Representation of emotion in linear and non-linear face dynamics

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BACKGROUND

- Ecologically valid facial expression stimuli encode dynamic qualities associated with movement seen in real face-to-face interaction (Krumhuber et al., 2017).
- The spatio-temporal dynamics of facial expressions influence perceptual decisions about emotion (Jack et al., 2014).
- Observers are sensitive to departures in spatiotemporal dynamics (Dobs et al., 2017, Furl et al. 2020).
- Facial expression stimuli used in psychological research largely fails to account for spatio-temporal dynamics and effects on perceptual processes.

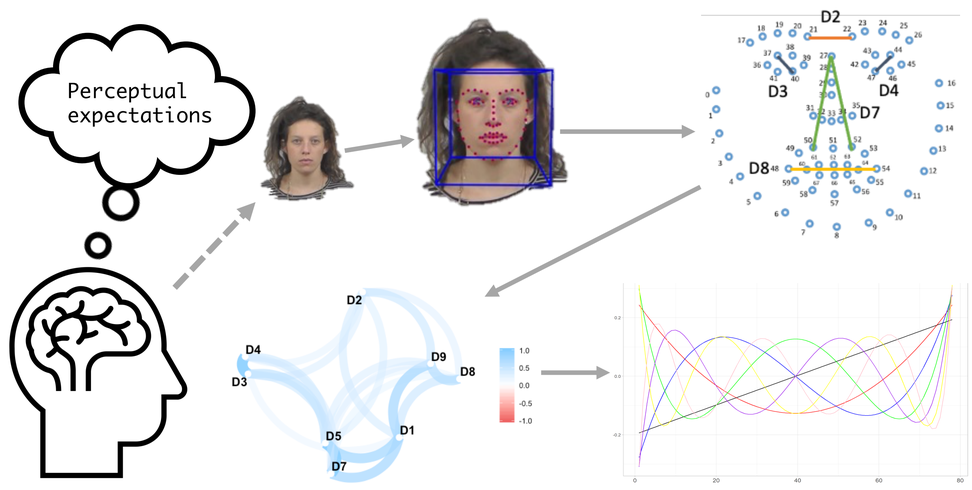


Fig.1. Not only do facial expressions vary in their spatio-temporal dynamics (which can be objectively quantified), observers have models for the spatio-temporal relations of face movements.

DESIGN AND METHODS

Study 1 – Facial analysis (Baltrušaitis et al., 2016) to approximate linear and non-linear patterns of facial movements of emotion, and how they varied systematically in common categories of *posed* facial expressions typically used in emotion research (*High* vs *Low prototypicality*) including common techniques to generate facial stimuli (e.g. *morphing*).

Analytical approach
Computed normalized frame-by-frame distances of face action points that code for emotional expression (Ekman & Friesen, 1987; Zane et al. 2019) – see Figure 1.

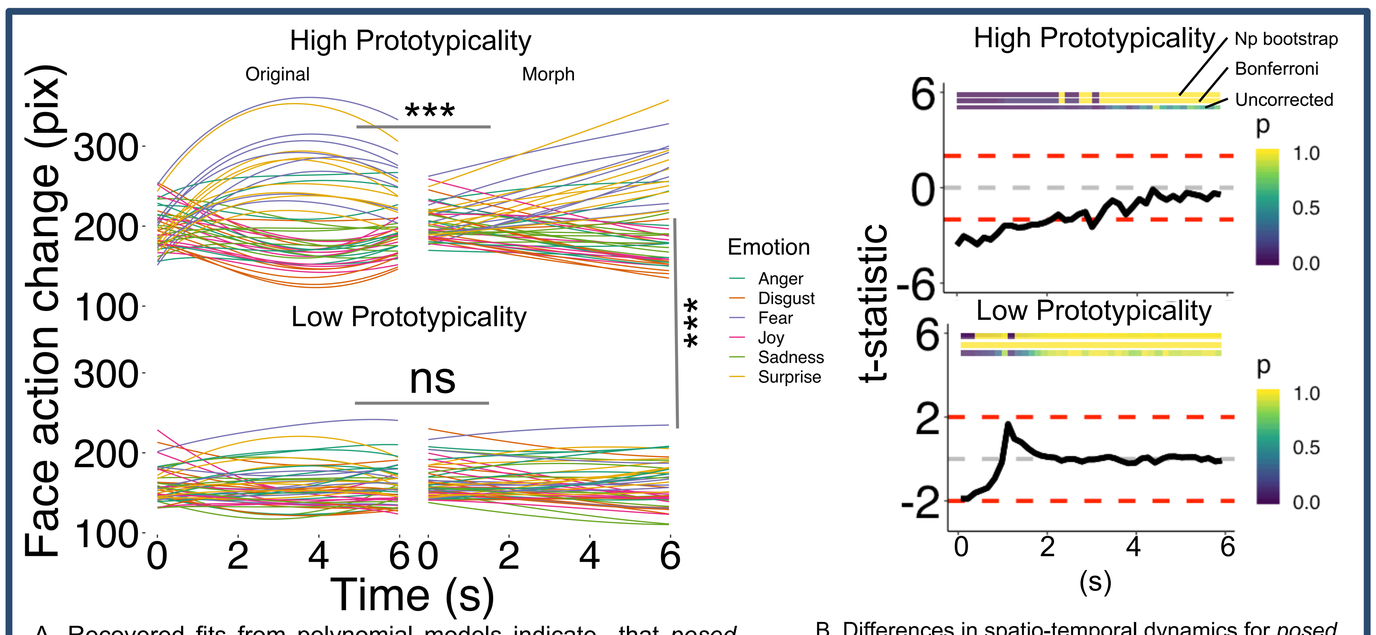
$$\sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}.$$

Timecourse modeling
We fitted **orthogonal polynomials** in multilevel models to describe the how the face distances (indicative of expression change) varied overtime (Mirmam et al., 2011).
Non-parametric bootstrap of time-series was used to identify temporal clusters where dynamics diverged (Maris & Oostenveld, 2007).

Study 2 - Investigated how perceptual representations of *valence*, *intensity*, *naturality* and emotion recognition *accuracy* were influenced by differences in spatiotemporal dynamics of stimuli in Study 1. We compared **120 controls** and **30 ASDs** to investigate whether any effects are consistent with expected emotion processing impairments in non-neurotypical groups.

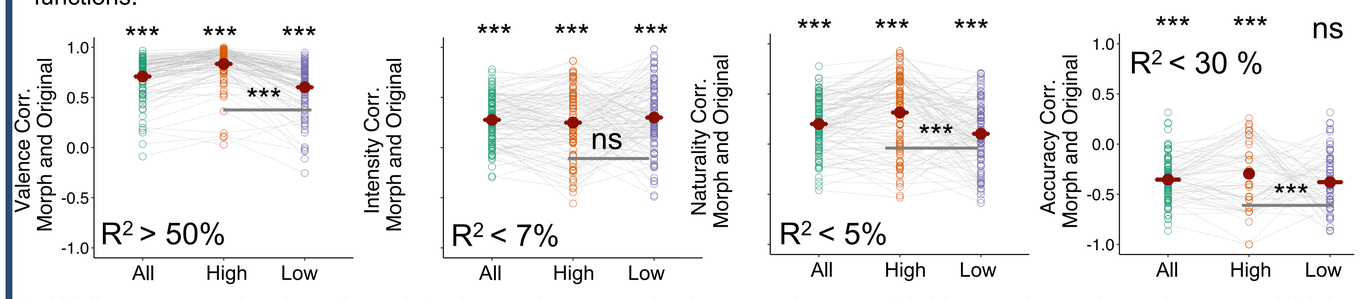
Analytical approach
Tested intra-individual representation matrices of perceptual decision ratings for *posed* and *morphed* expressions for *high* and *low* prototypicality emotion stimuli, in addition to modeling the explicit ratings in GLMMs.

RESULTS

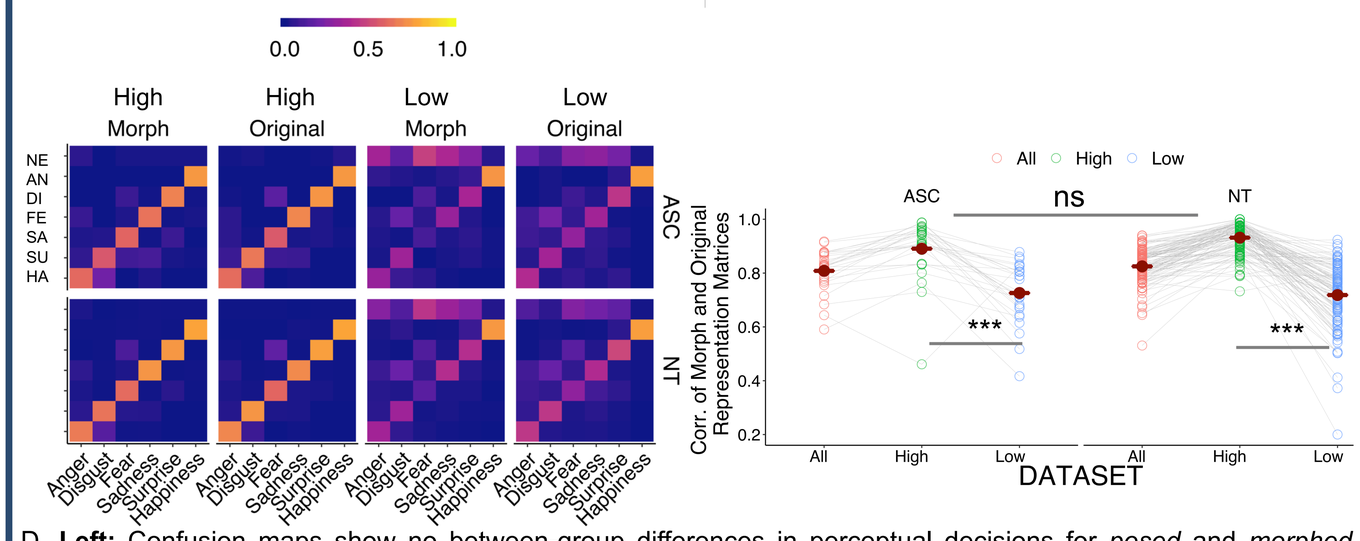


A. Recovered fits from polynomial models indicate that *posed high prototypicality* dynamics are best described with non-linear functions.

B. Differences in spatio-temporal dynamics for *posed* vs. *morphed* cluster temporally in early facial movements.



C. While perceptual ratings for *original posed* vs. *morphed* expressions are highly consistent for *valence*, and *high prototypicality* expressions, they are more inconsistent for *intensity*, *naturality* and *low prototypicality* expressions.



D. **Left:** Confusion maps show no between-group differences in perceptual decisions for *posed* and *morphed* stimuli. **Right:** High prototypicality expressions are more consistent across *morph* vs *original posed* videos. *** p< .001, ns = p > .05. ASC = Autism Spectrum Condition, NT = Neurotypical.

- Non-linear patterns distinguished *morphed* from *original posed* expressions only for *high prototypicality* stimuli (Fig. 2.A).
- Early signals in *posed* facial expressions carry temporal idiosyncrasies that are not well modelled by linear reconstructions of *morphed* expressions (Fig.2.B).
- Non-linear spatio-temporal dynamics impact consistence in perceptual ratings more strongly for *intensity*, *accuracy* and *naturality* than *valence* (Fig 2.C).
- Clinical participants are sensitive to spatio-temporal dynamic effects as much as controls, and perceptual decisions only diverges on prototypical expressions (Fig.2.D).

DISCUSSION AND CONCLUSION

- Study 1 adds to the growing body of work suggesting varying spatio-temporal dynamics by emotion (Sowden et al., 2020, Jack et al., 2014).
- Datasets and stimuli generation methods, are likely to influence these dynamics.
- Reduced consistency in perceptual ratings with *morphed* expressions suggests that emotion processing may be optimized to the expected appearance of moving expressions, consistent with the idea of face space representations of movement (Furl et al. 2020).
- ASDs' difficulties with emotion face processing lies on extraction or attribution of meaning to highly conventional (prototypical) social signals, rather than a failure to analyze face dynamics.

Selected References

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