Testing the effect of depth on the perception of faces in an online study

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Introduction

Faces are socially relevant stimuli, distinguished by 3D spatial arrangements of their features. The perceptual system orders these features in a cognitive "face space", where distance represents face similarity [1].

Previously, this "face space" has been mostly investigated with 2D faces. We plan an online behavioral study to **investigate the effect of 2D vs 3D representations on face perception**.

We present here the preliminary results from a pilot experiment before expanding our study online.

Hypotheses

In order to investigate the effect of depth on face perception and bridge the gap towards naturalistic stimuli, we hypothesize that:

(1) Similarity judgments can be used to investigate face dimensions.

(2) These facial dimensions differ between 2D and 3D representations.

Preliminary Results

Preliminary results suggest that male faces are judged to be more similar than female faces (*orange-red subsquare* in **Fig 4A**).

Similarity between female and male faces were perceived to be stronger in the 2D case (*bottom left subsquare* in **Fig 4A**).

To quantify the relationship between judgements in the 2D and 3D viewing condition, we calculated the Spearman correlation: $R = 0.77$, $p < 0.001$. That is, 40.7% of variance ($1\text{-}R^2$) in one viewing condition remains unexplained by the other condition.

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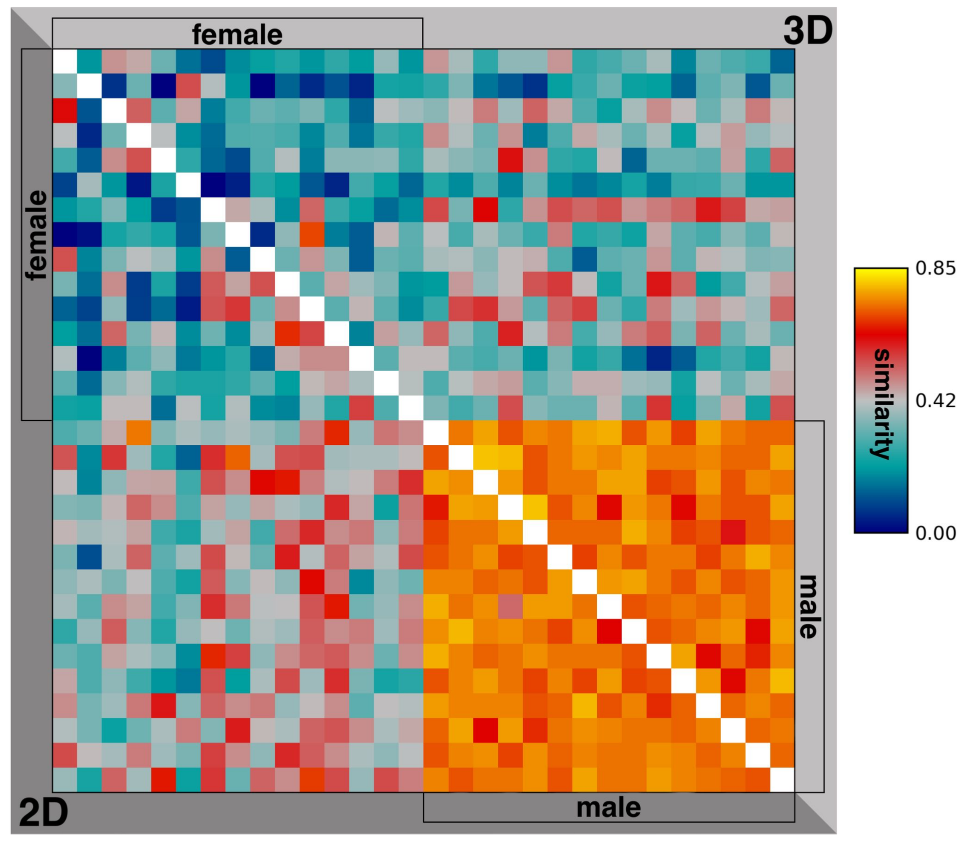
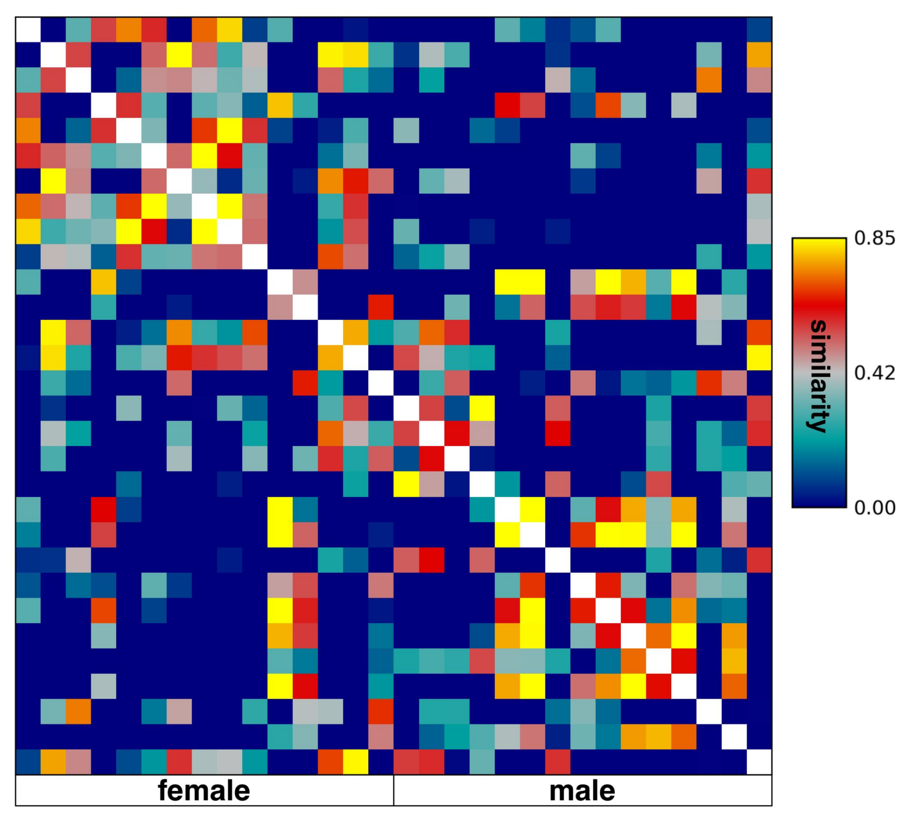
A. Behavioral Similarity Matrix (BSM)



BSM of both viewing conditions (*lower left*: 2D; *upper right triangle*: 3D). Cells represent aggregated pairwise similarity judgements. First 15 columns/rows represent female faces. Last 15 columns/rows represent male faces

Note, this includes noise, reflecting interindividual differences in similarity judgements independent of the viewing condition.

B. Similarity matrix of physical face attributes



44 attributes (e.g., face width) included in the Chicago-Face-Database [2] were subject to PCA. The first 5 components explaining 88.2% variance across attributes were used to compute the cosine similarity of face pairs.

While visual inspection of physical face attributes (**Fig 4B**) suggest an effect of gender, there is no significant correlation to the behavioral judgements (2D: $R = -0.00$, $p \leq 0.957$; 3D: $R=0.043$, $p \leq 0.38$).

Discussion

Our preliminary results show minor differences in representations between viewing conditions. Further analysis will follow this pilot study as we expand the dataset presented to 100 faces and launch it online to increase the sample size. The differences between 2D and 3D would have implications on previous 2D research and would encourage future studies on face perception with more naturalistic experimental designs using 3D.

Moreover, our methodological pipeline can be used for different stimulus sets or samples, for example, with different ethnical groups or clinical populations, and for psychophysiological studies.

Bibliography

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Methods

Stimulus Preparation: We randomly sampled neutral faces ($n_{female}=n_{male}=15$) from the standardized 2D Chicago-Face-Database (CFD) [2] and used a **deep learning-based pipeline (DECA) for 3D-face-reconstruction** [3] (**Fig 1**). All triplet combinations of 30 faces are **randomized and then subdivided** into unique sections for the pilot participants.

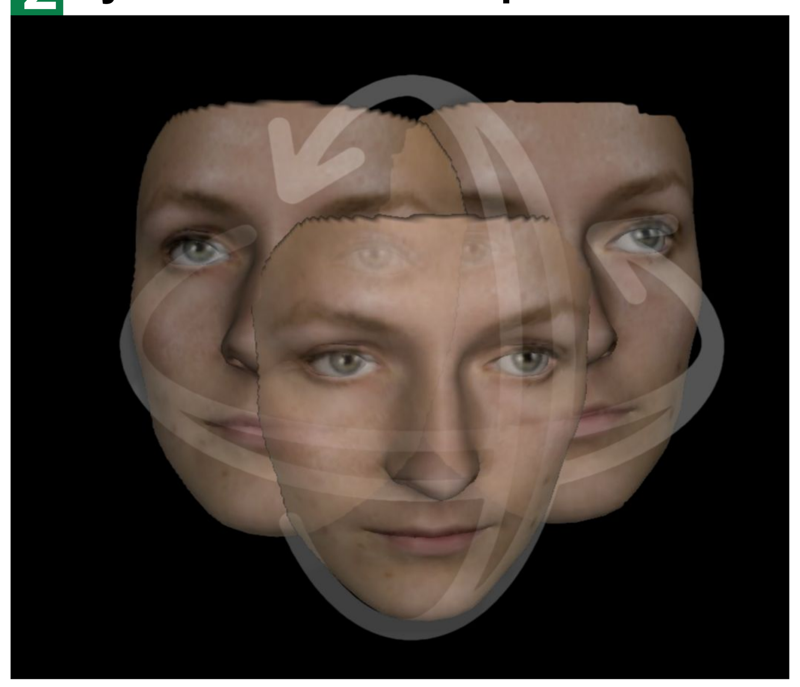
Similarity Judgement Task: We used a **triplet odd-one-out task** to acquire pairwise **behavioral similarity matrices** (BSMs). Two pilot participant groups were tested with static (2D, n=6, 3 females) or with rotating faces (3D, n=5, 1 female; **Fig 2**). Each participant completed 406 trials (average duration: 5 s) in 7 blocks (à 58 trials) with interleaved breaks of self-determined duration (**Fig 3**).

Representational similarity analysis (RSA): We applied RSA [4] on **BSMs** of human judgements to quantify the difference between viewing conditions. BSMs were computed across participants averaging over trials, where face pairs that contain the odd-one-out got a rating of 0, and 1 otherwise. That is, each trial resulted in 3 face pairs with 2 dissimilar pairs (rated with 0) and one similar pair. BSMs were compared using Spearman correlation.

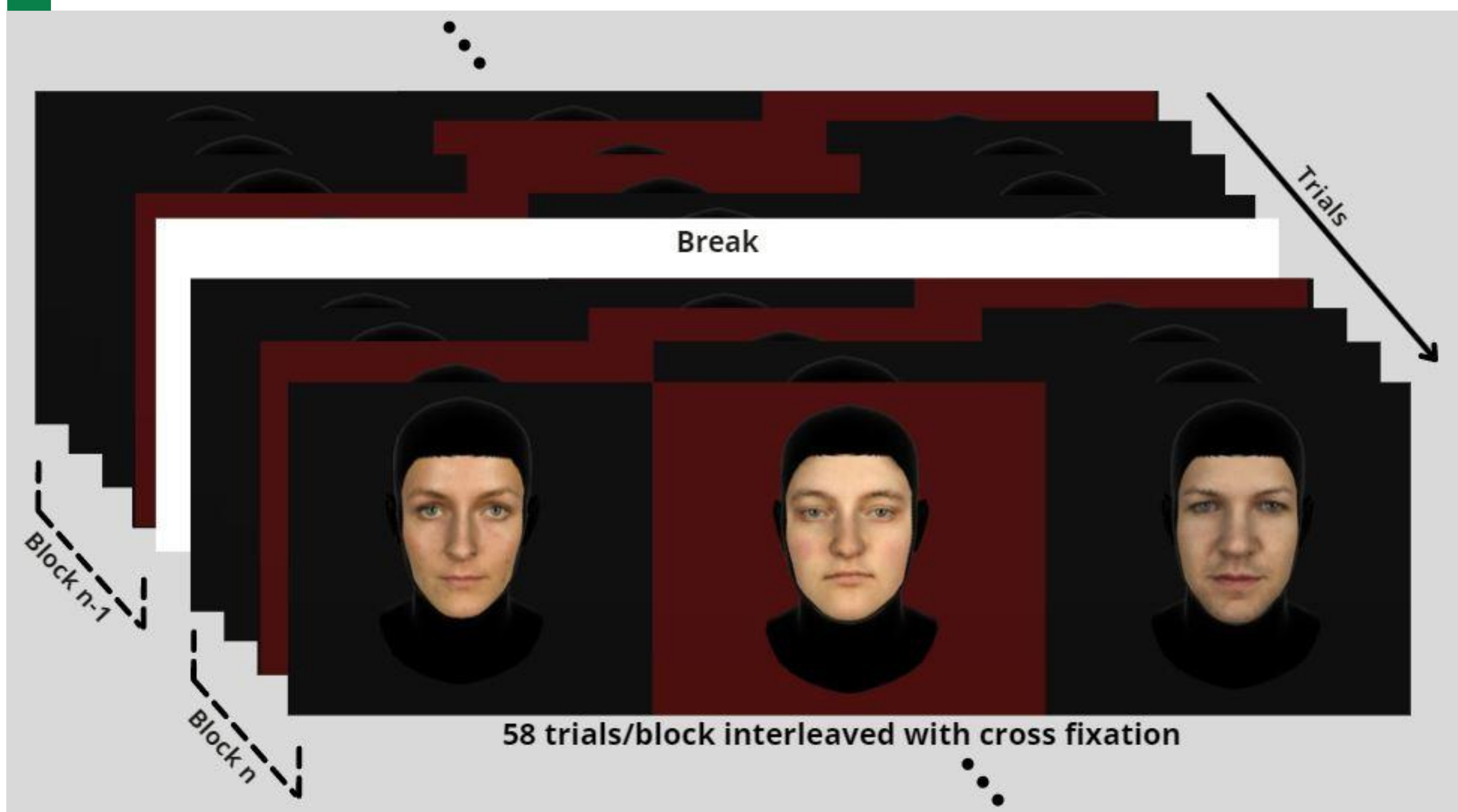
Similarity of physical face attributes (PFA): We tested the extent to which 44 PFA (e.g., face width) that are part of CFD [2] explain the cognitive "face-space" represented by the BSMs. The initial PFAs were subject to a principal component analysis (PCA). The 5 most informative PCs were used to compute cosine similarity measures of face pairs.

1 3D reconstruction using DECA

2 Dynamic 3D facial representation



3 Odd-one-out trial design for the 2D and 3D viewing condition



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