



SIGGRAPH2006

# Hybrid Images

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# Hybrid Images



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Angry man

Neutral woman



# Hybrid Images

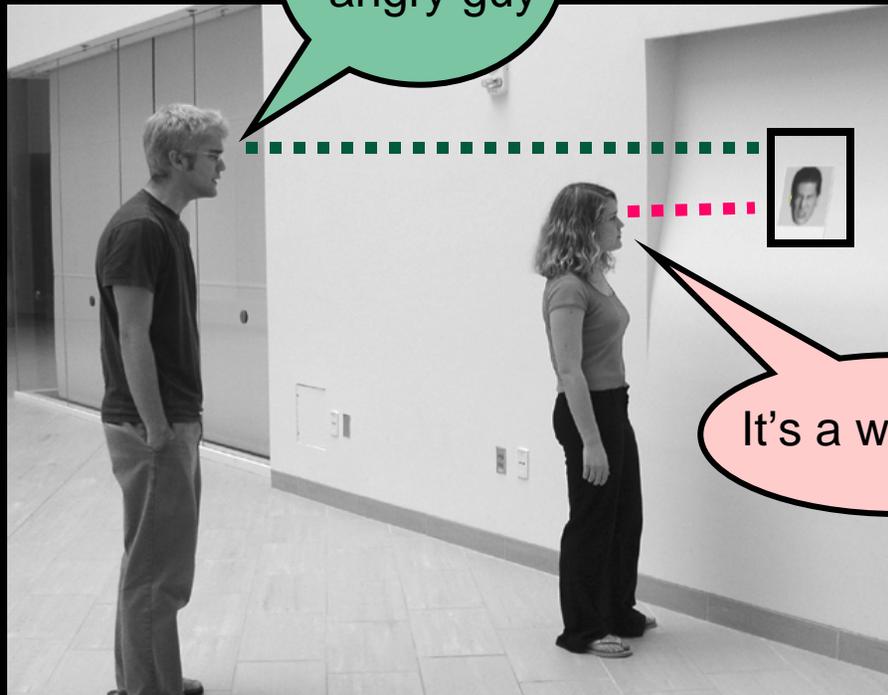


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What you see...

From Far Away

Up Close



I see an angry guy

It's a woman!





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# The quest for creating images with multiple meanings

# Multiple Meanings

## One global interpretation



A sunflower

Pieces of images



# Multiple Meanings

## Two global interpretations

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Two shoes or a butterfly



Image Copyright Ian Butterworth (2002)

# Multiple Meanings

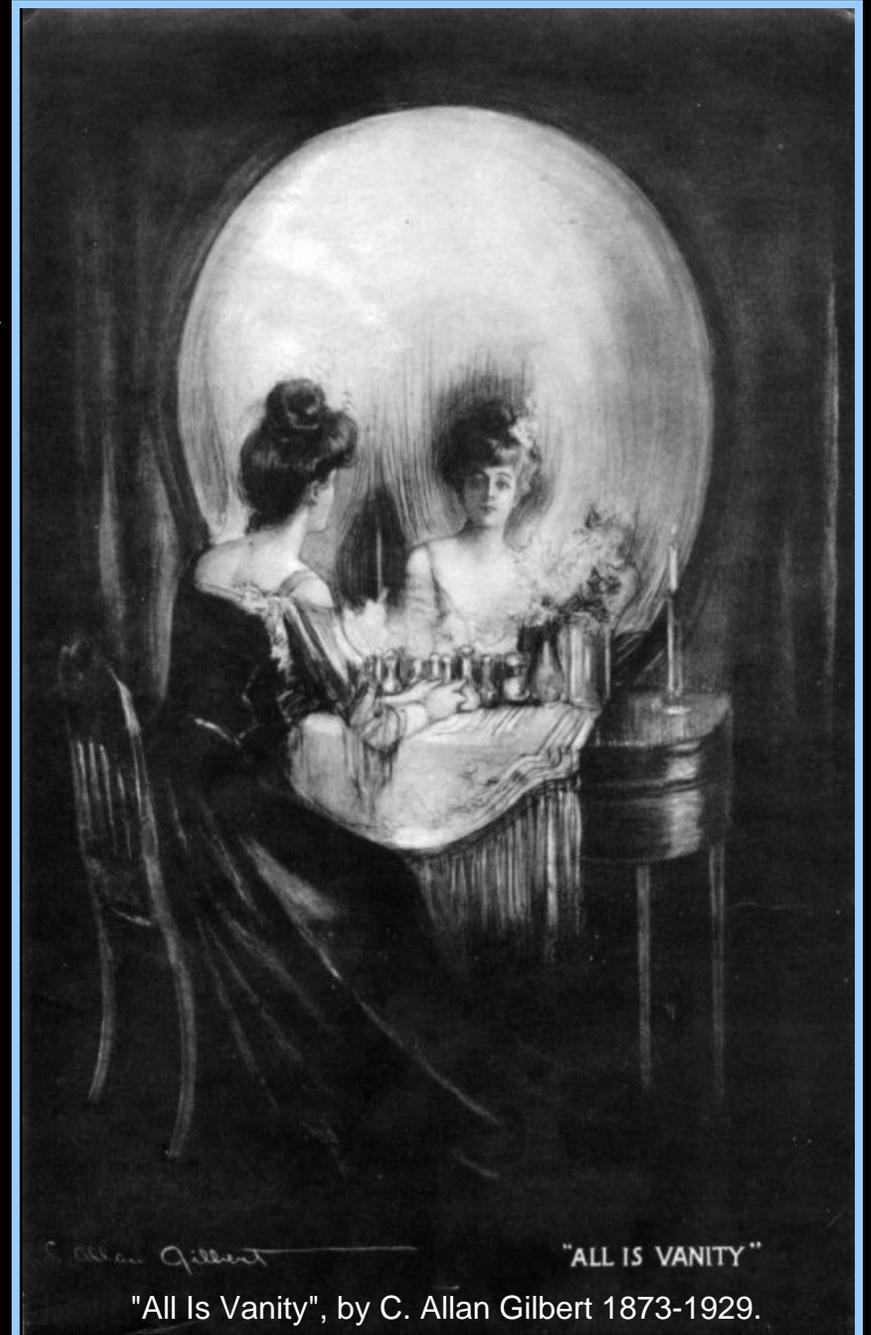
## Two global interpretations

Strong percept  
of a woman

Strong percept  
of a skull



Looking at the image one way, a skull appears, comprised of the woman's form and her reflection in a mirror (the outline of the skull itself).



# Subtle expression

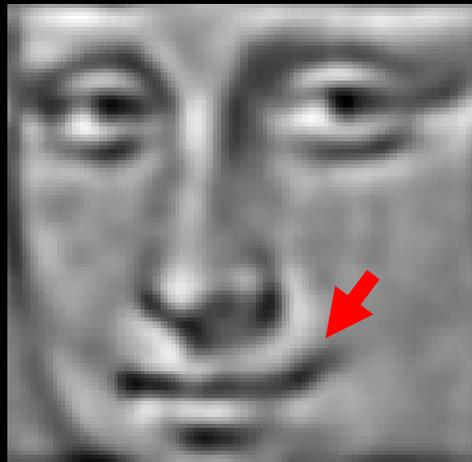
## Leonardo da Vinci's Mona Lisa



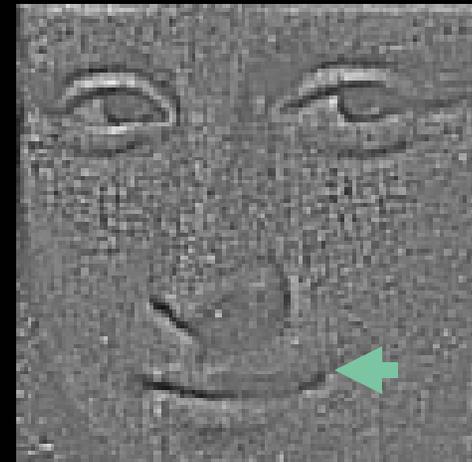
Smile



Smile



No smile



Low

Spatial frequency

High

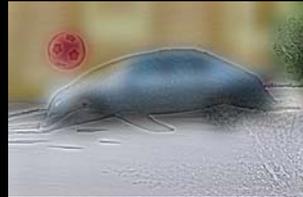
Livingstone, M. (2000). *Science*

Setlur & Gooch (2004), *NPAR*

# Hybrid Images



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# Hybrid Images

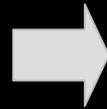
## How do they work?

# Human Visual Perception

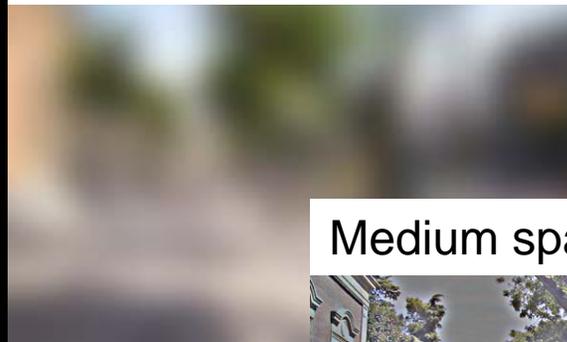


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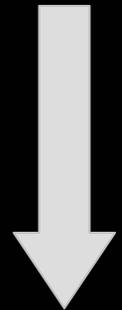
Blur image



Low spatial frequency



Sharp image



Medium spatial frequency



High spatial frequency



Spatial frequency channels



# Multiscale subband decomposition



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Low

Spatial Frequency

High



8

11

17

25

38

57

85

128 c/i

# Contrast Sensitivity Function

Blackmore & Campbell (1969)

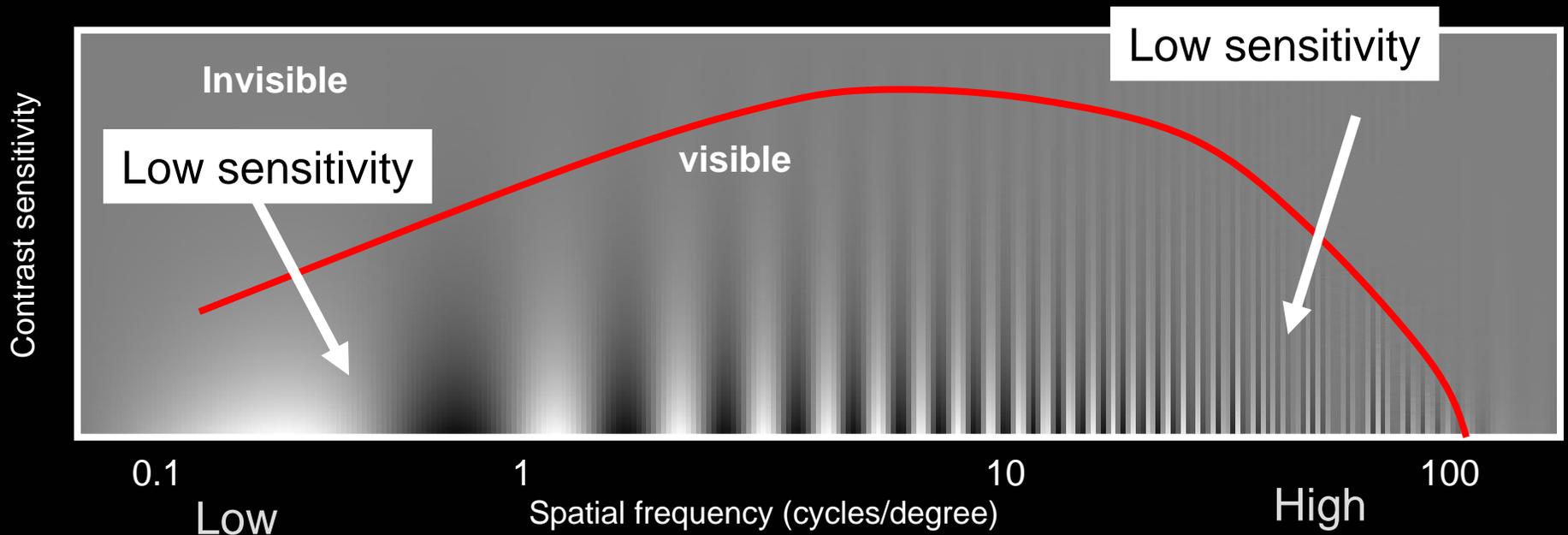


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Low

Spatial Frequency

High



# Contrast Sensitivity Function

Blackmore & Campbell (1969)



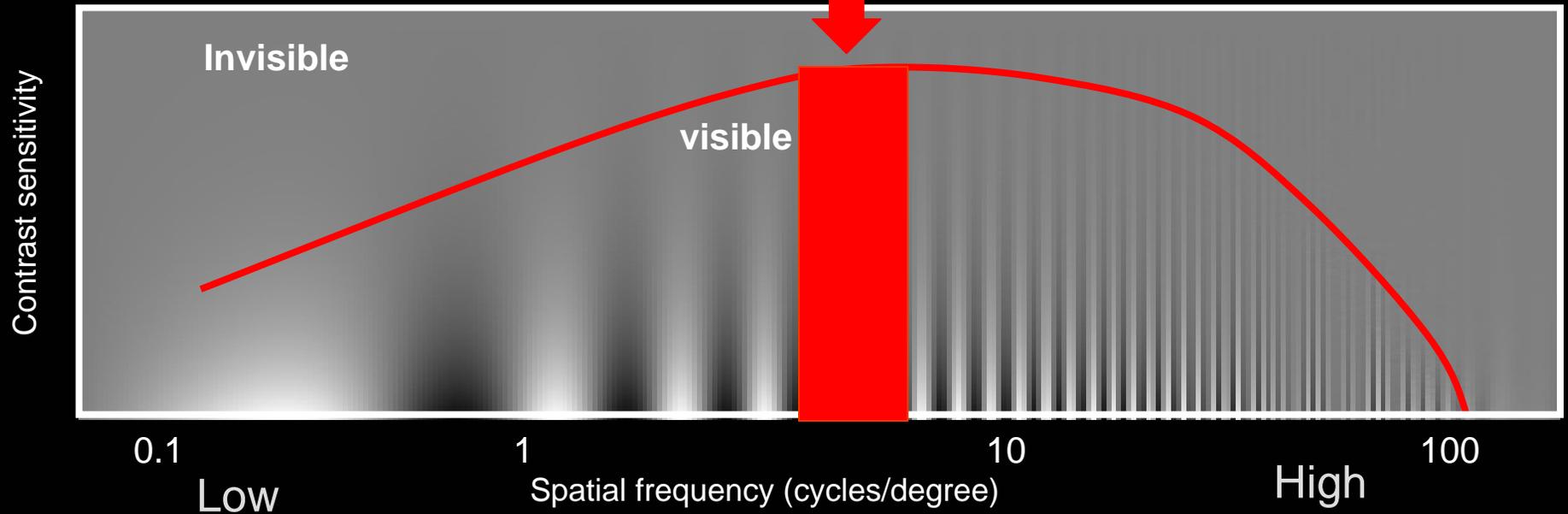
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Low

High



Maximum sensitivity  
~ **6** cycles / degree of visual angle

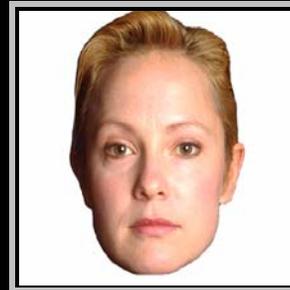




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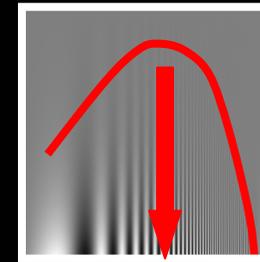


10 deg.



20 cm

1 meter



$6 \text{ c/d} * 10 \text{ deg/i}$

Peak sensitivity at 60 cycles/image



8

11

17

25

38

57

85

128 c/i

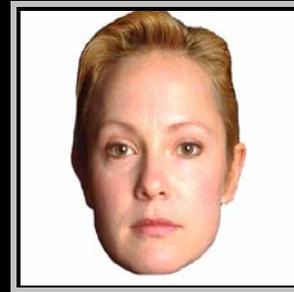
Spatial Frequency



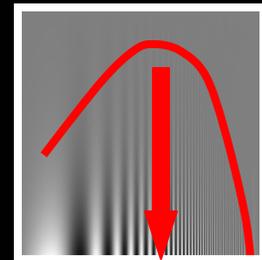
2 deg.



6 meters



20 cm



Peak sensitivity at 12 cycles/image

$6 \text{ c/d} * 2 \text{ deg/i}$



8      11      17      25      38      57      85      128 c/i

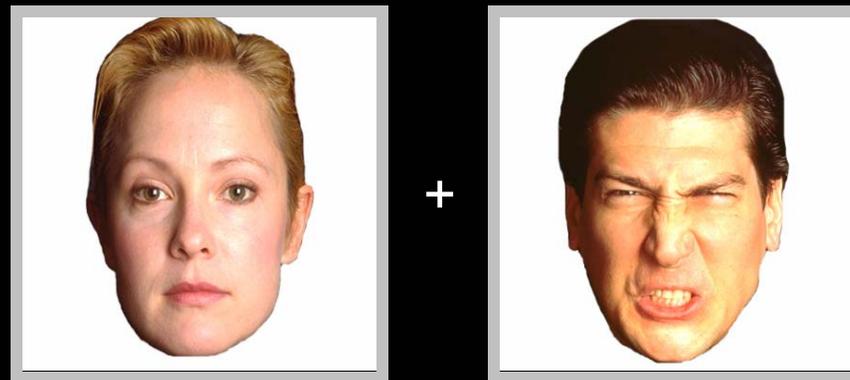


Spatial Frequency

# Perception of hybrid images



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8

11

17

25

38

57

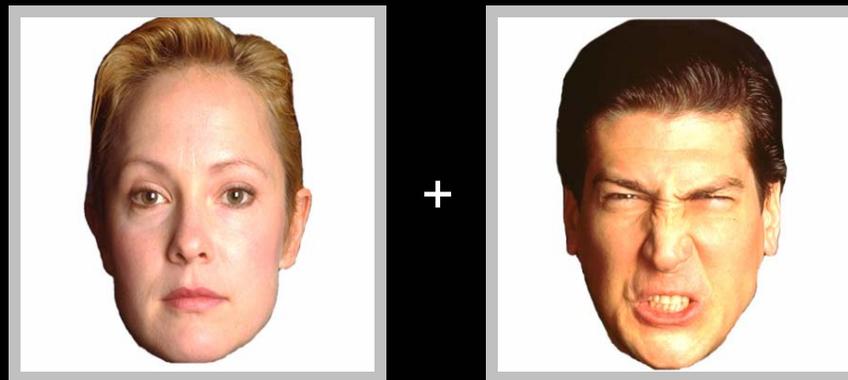
85

128 c/i

# Perception of hybrid images



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Male dominance

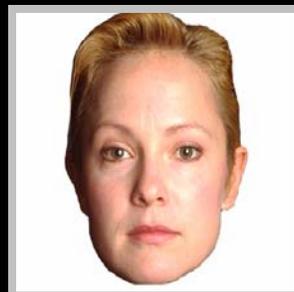
Female dominance



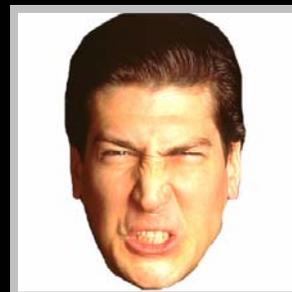
**A man or a woman ?**



10 deg.



+



20 cm

1 meter

It's a woman!

Peak sensitivity at 60 cycles/image



8

11

17

25

38

57

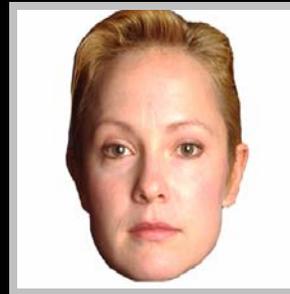
85

128 c/i

Spatial Frequency



2 deg.



+



20 cm



6 meters

I see an angry guy

Peak sensitivity at 12 cycles/image



8

11

17

25

38

57

85

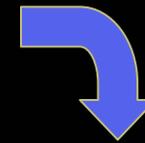
128 c/i

Spatial Frequency

# Perception of hybrid images

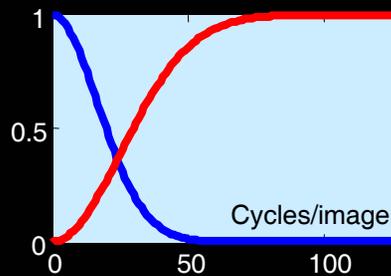


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1- Frequency cut = 16 cycles/image

Frequency domain



2- Frequency cut = 36 cycles/image



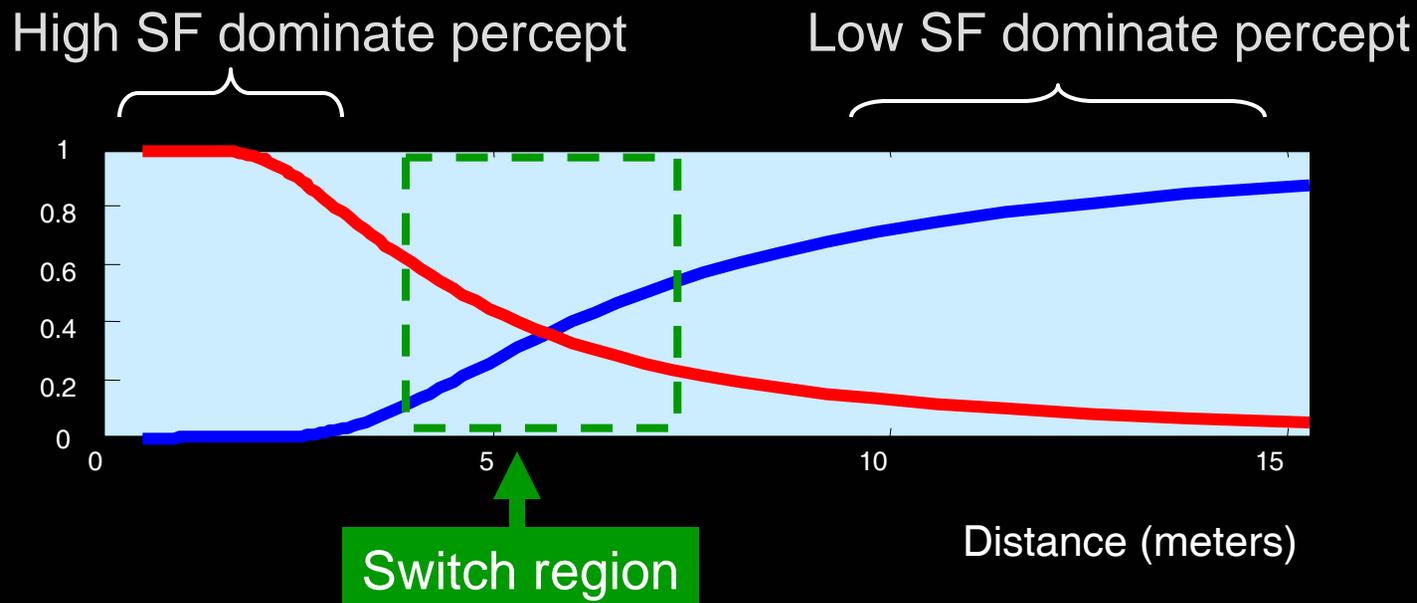
# Perception of hybrid images



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The distance of switch is a function of

- Image size
- Cut-off frequencies for the individual images





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# Hybrid Images

The little details that matter



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# Principles of Perception

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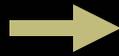
The challenge is to look good in close up

- Alignment
- Perceptual Grouping
- Color

# Alignment



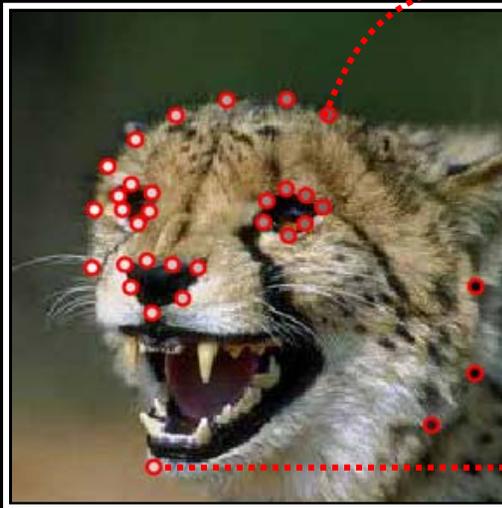
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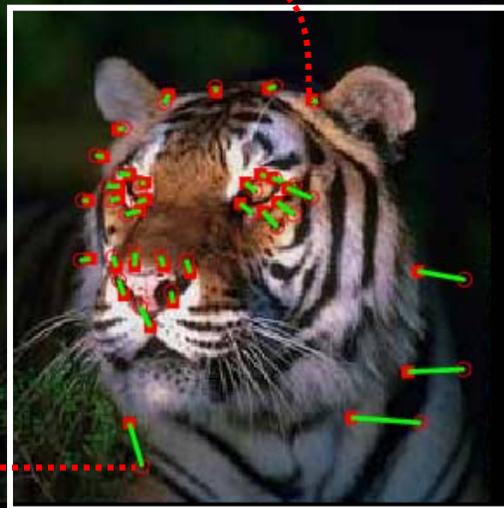
# Alignment



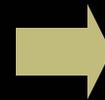
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Cheetah



Tiger



Aligned Tiger

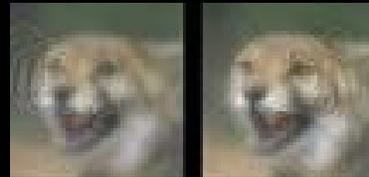
# Alignment



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Far view

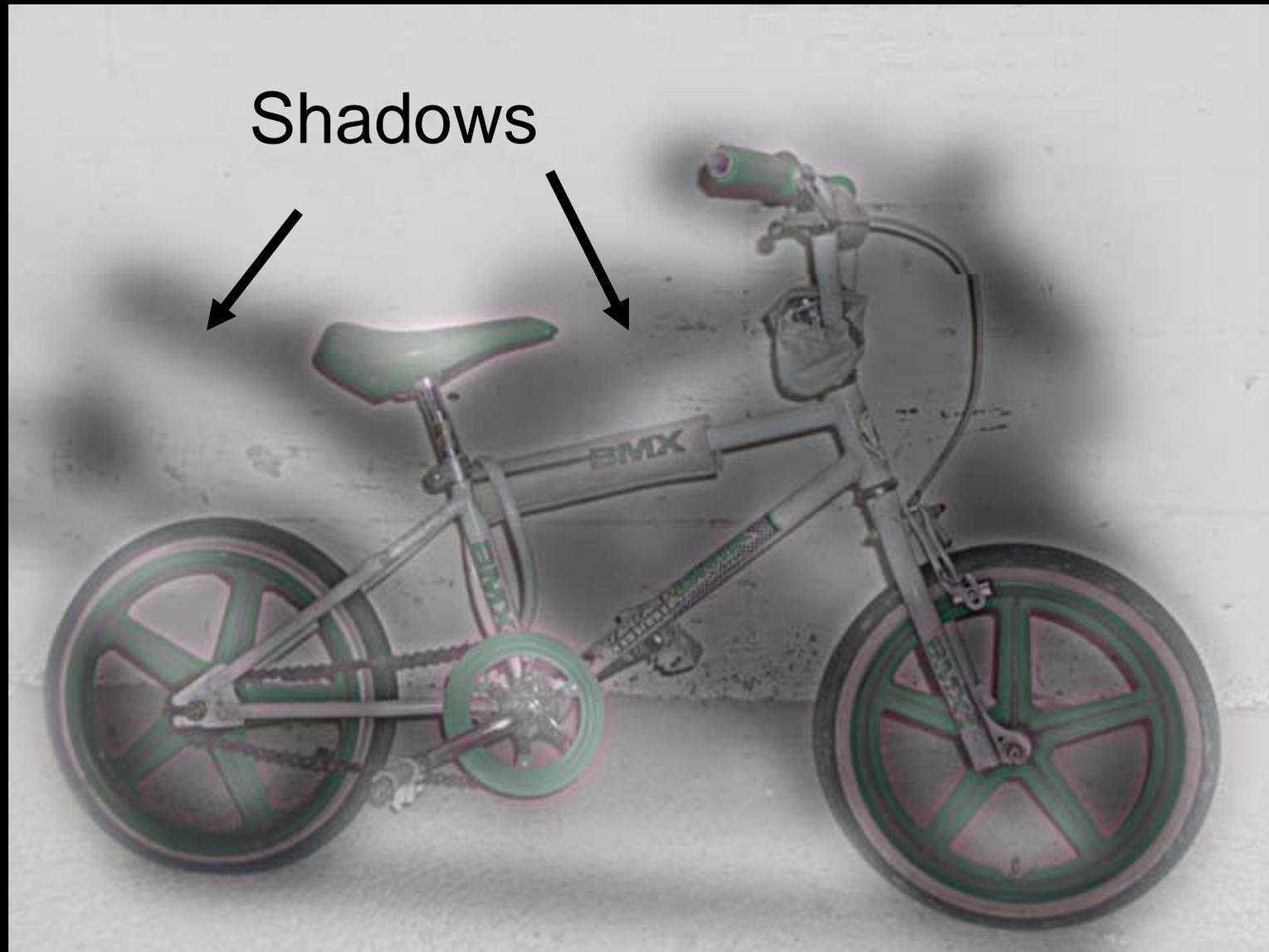
Not aligned



Aligned



# Perceptual Grouping

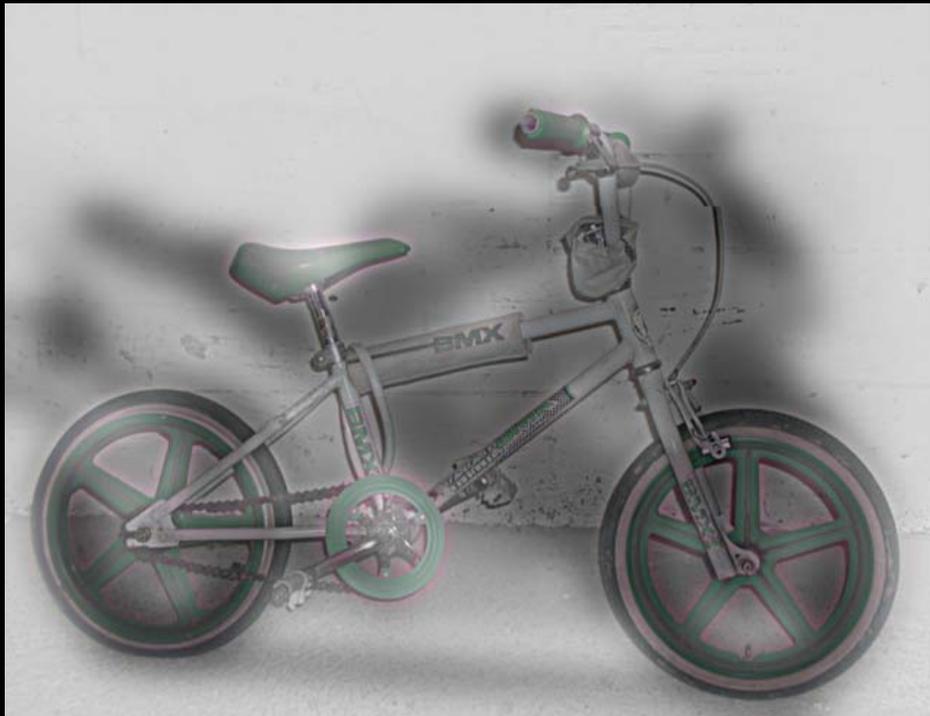


# Perceptual Grouping



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Reorganization of the shadows as a motorcycle



# Color in high spatial frequencies





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# A few examples of Applications

Especially, whenever you are  
“on the approach”

# Changing expression

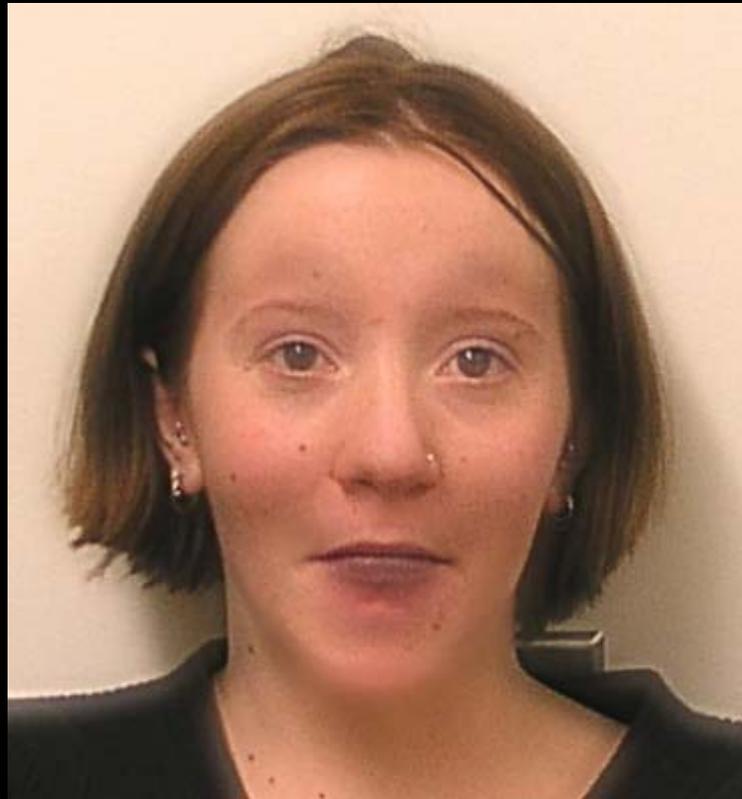


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Sad



Surprised



# Texture superposition



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# Texture superposition



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Original

Cat mask

Transparency

Hybrid

# Advertising



# Private font



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Low spatial frequencies in an hybrid can be used to mask text that will be readable otherwise





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# Private font

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This text can only  
be read by some-  
body close enough  
to the screen.

This text can be  
read at a distance.

Low spatial frequencies in an  
hybrid can be used to mask  
text that will be readable  
otherwise



# Hybrid Images

## “A change on the approach”

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- Images that change interpretations as a function of viewing distance
- Hybrid images are based on the band-pass characteristics of human vision

# Acknowledgments



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## Acknowledgments

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