Naturalistic movie-viewing reveals distinct patterns of cognitive-linguistic processing across clinical populations

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Background

Naturalistic paradigms offer unique insights into real-world processing that both complement and extend beyond traditional standardized assessments. Movie-viewing paradigms may be particularly valuable for distinguishing between different types of impairments and understanding how language, cognition, and emotion interact in integrated processing.

Traditional assessments face important limitations:

- Assess isolated cognitive functions rather than integrated processes
- Often lack ecological validity in representing daily communication demands
- May not capture emotional and contextual aspects of real-world interaction

Naturalistic movie paradigms offer compelling advantages:

- Integrate linguistic, cognitive, and emotional processing demands simultaneously
- Capture moment-by-moment dynamics of processing across modalities
- Allow examination of both group synchronization and individual variability patterns
- Provide multiple dependent measures (ratings, eye-tracking, linguistic tasks)
- May better reflect the complex demands of real-world social communication
- Can reveal compensatory strategies not apparent in structured tasks

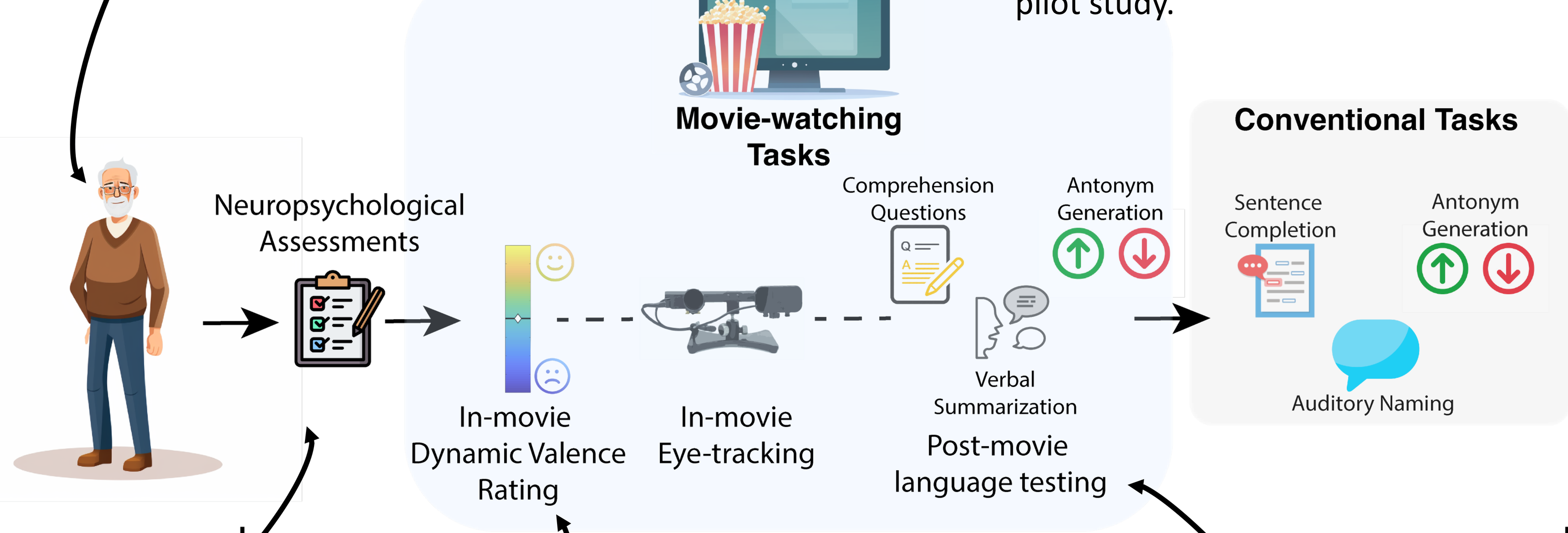
Study aims

1. Investigate how patterns of real-time emotional reactivity (RMSZ, Euclidean distance, sample entropy) differ between healthy controls (HC), persons with aphasia (AP), and persons with suspected mild cognitive impairment (MCI) groups during movie viewing.
2. Analyze how eye-gaze synchronization (horizontal and vertical ISC) varies across clinical populations and relates to rating patterns.
3. Determine the diagnostic value of combined behavioral measures for distinguishing between clinical groups using ROC analysis.

Study design

Participants: Adults diagnosed with post-stroke aphasia (38 **PWA**; mean age = 58.18 years, SD = 10.60), healthy controls (50 **HC**; mean age = 46.79 years, SD = 15.62), and 18 **MCI** (mean age = 59.12 years, SD = 9.82).

7/8 movie clips from DynAMoS (Girard et al., 2023), 2-5 mins each, selected for emotional variety & consistency of response elicited in pilot study.



PWA completed the **Western Aphasia Battery (WAB;** mean aphasia quotient [AQ] = 79.34, SD = 13.91), in addition to additional cognitive-linguistic assessments.

Participants provided **continuous** (-4 to 4) valence ratings using **Continuous Affect Rating and Media Annotation (CARMA)**.

Participants complete post-movie language testing: 1-minute **verbal summarization**, 3 **multiple-choice questions** per clip, and 5 **antonym generation** prompts, derived from subtitle text.

Feature derivation

Root Mean Squared Z-Score

```
For each time point t, participant p,
clip c:
  Z(p,c,t) = (Rating(p,c,t) -
mean(Rating(all_participants,c,t))) /
sd(Rating(all_participants,c,t))
  SZ(p,c,t) = Z(p,c,t)²
  MSZ(p,c) = mean(SZ(p,c,t)) across time
points
  RMSZ(p,c) = √MSZ(p,c)
  RMSZ(p) = √mean(MSZ(p,c)) across clips
```

Euclidean Distance

```
For each participant p, clip c:
  ED(p,c) = √(∑(Rating(p,c,t) -
mean(Rating(HC_group,c,t)))²) across time
points
  Normalized_ED(p,c) = ED(p,c) /
√n_timepoints
```

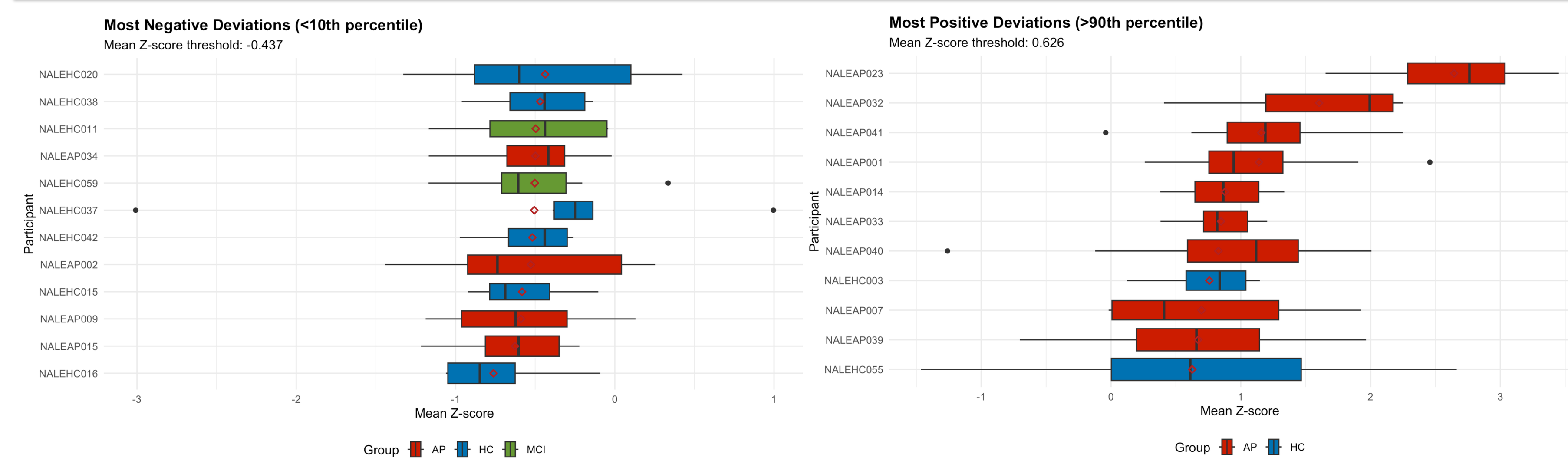
Sample Entropy

```
For each participant p, clip c, window
size w:
  SampEn(p,c,w) = -ln(probability that
patterns similar for w time points remain
similar for w+1 time points)
```

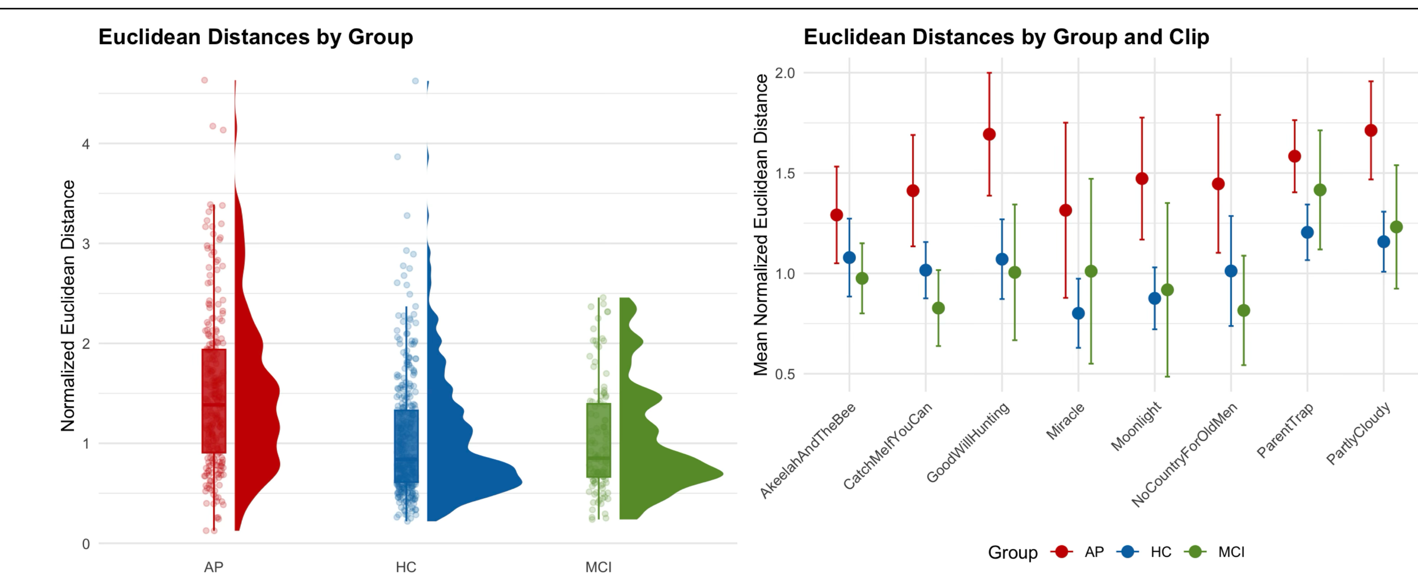
Intersubject Correlation

```
For each participant p:
  X(p) = [pos₁, pos₂, ..., posₙ] where
posₜ = gaze position at time t

  For each HC participant h:
    r(p,h) = Pearson correlation between
X(p) and X(h)

  ISC(p) = mean(r(p,h)) for all h in HC
group
```

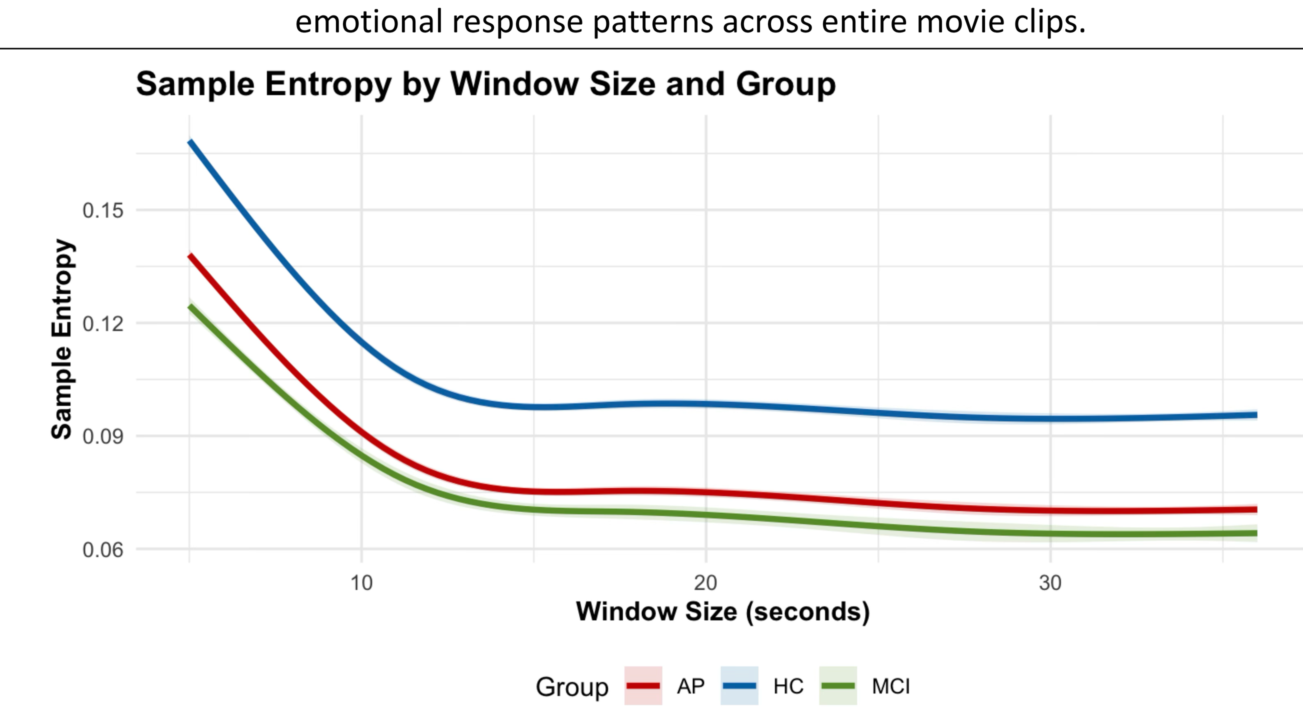
Quantitative findings



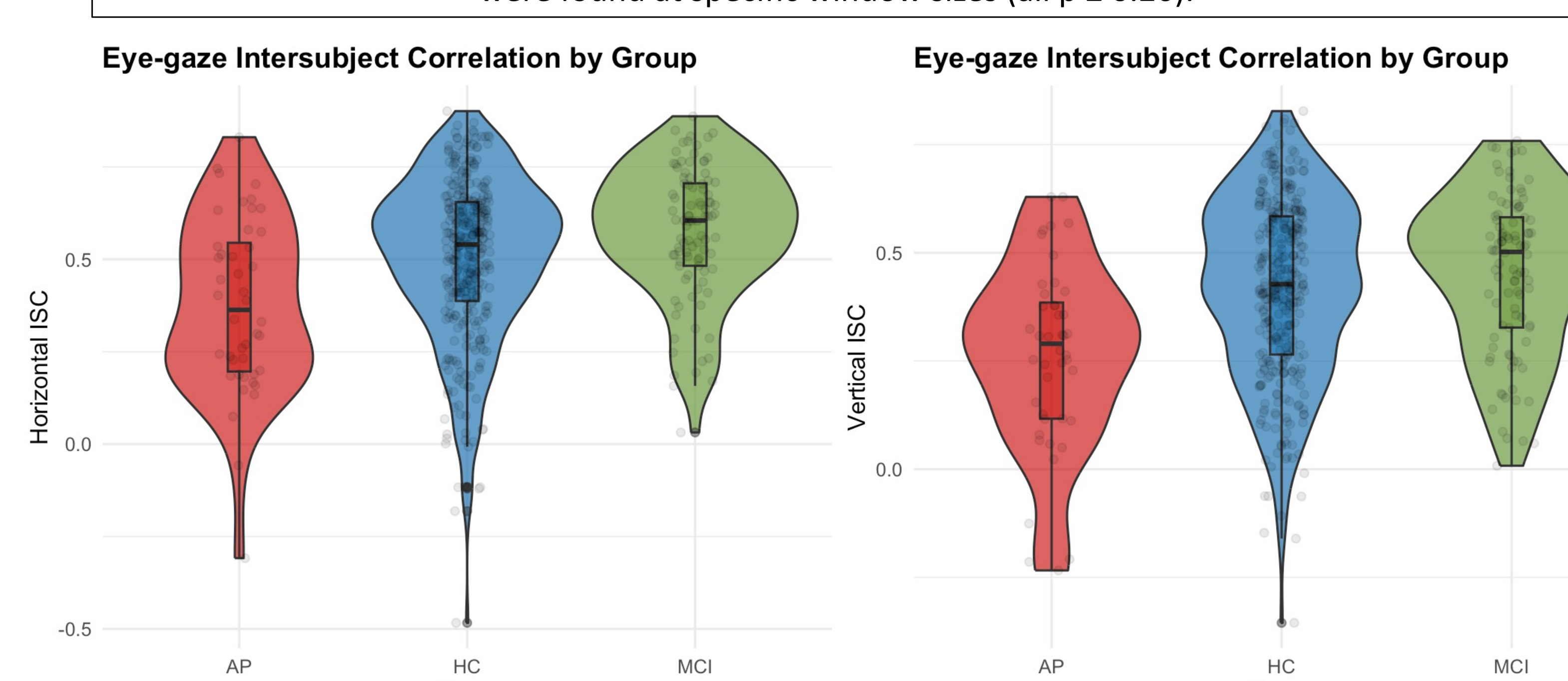
Individual rating patterns show that persons with aphasia (AP) *deviate significantly more* from HC consensus compared to both HC and MCI participants ($p<0.01$), while HC and MCI groups show similar patterns ($p>0.86$), indicating distinct emotional processing in aphasia.



AP participants show *significantly higher* normalized **Euclidean distances** from group average trajectories compared to both HC ($p=0.0001$) and MCI ($p=0.0034$) groups, with no significant difference between HC and MCI ($p=0.9774$), demonstrating that aphasia results in distinctly atypical emotional response patterns across entire movie clips.



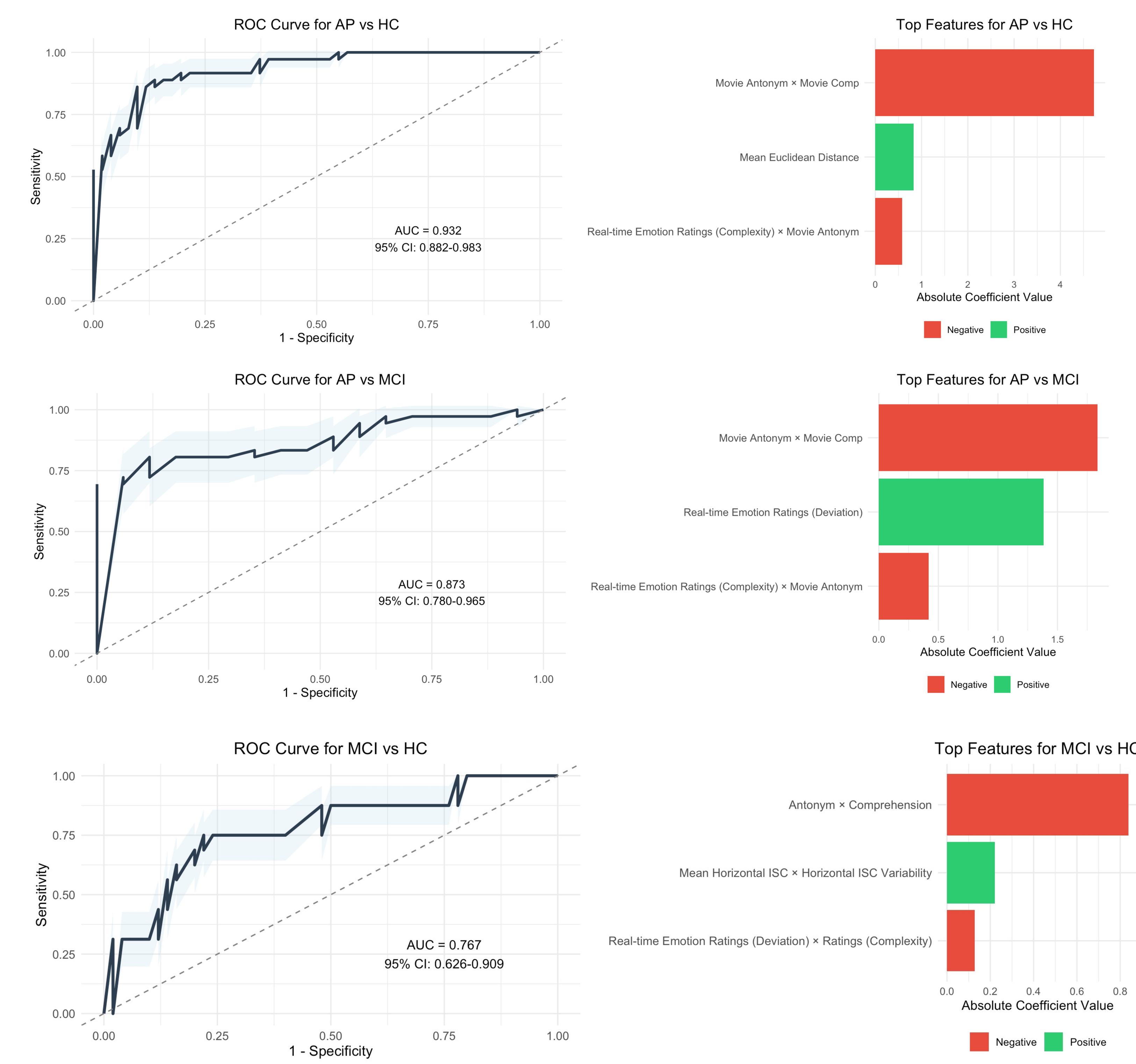
Sample entropy analysis reveals a significant Group × WindowSize interaction, suggesting different temporal dynamics in rating complexity across groups, though no significant pairwise differences were found at specific window sizes (all $p \geq 0.26$).



Eye-gaze intersubject correlation (ISC) shows horizontal synchrony follows MCI = HC > AP pattern (all $p < 0.05$), while vertical synchrony shows MCI ≈ HC > AP ($p<0.0001$), indicating reduced gaze synchronization in aphasia.

Quantitative findings

Language task performance shows AP significantly underperforms compared to both HC and MCI on comprehension ($p<0.0001$, $p=0.028$) and anticipatory generation tasks (both $p<0.0001$), with a significant difference between HC and MCI on the antonym task only ($p = 0.032$).



ROC curves demonstrate excellent discrimination between AP and HC (AUC = 0.932), good discrimination for AP vs MCI (AUC = 0.873), and moderate discrimination for HC vs MCI (AUC = 0.767).

Conclusion

- Aphasia is associated with distinct patterns of emotional reactivity and gaze synchronization compared to both healthy controls and MCI.
- Movie-based measures effectively distinguish between clinical groups.
- Naturalistic paradigms complement traditional assessments by capturing integrated processing dynamics.
- Next steps: Explore potential for early detection and treatment monitoring, employ fMRI with naturalistic movie-viewing.

References

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