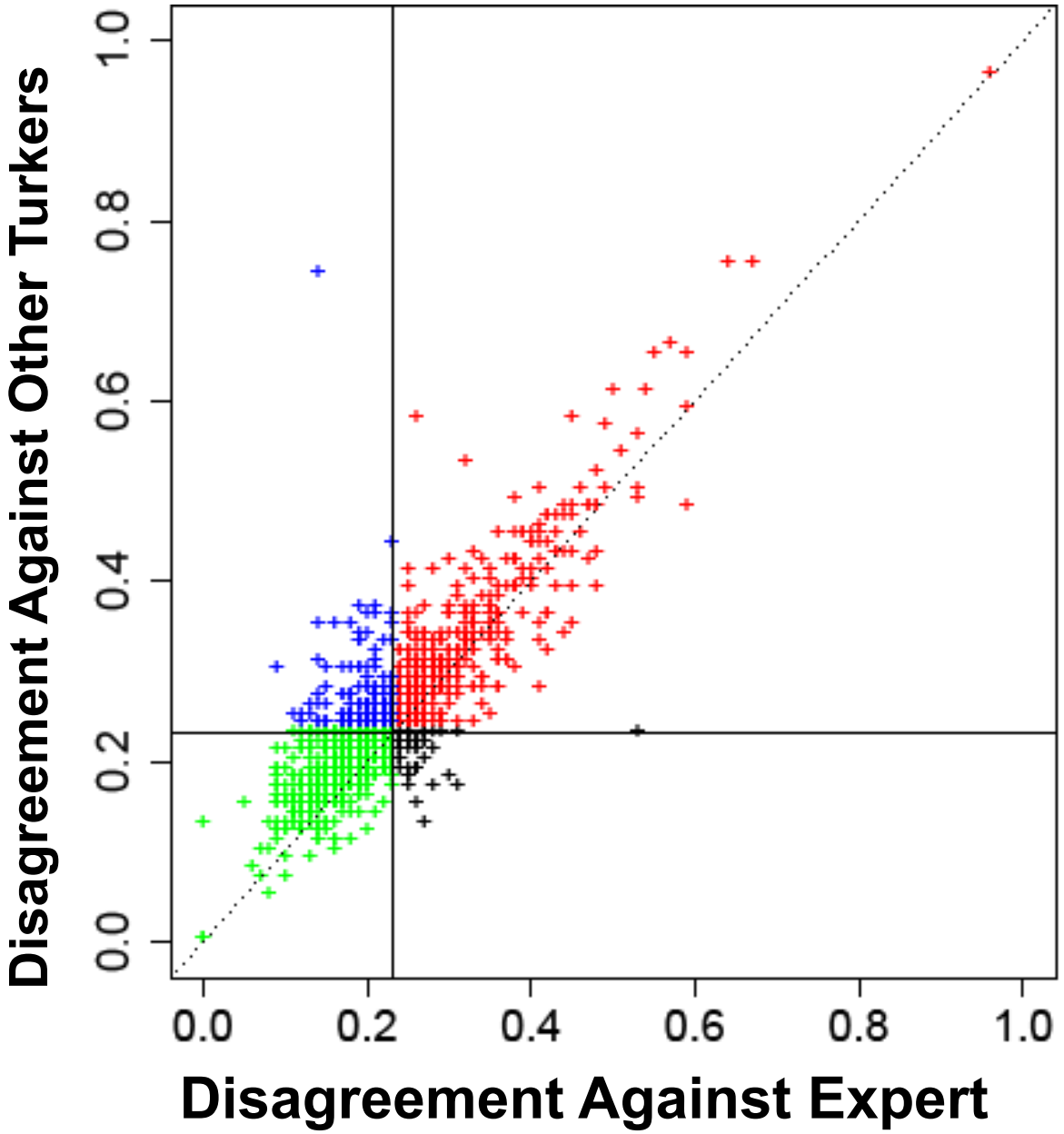


Transcription	WER	Est. WER
well ITS been nice talking to you again	**12%**	**43%**
well it's been [DEL] A NICE PARTY JENGA	**71%**	**78%**
well it's been nice talking to you again	**0%**	**37%**

Rating Turkers: Expert vs. Non-Expert



Selecting Turkers by Estimated Skill



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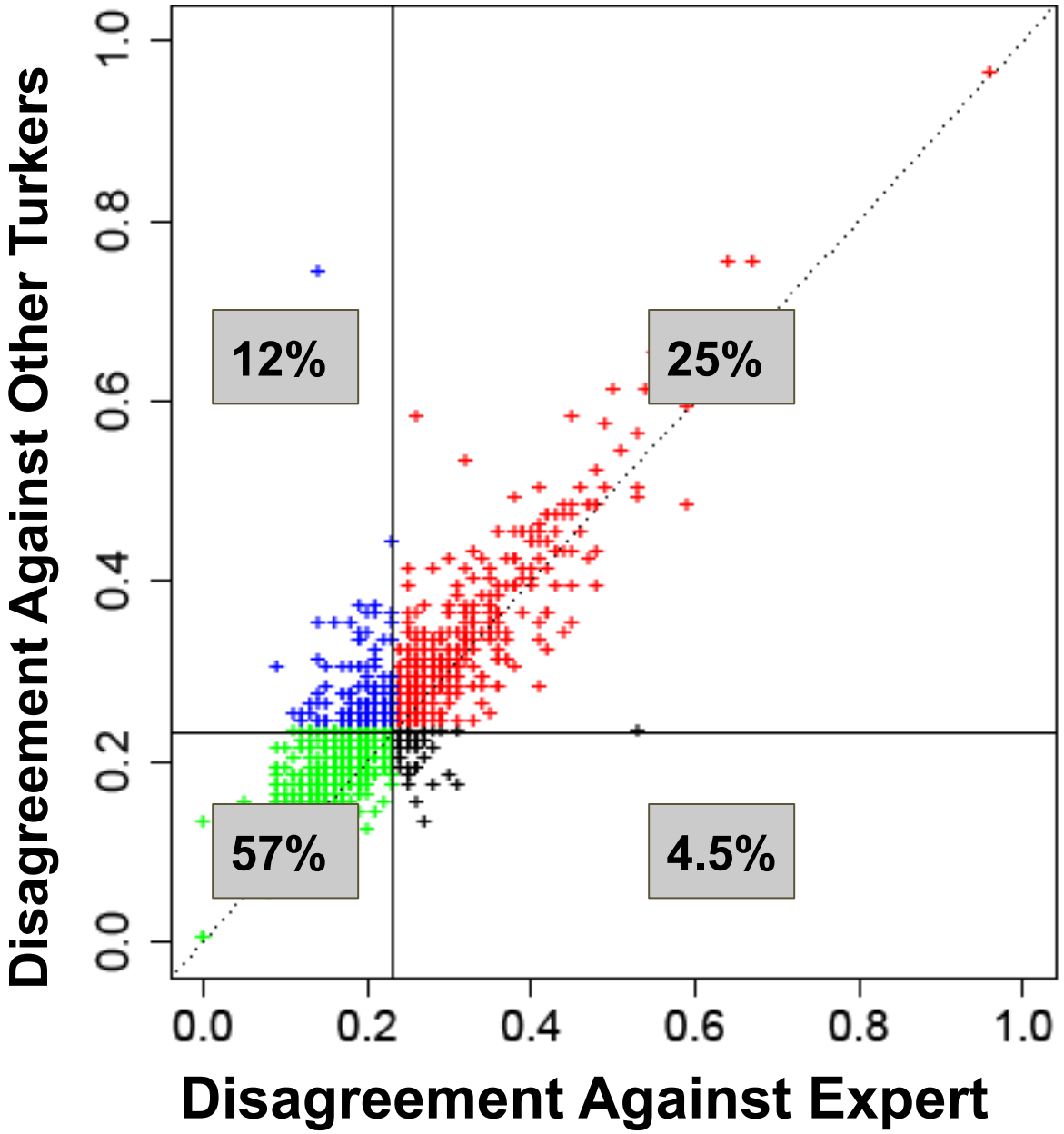

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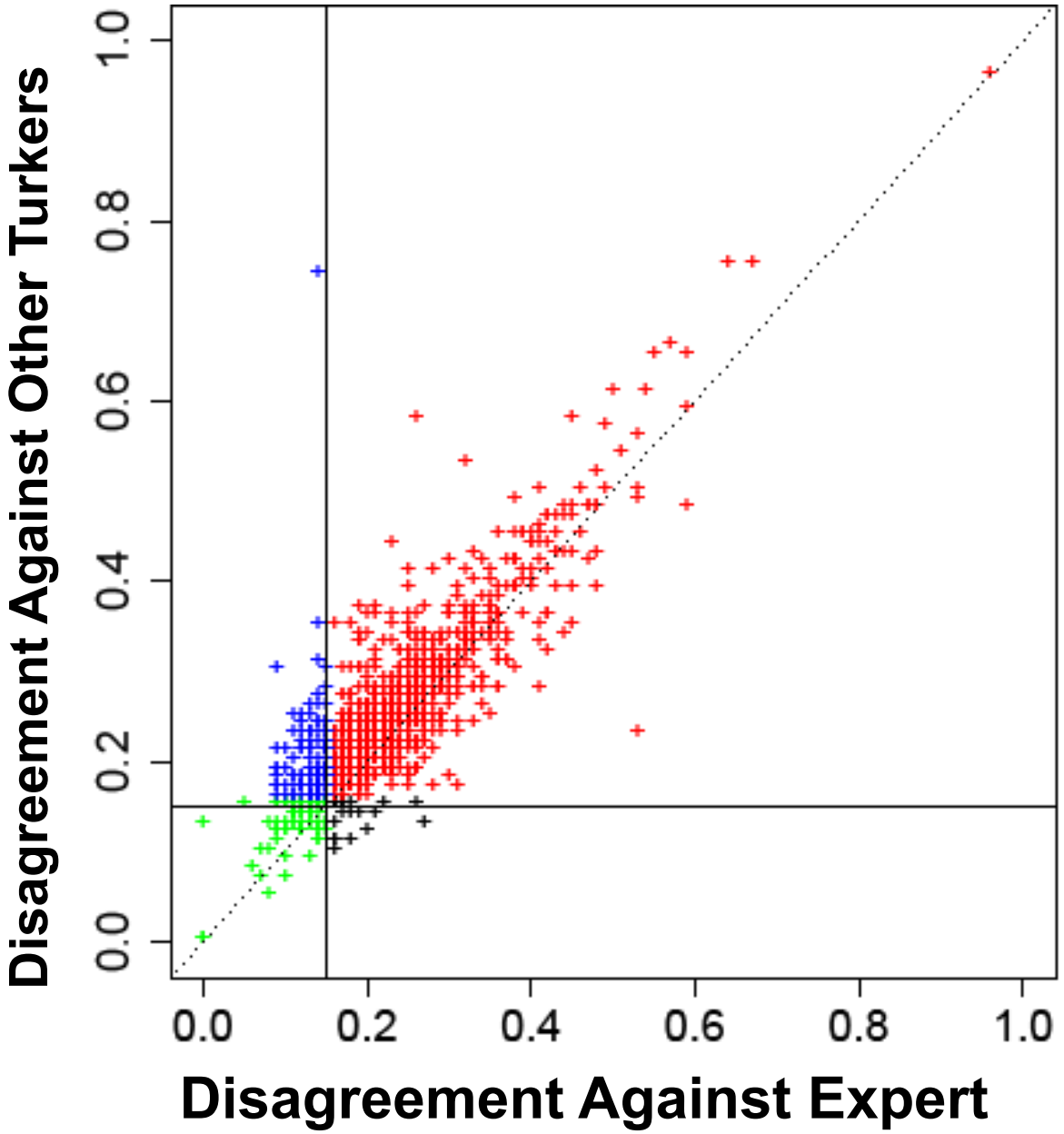

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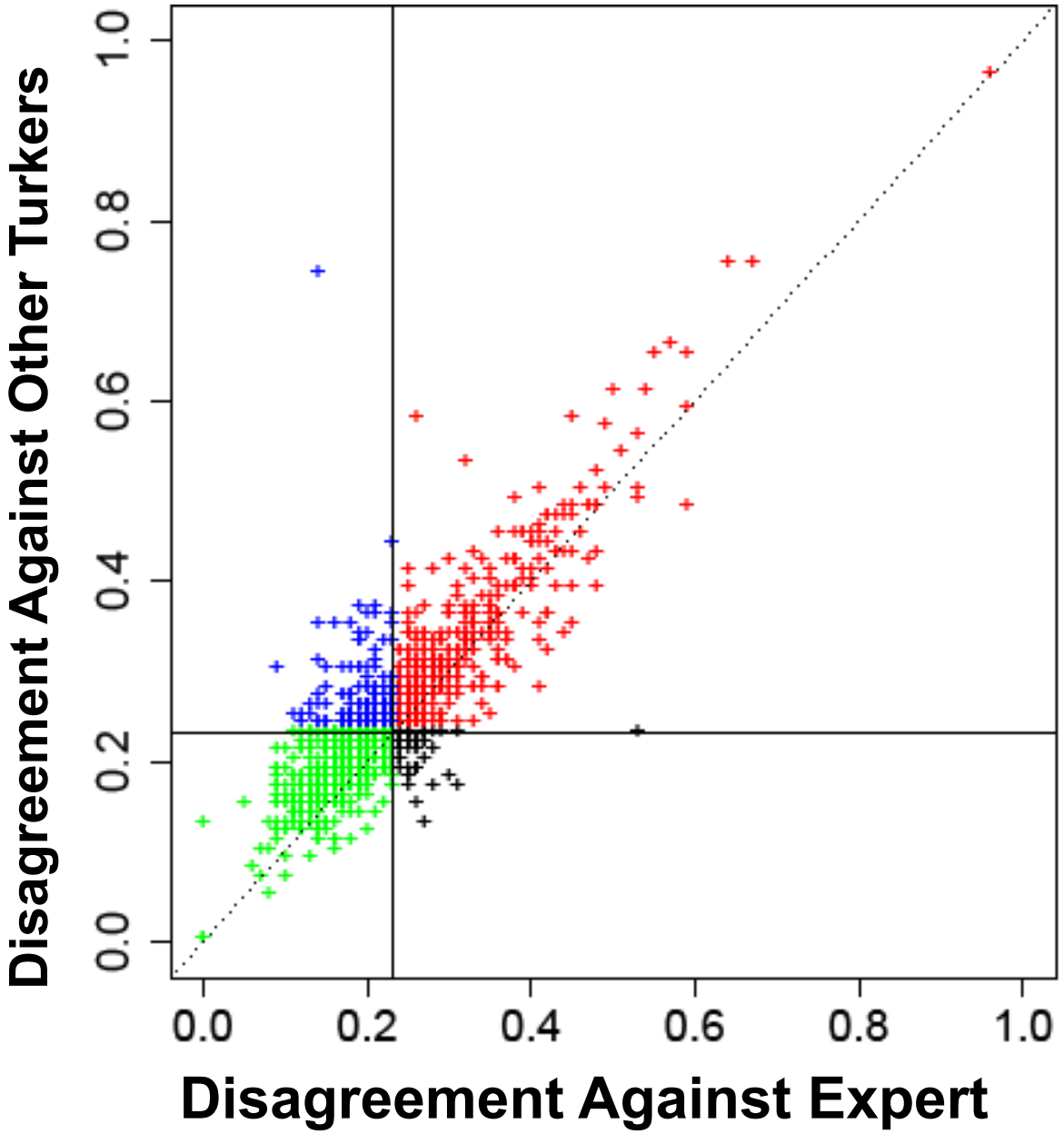

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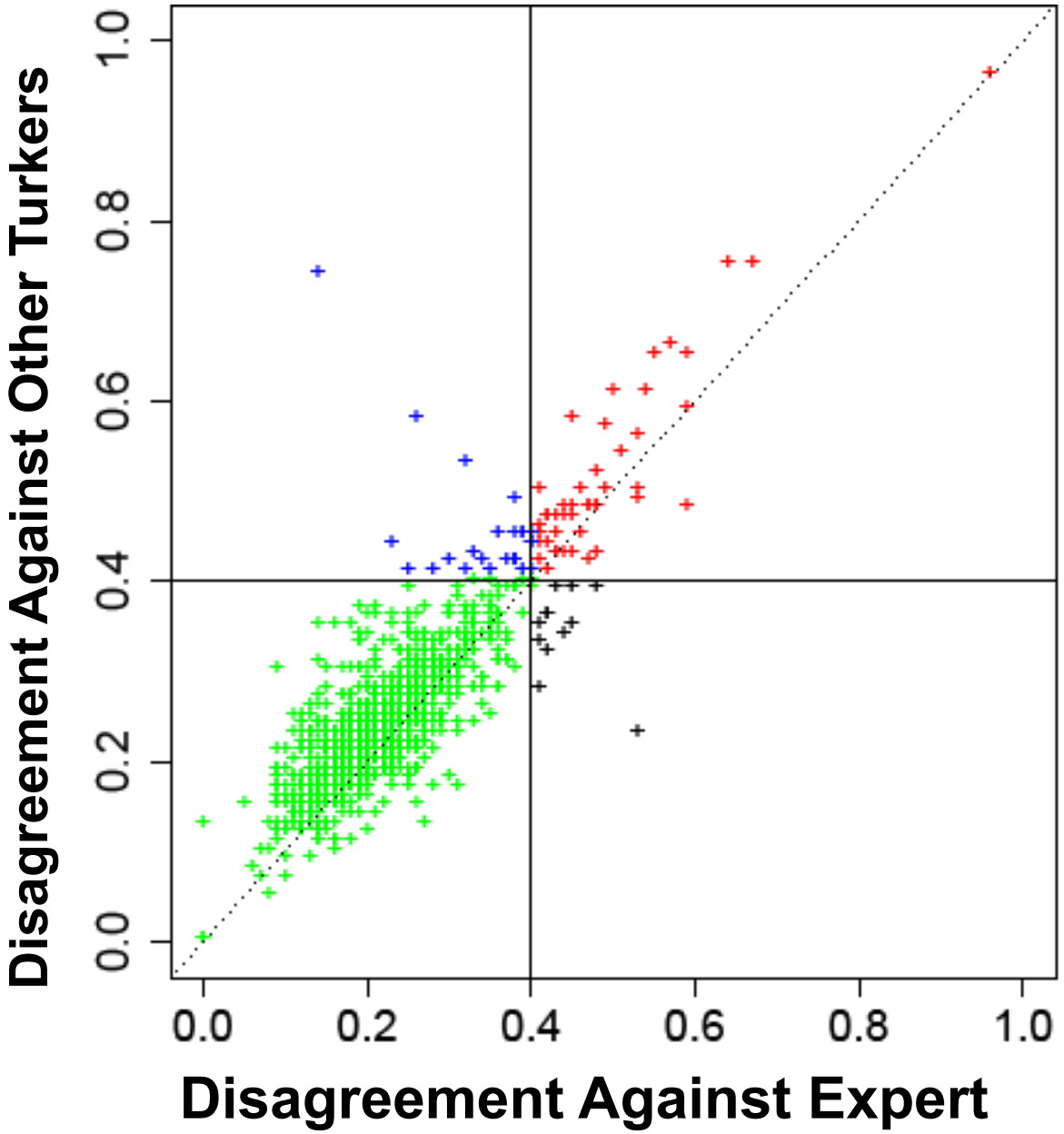
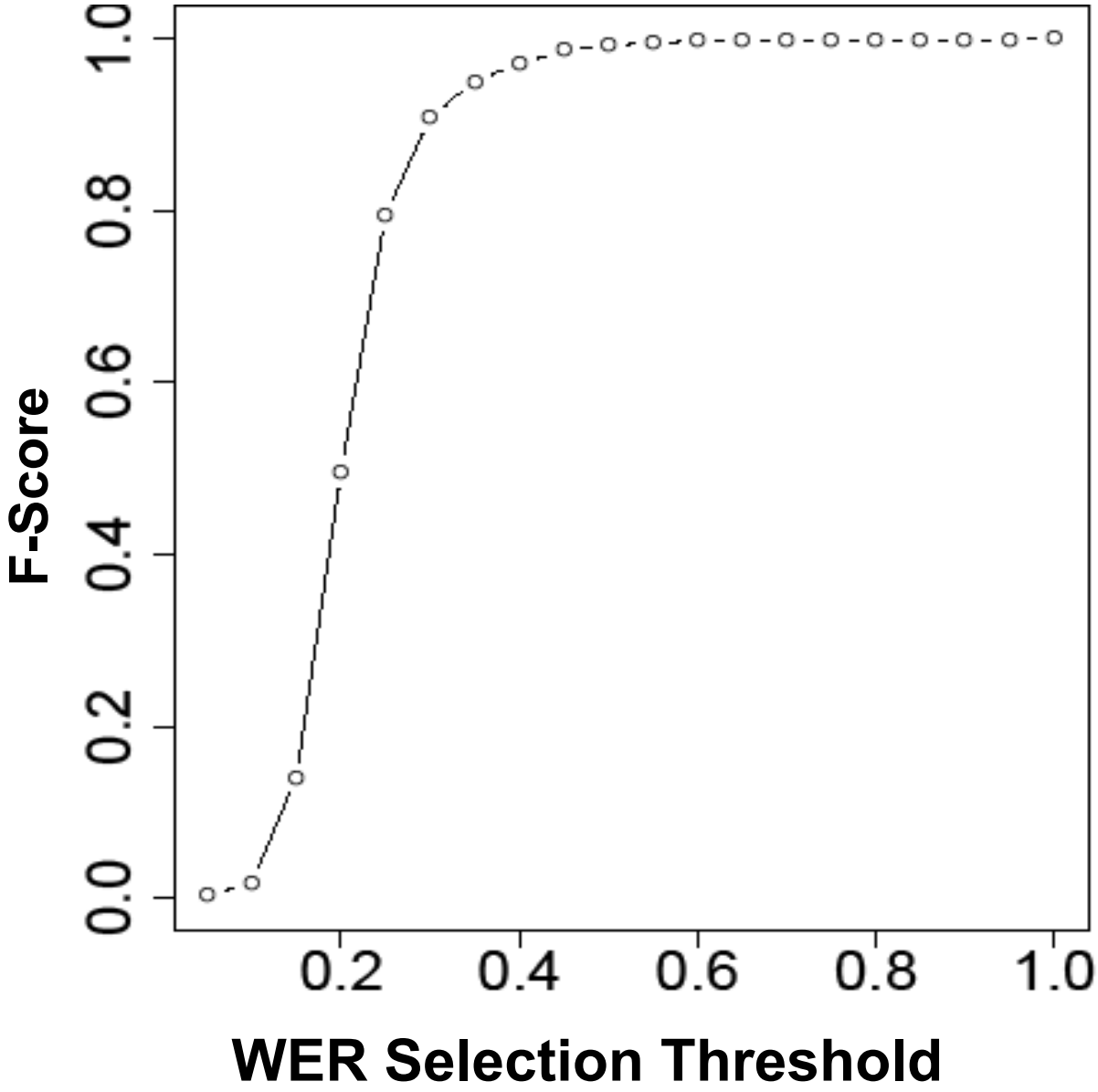


Finding the Right Turkers



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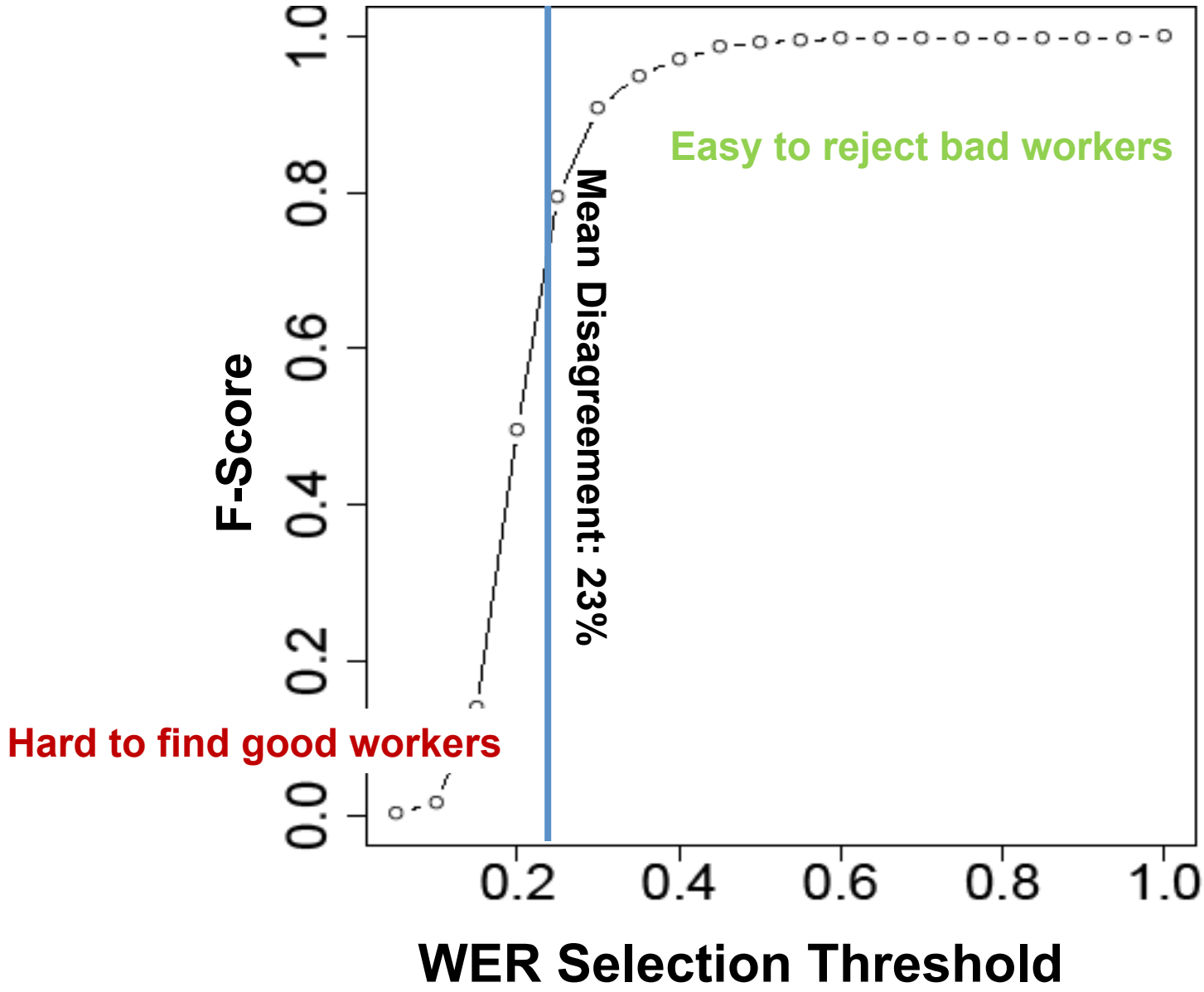

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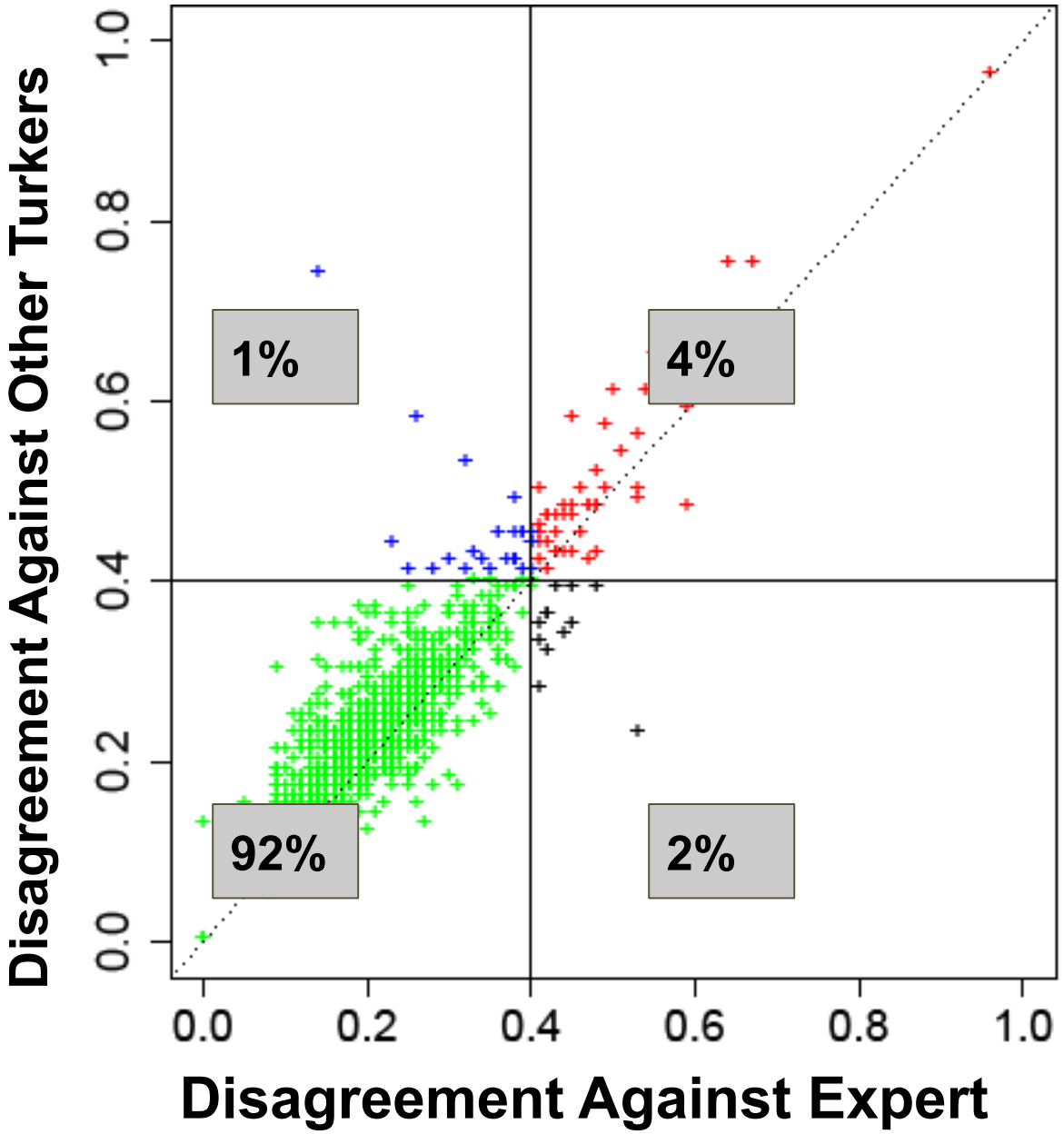


Reducing Disagreement

Selection	LDC Disagreement
None	23%
System Combination	21%
Estimated Best Turker	20%
Oracle Best Turker	18%
Oracle Best Utterance	13%

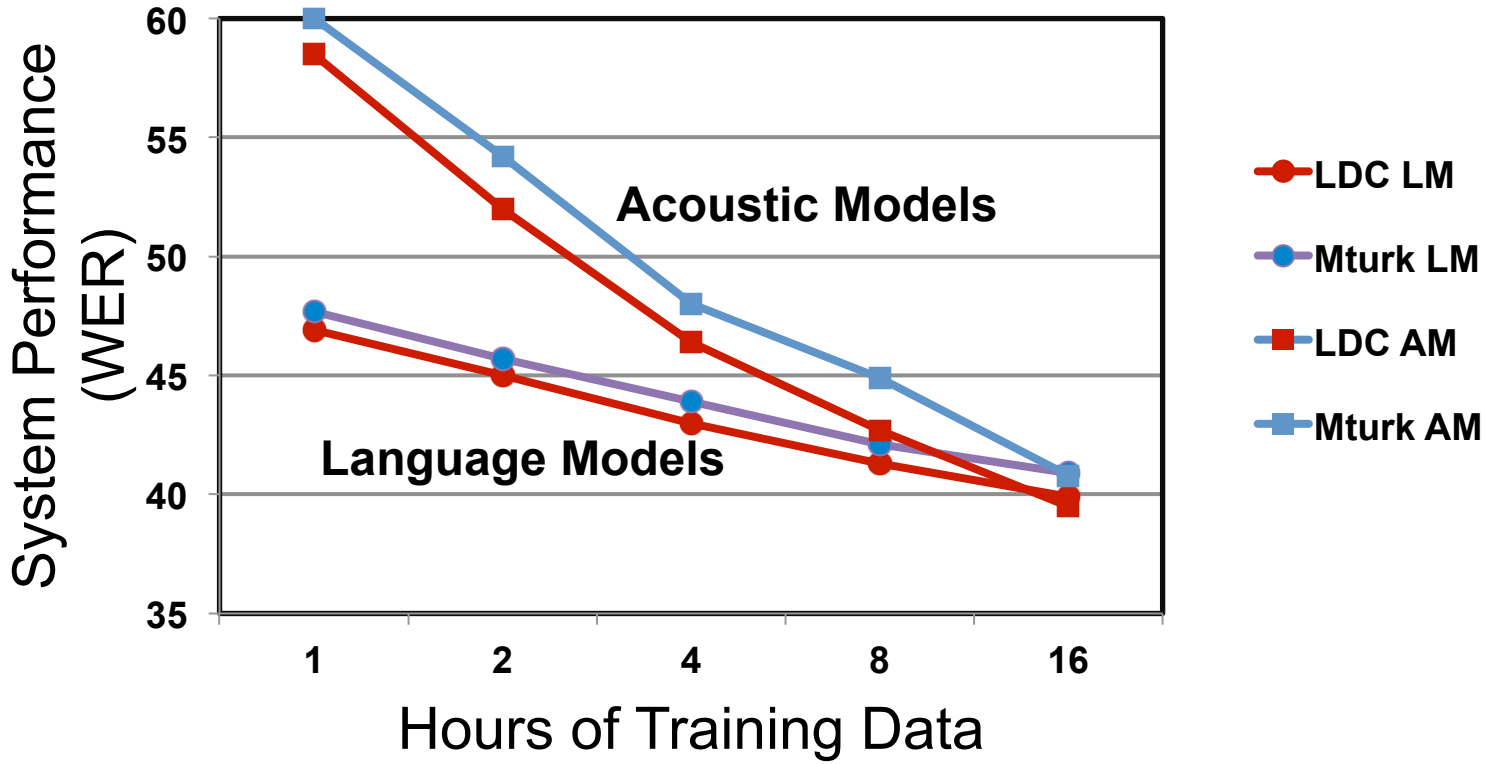
Mechanical Turk for ASR Training

- **Ultimate test is system performance**
  - Build acoustic and language models
  - Decode test set and compute WER
  - Compare to systems trained on equivalent expert transcription

- **23% professional disagreement might seem worrying**
  - How does it effect system performance?
  - Do reductions in disagreement transfer to system gains?
  - What are best practices for improving ASR performance?

Breaking Down The Degradation

- **Measured test WER degradation from 1 to 16 hours**
  - 3% relative degradation for acoustic model
  - 2% relative degradation for language model
  - 5% relative degradation for both
  - *Despite 23% transcription disagreement with LDC*



Value of Repeated Transcription

- **Each utterance was transcribed three times**

- **What is the value of this duplicate effort?**
  - Instead of dreaming up a better combination method, use oracle error rate as upper bound on system combination

Transcription	LDC Disagreement	ASR WER
Random	**23%**	**42.0%**
Oracle	**13%**	**40.9%**
LDC	**-**	**39.5%**

- **Cutting disagreement in half reduced degradation by half**

- **System combination has at most 2.5% WER to recover**

How to Best Spend Resources?

- **Given a fixed transcription budget, either:**
  - Transcribe as much audio as possible
  - Improve quality by redundantly transcribing

Transcription	Hours	Cost	ASR WER
Mturk	**20**	**$100**	**42.0%**
Oracle Mturk	**20**	**$300**	**40.9%**
MTurk	**60**	**$300**	**37.6%**
LDC	**20**		**39.5%**

- **Get more data, not better data**
  - Compare 37.6% WER versus 40.9% WER
- **Even expert data is outperformed by more lower quality data**
  - Compare 39.5% WER to 37.6% WER

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MTurk	**60**	**$300**	**37.6%**
LDC	**20**	**~$3000**	**39.5%**

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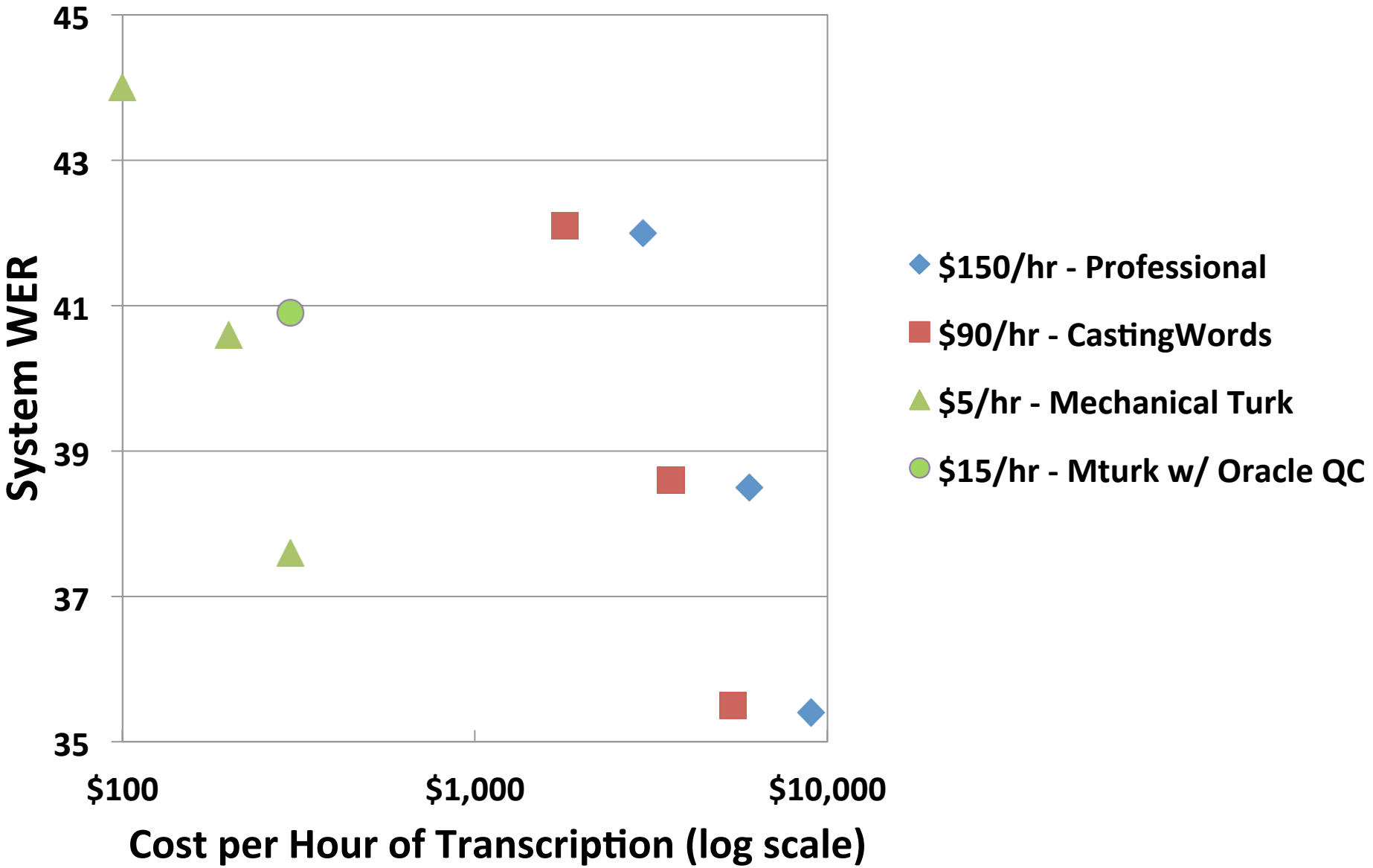
Comparing Cost of Reducing WER



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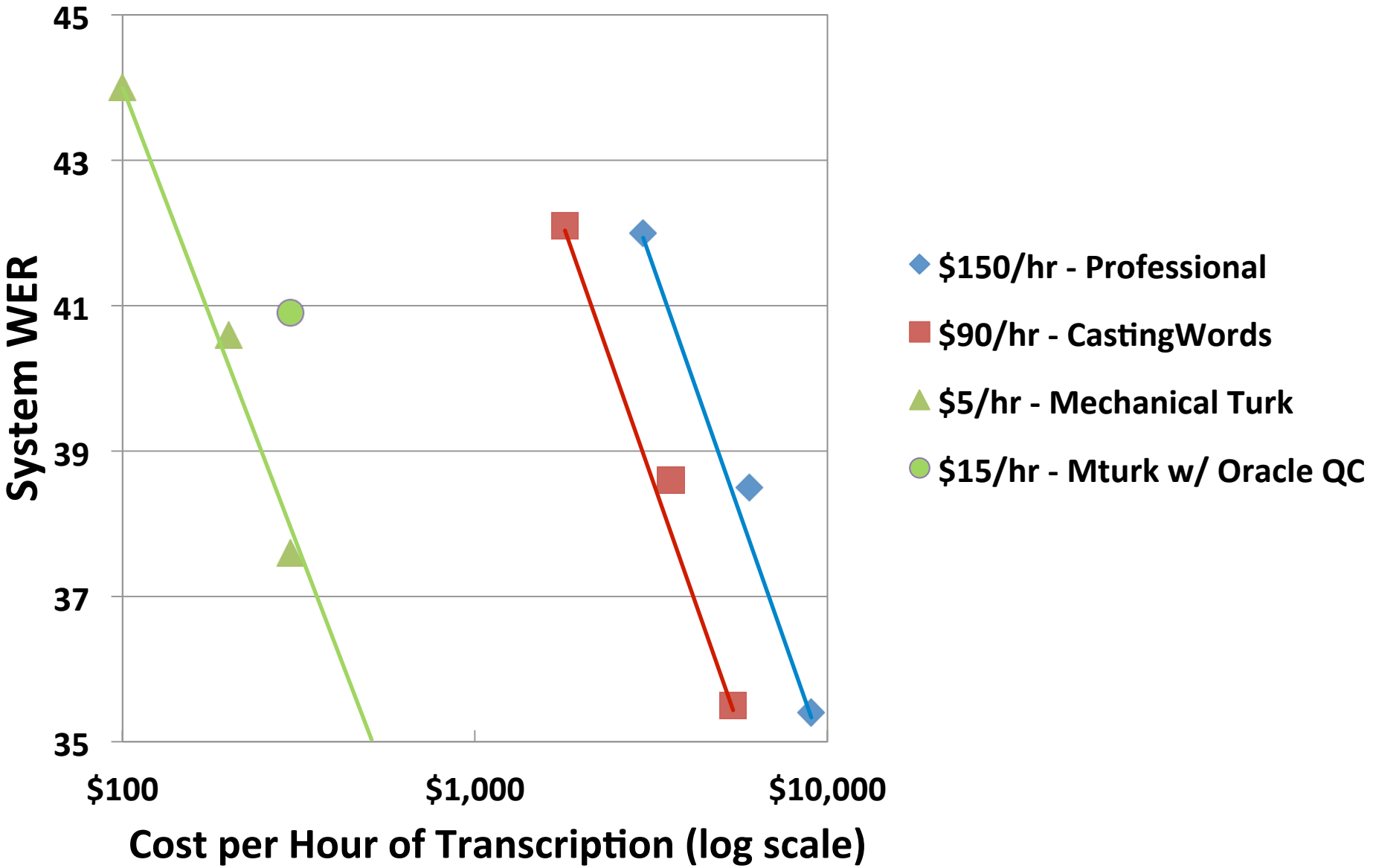

Korean

- **Tiny labor pool *(initially two Turkers versus 1089 for English)***

- **Posted separate 'Pyramid Scheme' HIT**
  - Paid referrer 25% of what referred earns transcribing
  - Transcription costs $25/hour instead of $20/hour
  - 80% of transcriptions came from referrals

- **Transcribed three hours in five weeks**
  - Paid 8 Turkers $113 at a transcription rate of 10xRT

- **Despite 17% CER, test CER only goes down by 1.5% relative**
  - from 51.3% CER to 52.1% CER
  - Reinforces English conclusions about the usefulness of noisy data for training an ASR system

Tamil and Hindi

- **Collected one hour of transcripts**
  - Much larger labor pool – how many?
  - Paid $20/hour, finished in 8 days
  - Difficult to accurately convey instructions
    - Many *translated* Hindi audio to English

- **No clear conclusions**
  - A private contractor provided transcriptions
  - Very high disagreement (80%+) for both languages
    - Reference transcripts inaccurate
    - Colloquial speech, poor audio quality
    - English speech irregularly transliterated into Devanagari
    - Lax gender agreement both for speaking *and* transcribing
  - Hindi ASR might be a hard task

English Conclusions

- **Mechanical Turk can quickly and cheaply transcribe difficult audio like English CTS**
  - 10 hours a day for $5 / hour
- **Can reasonably predict Turker skill w/out gold standard data**
  - But this turns out not to be as important as we thought
  - Oracle selection still only cuts disagreement in half
- **Trained models show little degradation despite 23% professional disagreement**
  - Even perfect expert agreement has small impact on system performance (2.5% reduction in WER)
  - Resources better spent getting *more* data than *better* data

Foreign Language Conclusions

- **Non-English Turkers are on Mechanical Turk**
  - But not a field of dreams
    - "If you post it, ~~they will come~~"
- **Korean results reinforce English conclusions**
  - 0.8% system degradation despite 17% disagreement
  - $20/hour (still very cheap)
- **Small amounts of errorful data is useful**
  - Poor models can still produce useable systems
    - 90% topic classification accuracy possible despite 80%+ WER
  - Semi-supervised methods can bootstrap initial models
    - 51% WER reduced to 27% with a one hour acoustic model
- **Noisy data is much more useful than you think**

Swahili and Amharic (Gelas, 2011)

- **Two under-resourced African languages**
  - 17M speak Amharic in Ethiopia
  - 50M speak Swahili in East Africa (Kenya, Congo, etc…)
- **Not many workers on Mturk**
  - 12 Amharic, 3 Swahili
- **And they generated data very slowly**
  - 0.75hrs after 73 days, 1.5hrs after 12 days
- **But despite being worse than professionals**
  - 16% WER, 27.7% WER
- **ASR systems performed as well as professionals**

- **At the end of the day, researchers paid grad students at $103/hr of transcription to get 12 hours vs. $37/hr on MTurk**

Other Speech Tasks

- **Use MTurk to elicit speech for the target domain**
  - Data collected on microphone, so point them to an app instead
- **Use Turkers to perform verification and correction**
  - Listen to <audio, transcript> pairs and verify right or wrong
  - Correct automatic speech output
- **Speech Science**
  - How sensitive are humans to noise?
  - Can they detect accent, fluency, etc…
- **System Evaluation**
  - Synthesized Speech (but again non-English was tough)
  - Spoken Dialog Systems *a.k.a.* Siri

If You're Curious

- **Praat - http://www.fon.hum.uva.nl/praat/**
  - Speech analysis
- **Kaldi - Open Source State of the Art Recognizer**
  - http://kaldi.sourceforge.net/
- **Linguistic Data Consortium**
  - Based right here at Upenn!
  - Creates almost all of the speech corpora used in research

BACKUP

Cheaply Estimating Turker Skill