#### Matching face-like objects is invariant to differences in direction of contrast

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#### Subramaniam & Biederman Study

- There is a dramatic decline in face matching performance for faces that differ in contrast polarity.
- No such costs are apparent when matching chairs, even when the chairs and faces were scaled to be equally similar (Lades et al., 1993) according to a wavelet model of similarity (Subramaniam & Biederman, 1997).



The face database was provided by the Max-Planck Institute for Biological Cybernetics in Tuebingen, Germany," courtesy of N.F. Troje



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#### **Results of Biederman & Subramaniam**



Note the enormous cost to FACE, but not OBJECT, matching, when matching images of different polarity vs same polarity.

# Why this difference in the costs of contrast inversion for faces and objects?

- Unlike face matching, subordinate level object matching (such as the chairs in Subramaniam's experiment) can generally be accomplished by using parts and discontinuities.
- Parts and discontinuities would be unaffected by changes in contrast polarity.
- Could the presence of this contrastinvariant information account for the difference between faces and objects?



#### Would object recognition remain invariant to contrast polarity with smoothly curved, novel, non-face 3D objects?

If such stimuli were generated in a restricted space in which only the amplitudes of the 2nd and 3rd harmonics of a sphere varied, it would require discriminating among blobs with the same configuration but different metrics. This type of information, along with pigmentation, may be used to match faces.



#### Method for Generating 3D "Blobs" by Amplitude Variation of Harmonics





- We investigated a matching task with non-face objects whose surfaces, like those of faces, vary smoothly.
- Each "blob" stimuli space was generated by varying the amplitudes of the 2nd and 3rd harmonics of a sphere.

#### **Amplitude-Varied "Blob" Spaces**



- The stimuli produced were smooth, blobby, asymmetric volumes, only varying in their degree of surface curvature.
- This "amplitude-variation" was done for 4 different harmonic configurations producing 4 "blob" stimuli spaces.



#### **Amplitude-Varied Stimuli Space**



- These amplitude variations produced smooth, blobby, asymmetric volumes with small metric curvature differences so the effects of a wide range of stimuli similarity could be assessed.
- Nearby stimuli in this space do not differ in parts or nonaccidental properties.

### **Blob Similarity**



- The similarity of pairs of objects was scaled according to a wavelet similarity measure (Lades, et al., 1993).
- These distances are highly correlated, r = .998, with city-block distance in each stimuli space.
- Gabor jet values vary from 65 (= most dissimilar) to 100 (= identical)



#### **Expert Recognition**

- It is possible that the sensitivity to direction of contrast in face matching is a consequence of the experience (expertise) we have with face images of positive contrast (Gauthier & Tarr, 1997).
- Would intensive training on matching blobs of positive contrast lead to deficits in matching blobs of different contrast?



- Expertise in these types of tasks has been reported to require about 3,240 trials (or 7-10 hrs. of training) on average (Gauthier & Tarr, 1997; Gauthier et al., 1998). To produce expertise in our subjects, they each performed eight sessions (1 hr) of 1,024 trials for a total of 8,192 trials.
- All of the training sessions were conducted with stimuli of positive contrast.
- They were then tested in a session with images of both positive and negative contrast, identical in procedure to the training trials.

#### **Testing for Expertise**



- Four amplitudevaried "blob" spaces
  makes it possible to
  test for a transfer of
  expertise to a blob of
  a different
  configuration of
  harmonics.
- Can compare experts' performance on old & new blobs to novices' performance.

#### Match-to-sample forced-choice method

- The task does not rely on memory.
- It eliminates criterion and response bias effects for judging same vs. different.



## Match the top blob to one of the blobs below.

#### **Experimental Conditions**



- Stimuli presented for 1 sec
- Subjects had 4 sec. in which to respond.
- Experts trained for 8-1024 trial sessions in positive contrast.
- Both experts and novices tested for 512 trials in both positive and negative contrast blobs (block 1)
- Both then tested again for 512 trials with a new blob configuration in positive and negative contrast (block 2)

#### **Results for Experts&Novices:Block1**



• Experts performing significantly better than novices with respect to both reaction times and error rates.

#### **Results for Experts&Novices:Block1**



• Neither experts nor novices show sensitivity to contrast inversion.

#### **Results for Block 2: New Configuration**



- Experts show no cost for matching blobs from the new space--transfer of expertise!
- Novices perform slightly better during block 2 (new blob configuration): effect of training.

#### **Results for Block 2: New Configuration**



• Neither experts nor novices show an effect of contrast in reaction times or error rates.

Would object recognition remain invariant to contrast polarity with smoothly curved objects with constrained pigmentation ?

In addition to surface curvature, pigmentation, such as high contrast patches including the eyebrows and the shadows of the nostrils, may be used in face recognition (Cavanagh; Bruce & Langton, 1994).

If the matching of these objects were invariant to contrast polarity, it would suggest that faces are special with respect to their sensitivity to contrast inversion.



#### Method for Generating 3D "Blobs" with Pigmentation Information





- Stimuli were again generated by adding the harmonics of a sphere with a set high contrast patches in a specific configuration.
- The harmonics varied in size, changing the patches with the surface curvature.

#### **Experimental Conditions**



- Stimuli presented for 1 sec
- Subjects had 4 sec. in which to respond.
- Experts trained for 8-1024 trial sessions in positive contrast.
- Both experts and novices tested for 512 trials in both positive and negative contrast blobs (block 1)
- Both then tested again for 512 trials with a new blob in positive and negative contrast (block 2)

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- Experts show no cost for matching blobs from the new space--transfer of expertise!
- Novices perform slightly better during block 2 (new blobs): effect of training.

#### **Results for Block 2: New Configuration**



• Neither experts or novices show an effect of contrast reversal in reaction times or error rates.

# Why does face and object matching differ in the effects of contrast polarity?

#### 

#### 2. Similarity.....

-Because the matching of blobs that were more similar than highly similar faces was invariant to contrast polarity.

#### 3. Expertise.....

-Because neither expert nor novice subjects showed sensitivity to differences in contrast polarity when matching blobs.

#### 4. Pigmentation.....

-Because the matching of non-face objects with face-like pigmentation is contrast invariant.









### The only way we have been able to get an effect of contrast inversion in shape matching is to use...



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