Perceived shape similarity is represented
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Introduction
A) Object representation = distributed, view-based
B) Edelman

ventral visual stream represents similarities between distal shapes by the distance between their positions in a low-dimensional proximal neural space

Aim: To investigate the (behavioral and neuronal) representation of similarity using everyday stimuli

Research question: Is shape similarity represented systematically in human object-selective cortex?

Outline
Stimulus construction
First stimulus set
original line drawings
Adobe Photoshop 5.5
silhouettes
contours
Morphing algorithm Magic Morph

Second stimulus set

Third stimulus set

Stimulus spaces with 6 continua of parametric shape differences as a result of morphing between the 4 extreme contour stimuli (Exp. 1). In total 11 spaces with 66 morphlines (i.e shape difference continua)

Empirical Research

EXP 1 Semi-parametric stimulus space

Aim: To have parametric control over shape differences in a stimulus set of everyday objects by using the Multi-Dimensional Scaling technique (i.e second stimulus set of morphs)

Stimuli: We started with a stimulus set of 257 original line drawings, i.e first stimulus set (Op de Beeck & Wagemans, 2001 Perception 30 1337-1361). Silhouettes and contours were created using Adobe Photoshop and the Edge Software Program. In total 17 categories.

Method: These 3 versions were presented in a similarity rating task (1-6). All intra-category combinations were shown to 30 subjects (10 subjects in each stimulus version).

Procedure:

Result:

11 categories passed the criteria: example category car, with illustration of the 4 extremes selected to obtain parametric morphed stimulus spaces by applying the morphing procedure on the contour version

EXP 2 Validation: Typicality

Aim: To investigate the ecological validity of the artificially generated morph stimuli

Stimuli: 11 stimulus spaces with 6 morph lines in each category

Method: 56 subjects had to judge how typical each examplar was in respect to its basic level category

Procedure: The stimuli were presented on paper

Results:

Behavioral Testing

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**EXP. 3a Categorisation task**

**Aim:** To investigate the relationship between behavioral performance and the manipulated shape differences (validity of the second stimulus set of morphs = OK, Exp 2a & 2b).

**Stimuli:** The 11 stimulus spaces with semi-parametric control over the shape differences, resulting from Exp. 1 and validated in Exp 2a & 2b, were used.

**Method:**
- The stimuli were presented in a same-different paradigm. The 22 subjects had to judge whether the two presented stimuli belonged to the same category.
- 2112 trials: 1056 same (11 categories x 6 morph lines x 16 pairs) and 1056 different (created by combining the first stimulus of a same trial randomly with another stimulus from another category).

**Procedure:**
- The grid (18.12 x 17.21 visual degrees) that was used for scrambling was also present in the intact version.

**Results:**
- General behavioral trend: higher reaction times (and more errors, not shown) with increasing distance between two exemplars. The manipulated shape differences, i.e. difference in similarity, cause significant behavioral effects.
- Effect of training did not alter the systematic trend.
- No difference found between biological and artefact categories.

**Neuronal Testing**

**EXP. 4a LOC-localiser for ROI analysis**

**Aim:** To investigate the effect of the manipulated stimulus continuum of shape differences, i.e. the effect of similarity, in higher visual areas, i.e. Lateral Occipital Complex — necessary to isolate LOC and test research questions in Region of Interest.

**Stimuli:** Black 2D-contours in 4 conditions: familiar intact (a), familiar scrambled (b), novel intact (c) and novel scrambled (d) (Kourtzi & Kanwisher, 2000) plus a fixation condition. An oscillating fixation cross was used to address attention (33 Hz).

**Method:**
- A simple alternating block-design was used for localising object-related voxels. Each of the 4 LOC-scans consisted of 3 blocks of 5 conditions: 7’30” for each scan.

**MRI-acquisition:**
- 3T Philips Intera scanner, whole-brain EPI ascending sequence (157 dynamical scans, TR = 3000 ms, FOV = 200 x 200 mm, TE = 30 ms, alpha = 40°, 32 slices, 1.2 mm thick, in plane resolution = 1 x 1 mm).

**Data analysis:**
- General linear model with a simple box-car function for each condition was used to model the data. LOC was defined as the cluster of voxels exceeding a certain statistical threshold (p < .001, uncorrected). The contrast of interest was estimated for each subject as the effect size of the interaction of condition and the manipulated shape differences.

**Results:**
- Example of one subject

**EXP. 4b Neuronal effect of similarity**

**Aim:** See Exp. 4a.

**Stimuli:** The morphed stimulus spaces with semi-parametric control over the manipulated shape differences: differences in similarity.

**Method:**
- Eight event-related adaptation scans, one for each category, were used. Subjects performed a categorisation task, i.e. sequential entry-level matching, and received 18 trials of each of 5 conditions: distance-0, distance-33, distance-66, distance-100, and different category. In each scan only the stimulus pairs based on the 4 extremes from one category were presented. Order of trial types was determined by a genetic algorithm.

**MRI-acquisition:**
- 3T Philips Intera scanner, fast event-related Echo Planar Imaging (FE-EPI) with ascending sequence (364 dynamical scans, TR = 1015 ms, FOV = 230 x 230 mm, TE = 30 ms, alpha = 6°, 17 axial/ transverse slices with an in-plane resolution of 1.8 x 1.8 mm were positioned to cover the ventral part of the brain)

**Data analysis:**
- SPM 2 for preprocessing and analysing the imaging data. A generalised linear model based on actual timing data was constructed in which the expected hemodynamic response changes were modelled using an informed basis-set for each condition. Two parametric modulated regressors modelling the possible presence of linear and/or quadratic effects over time, that could result from a general adaptation in the relevant category-related regions in LOC, were also included.

**Results:**
- Significant linear trend for the first 4 conditions in both ROIs and in both hemispheres.

Responses to shapes located close to the center of the shape-space (Exp. 1) were lower than those to shapes located in the periphery.

**EXP. 3b Robustness of effect**

**Method:**
- The morphed stimulus spaces with semi-parametric control over the shape differences, resulting from Exp. 1 and validated in Exp 2a & 2b, were used.

**MRI-acquisition:**
- 3T Philips Intera scanner, whole-brain EPI ascending sequence (157 dynamical scans, TR = 3000 ms, FOV = 200 x 200 mm, TE = 30 ms, alpha = 8°, 182 slices, 1.2 mm thick, in plane resolution = 1 x 1 mm).

**Data analysis:**
- General linear model with a simple box-car function for each condition was used to model the data. LOC was defined as the cluster of voxels exceeding a certain statistical threshold (p < .001, uncorrected). The contrast of interest was estimated for each subject as the effect size of the interaction of condition and the manipulated shape differences.

**Results:**
- Example of one subject

The systematic trend in our data could not be accounted for by changes in aspect ratio. The trend persisted also in a restricted analysis with only those morph lines with less than 20% changes in aspect ratio.