Accounting for a six year time difference between questioned and known speaker recordings in a forensic voice comparison case

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$\frac{p(E|H_p)}{p(E|H_d)}$
Forensic Evaluation

UTD CRSS

OxfordWaveResearch

Case

- Questioned-speaker recording made in 2011
- Known-speaker recordings made in 2017 (6 year time interval)
- Recordings of ~100 speakers sampled from relevant population (sample speakers):
  - multiple recordings of each speaker
  - hours to days apart
- Sample-speaker recordings used for:
  - training
  - testing (empirical validation under casework conditions)
  - 50-50 split + cross validation

Forensic voice comparison system

- Features: MFCCs + deltas + double deltas
- Feature domain mismatch compensation: CMS
- i-vector extractor: UBM + T matrix (**Vocalise** pre-trained models)
- i-vector domain mismatch compensation: LDA trained using sample-speaker recordings (set 1)
- i-vector to score model: PLDA trained using sample-speaker recordings (set 1)
- score to likelihood ratio (calibration) model: logistic regression trained using sample-speaker recordings (set 2)

Problem

- Within-speaker variability generally increases with time interval between recordings
- Training and testing on sample-speaker recordings made hours to days apart will give misleadingly good results compared to if there were a 6 year time interval
- Likelihood ratio calculated for comparison of the questioned and known speaker recordings may be highly misleading

Observation

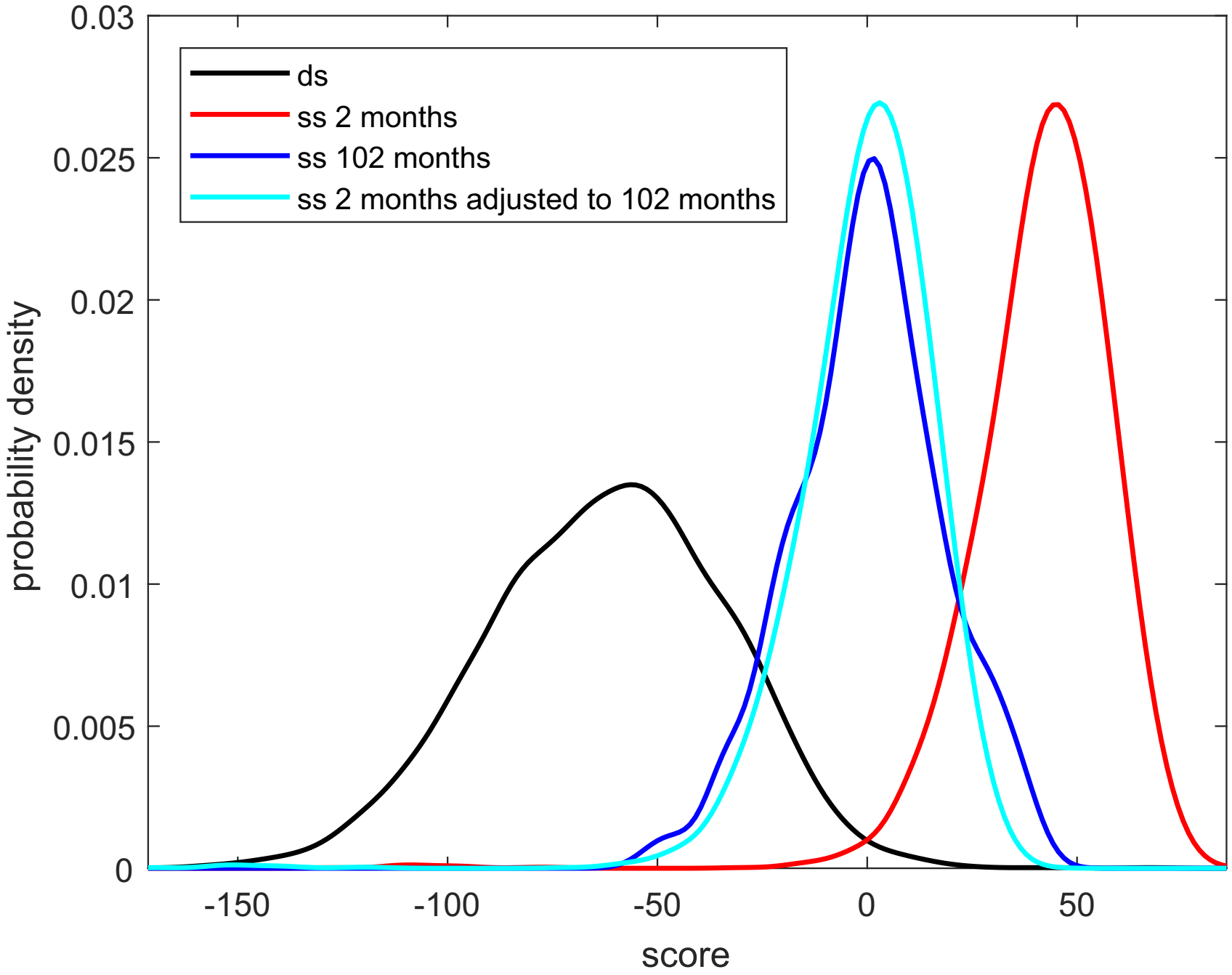
- In Kelly & Hansen (2016)
  - as time interval increased
  - same-speaker score values decreased

Solution

- Decrease the short-interval same-speaker score values so that they approximate the values expected for the longer target interval
  - similar to within source degradation (González-Rodríguez et al., 2006)

Kelly F., Hansen J.H.L. (2016). Score-aging calibration for speaker verification. *IEEE/ACM Transactions on Audio, Speech, and Language Processing*, 24, 2414–2424. http://dx.doi.org/10.1109/TASLP.2016.2602542

González-Rodríguez J., Drygajlo A., Ramos-Castro D., García-Gomar M., Ortega-García J. (2006). Robust estimation, interpretation and assessment of likelihood ratios in forensic speaker recognition. *Computer Speech and Language*, 20, 331–355. http://dx.doi.org/10.1016/j.csl.2005.08.005

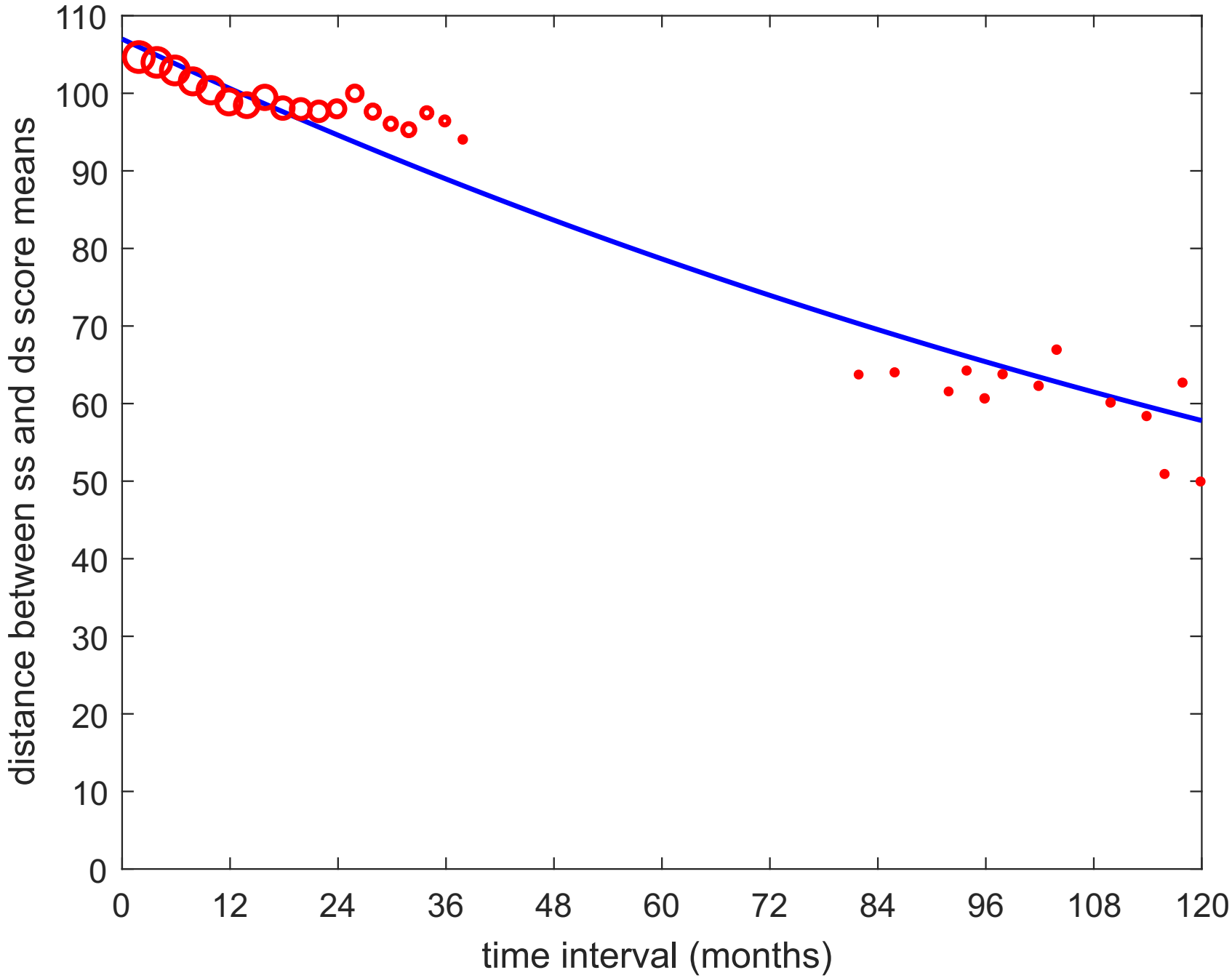

ds
ss 2 months
ss 102 months
ss 2 months adjusted to 102 months
probability density
score
0.03
0.025
0.02
0.015
0.01
0.005
0
-150
-100
-50
0
50

Training

- Multisession Audio Research Project (MARP) corpus
- Recordings from 46 male speakers
- Recorded approximately once every two months over a period of three years + one additional recording session approximately ten years after start
- Different-speaker scores: all possible session 1 v session 2 comparisons
- Same-speaker scores: all possible comparisons over all possible time intervals (excluding same-session comparisons)

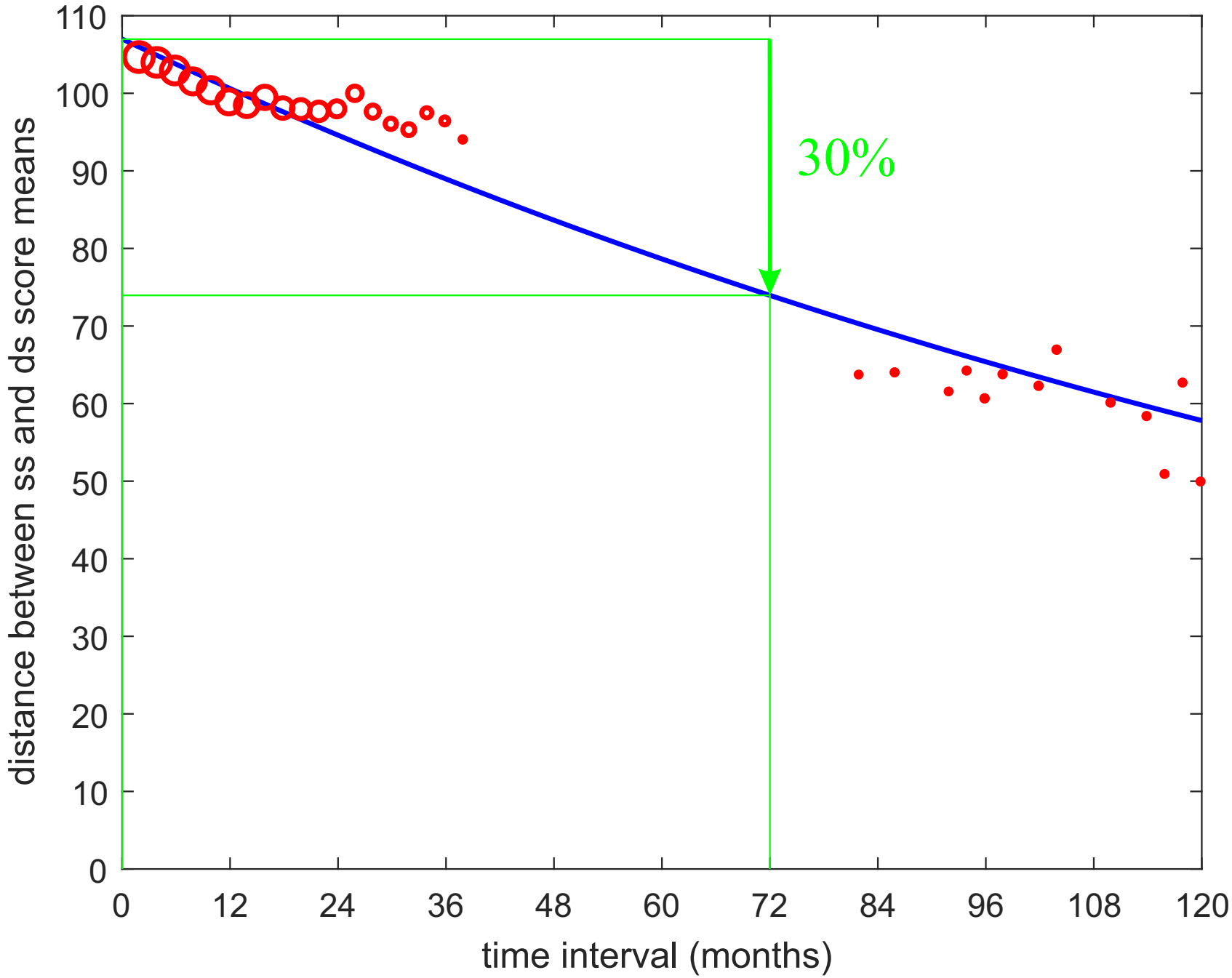
Training

- Calculate trimmed mean for different-speaker score distribution
- Calculate trimmed mean for same-speaker score distribution for each time interval
- Fit weighted linear regression with exponential link function
  - distance between the same-speaker and different-speaker means
  - time interval


distance between ss and ds score means
time interval (months)
0
10
20
30
40
50
60
70
80
90
100
110
0
12
24
36
48
60
72
84
96
108
120

Application

- Read off distance between the ss and ds means at short interval
- Read off distance between the ss and ds means at longer target interval
- Calculate proportional reduction in the distance between the means
- Apply that proportional reduction to the casework same-speaker scores
  - the casework data do not have the same conditions as the MARP data or have the same absolute ds and ss score means, hence a **proportional reduction** in the difference between the ss and ds means is applied
  - applied to training and test ss scores, not to questioned v known speaker score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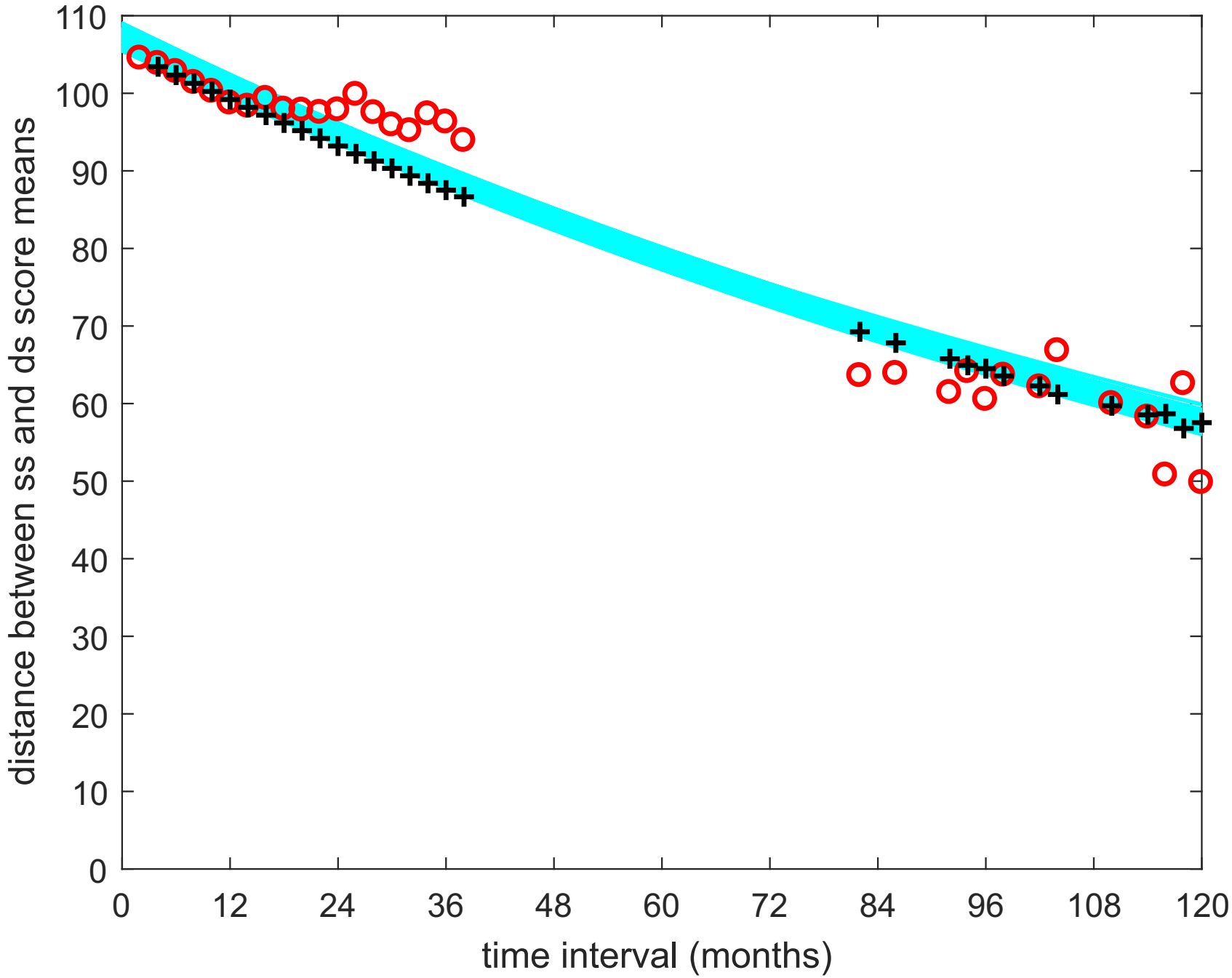
20
10
0
0
12
24
36
48
60
72
84
96
108
120
distance between ss and ds score means
time interval (months)
30%

Testing

- Cross-validation on MARP data
- Leave out 2 month interval plus target interval
- Leave one speaker out

Results

- RMS error rate expressed as a percentage of the original distance between the different-speaker and same-speaker means: 4.51%
- Worst per-interval error (at 34 month interval): 8.53%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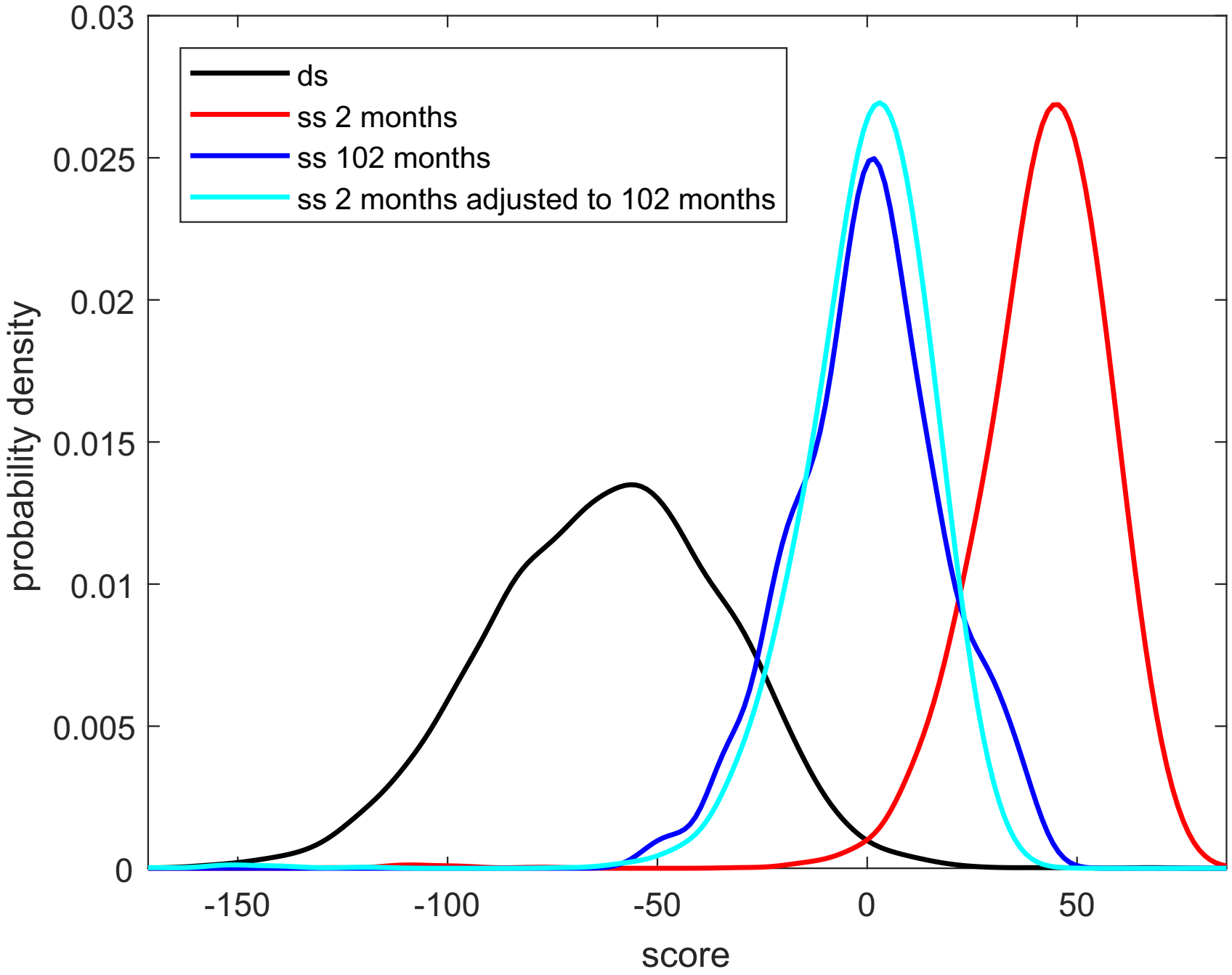
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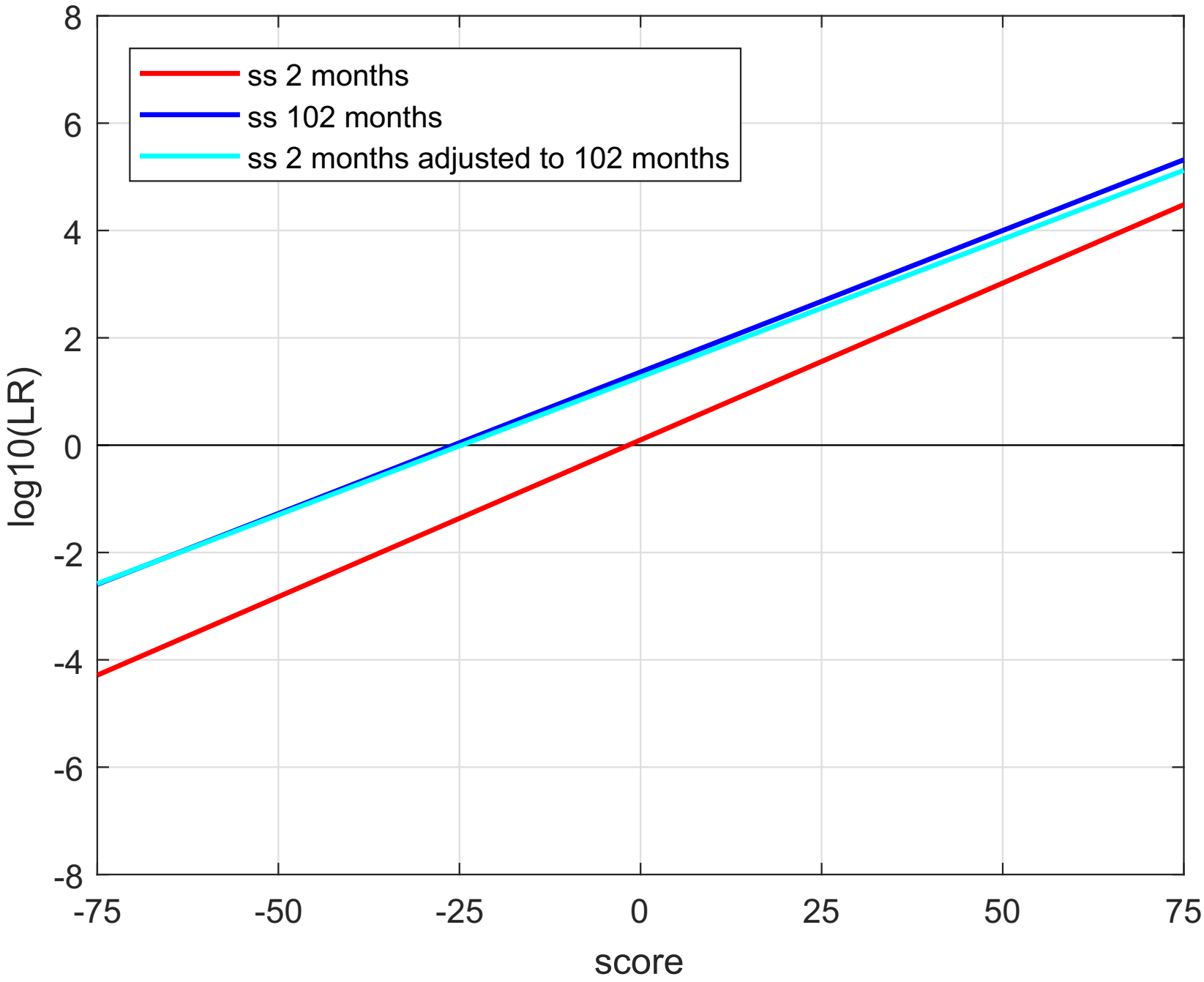
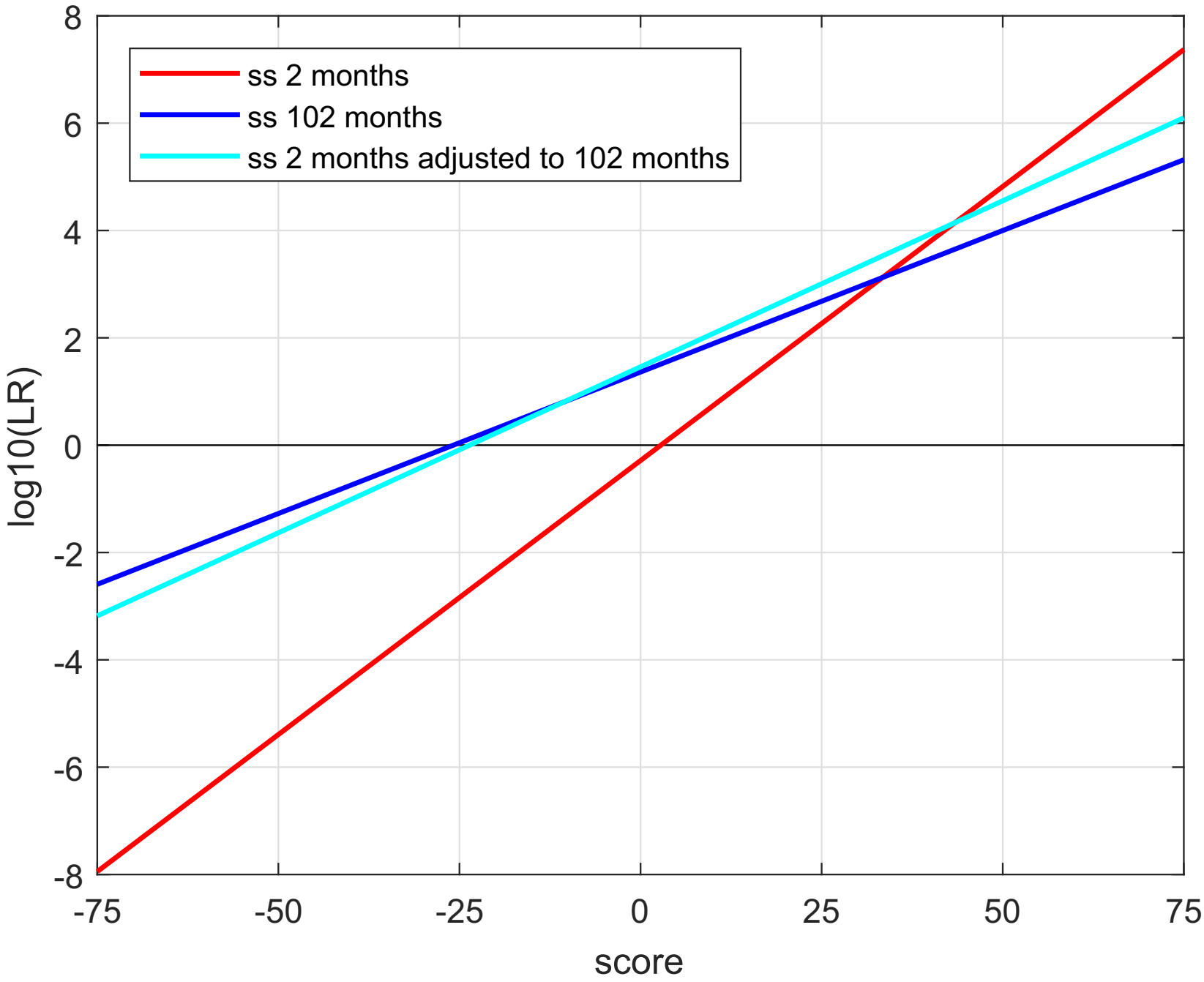

ss 2 months
ss 102 months
ss 2 months adjusted to 102 months
log10(LR)
score
8
6
4
2
0
-2
-4
-6
-8
-75
-50
-25
0
25
50
75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75

Additional work needed

- Validation work so far has been cross-validation on the MARP data
- Actual application is to case data that have conditions that differ from those of MARP
- Cross-database validation is needed

Thank You

http://geoff-morrison.net/