Non-Photorealistic Rendering and the Science of Art

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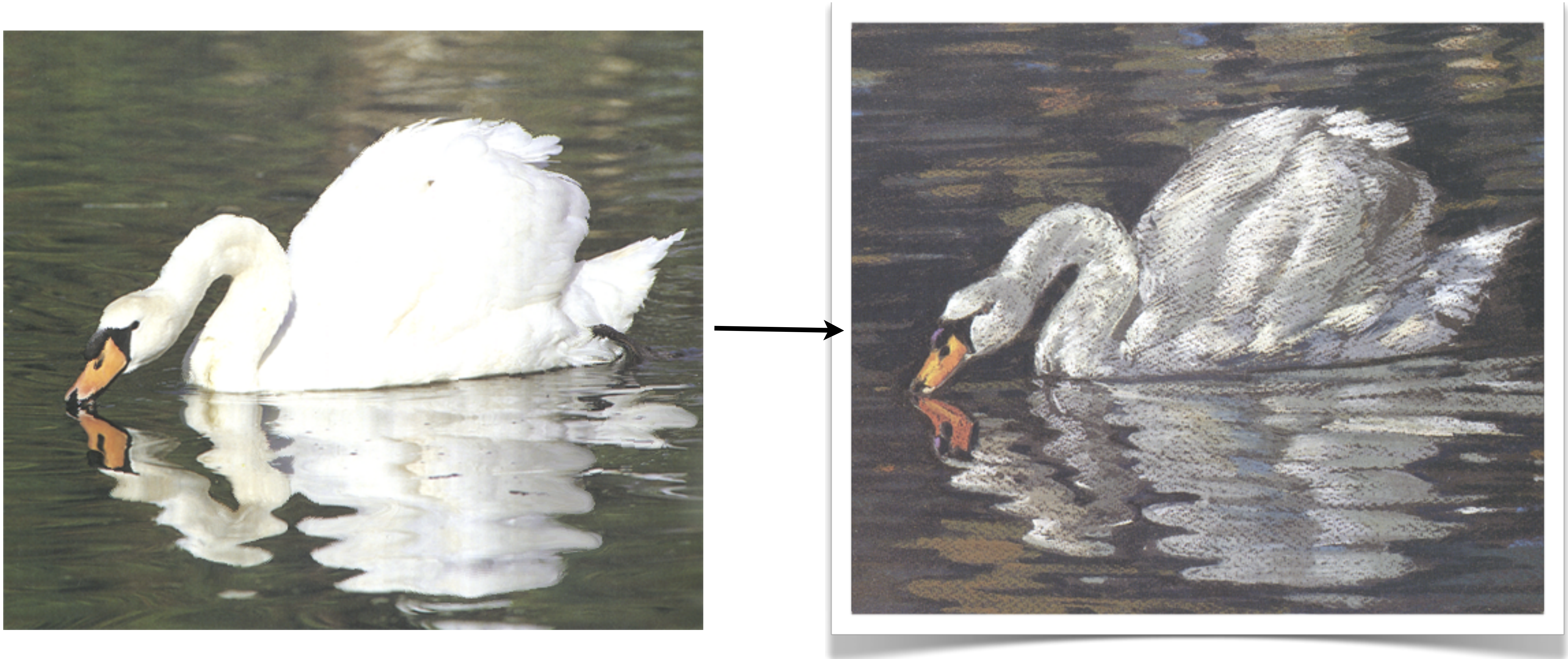
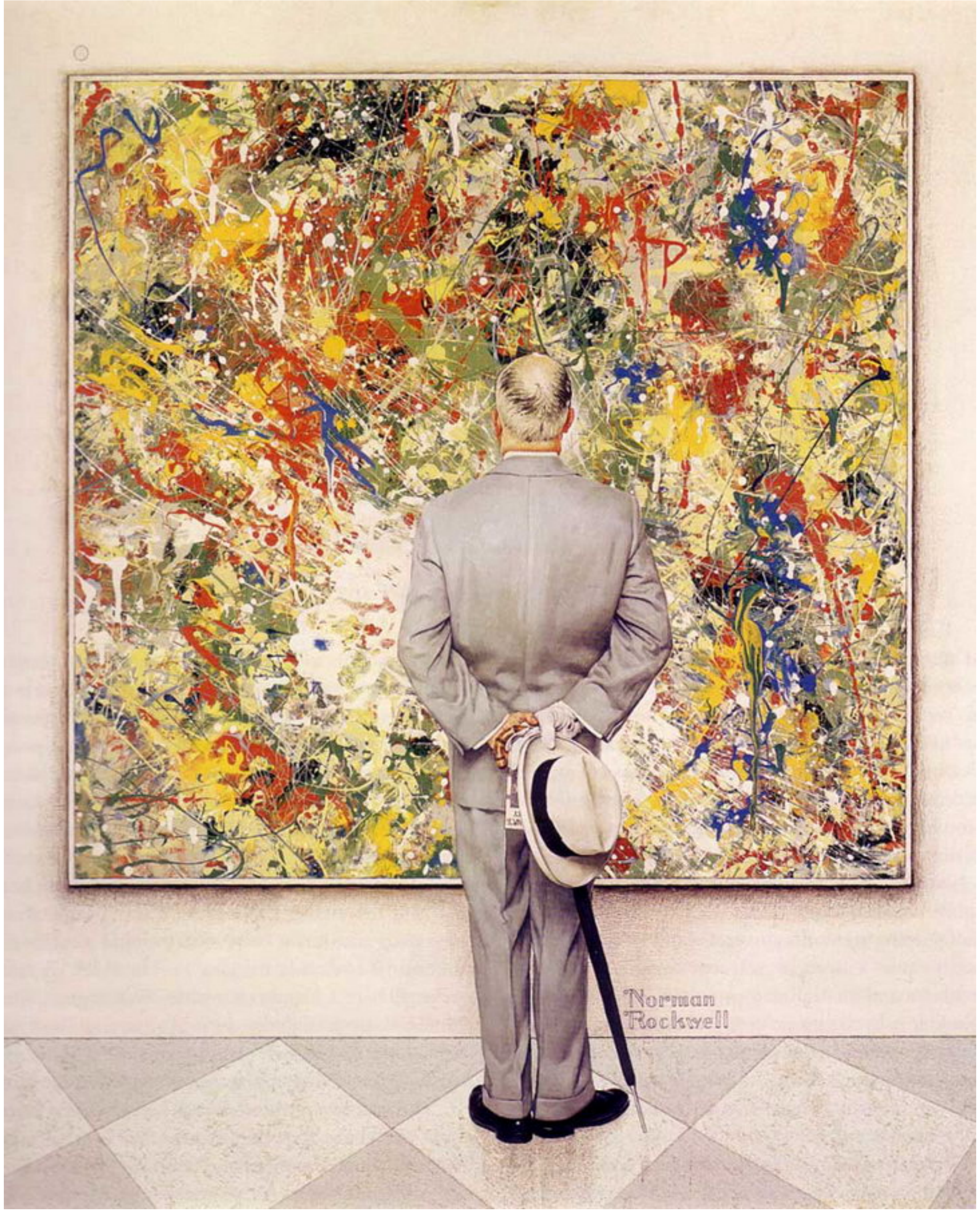
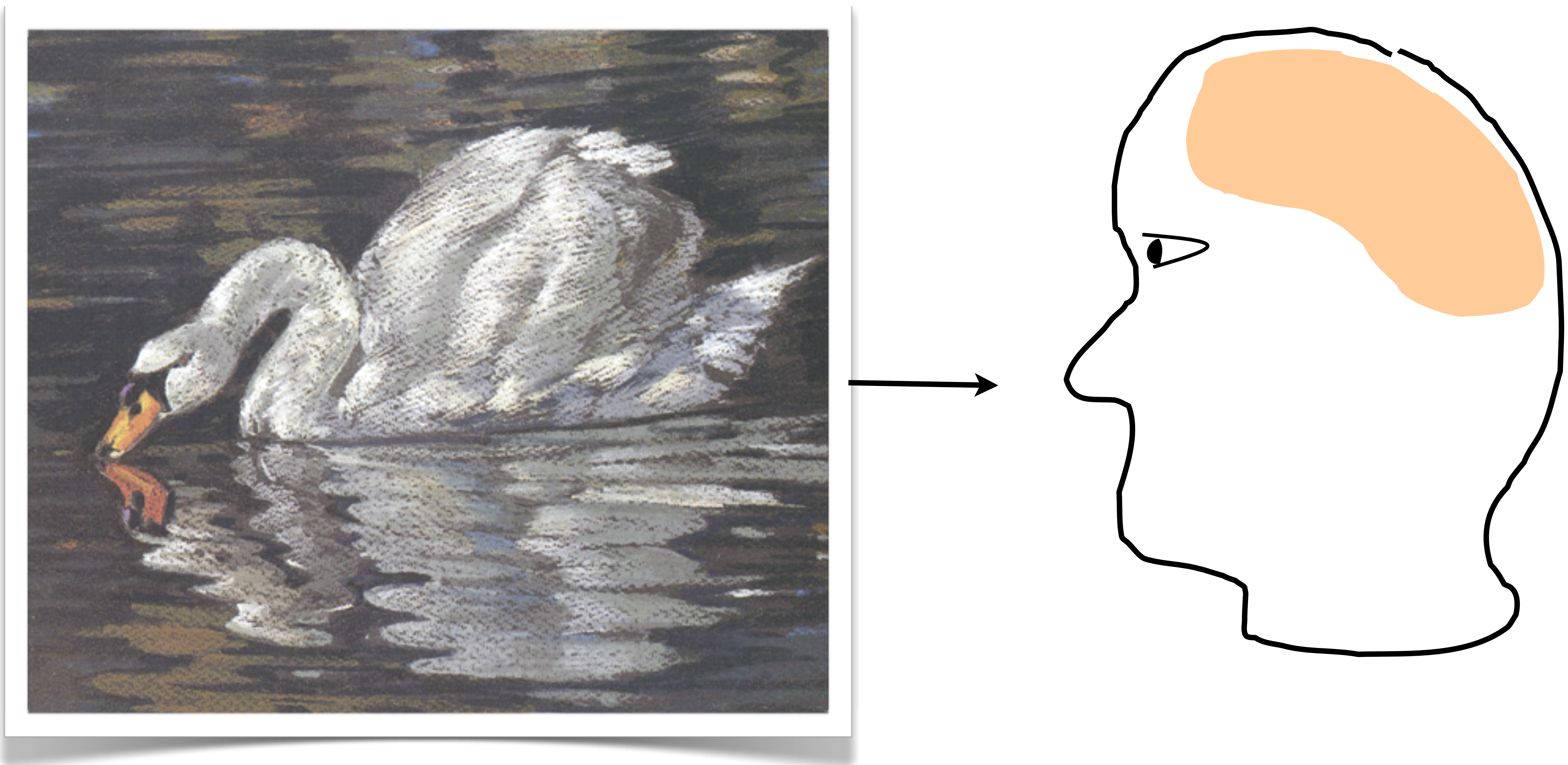
1. How do artists create imagery?



1. How do artists create imagery?



2. How do viewers respond to artistic imagery?

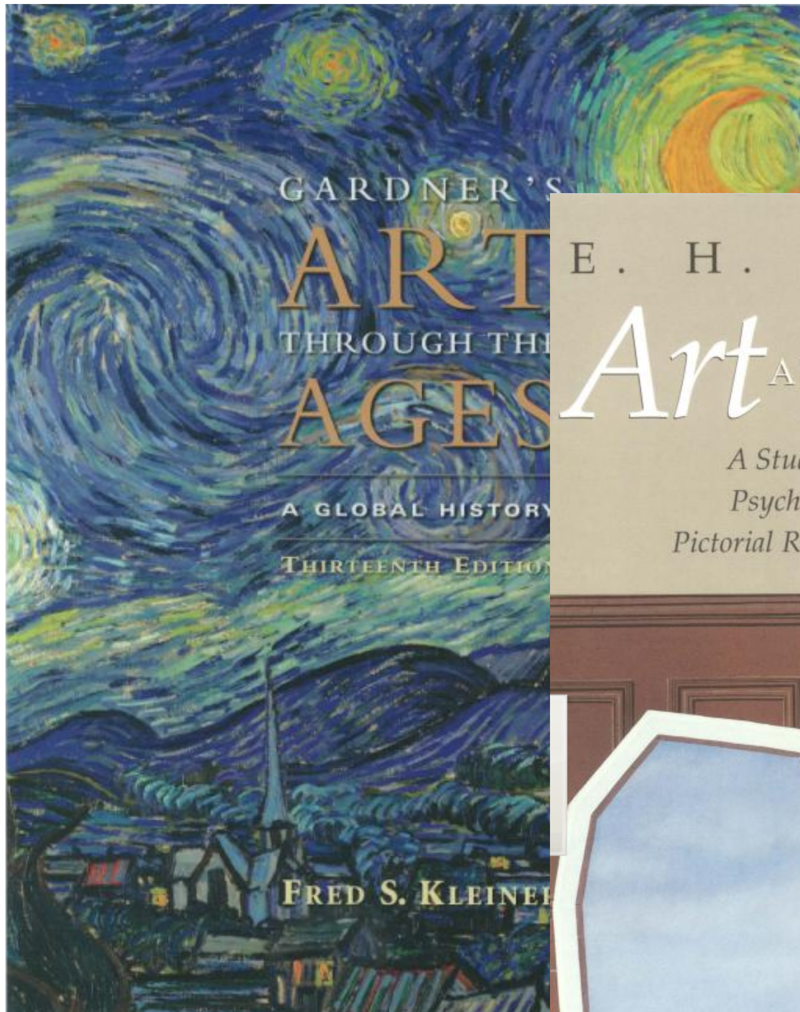


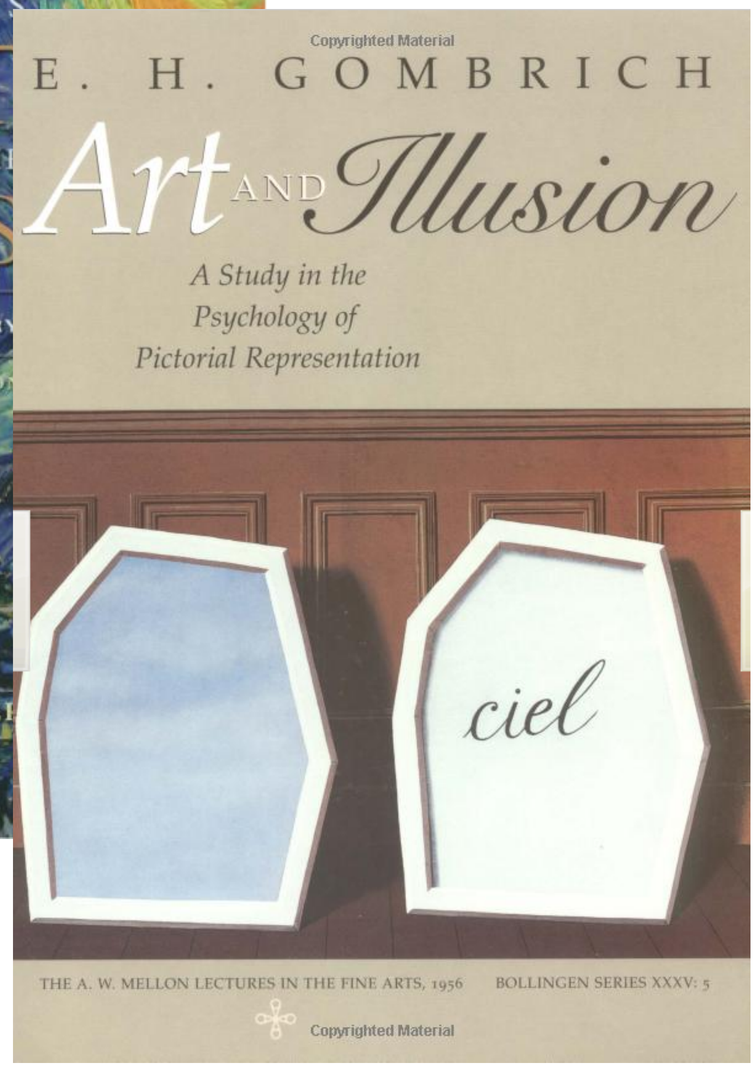
2. How do viewers respond to artistic imagery?

Non-Photorealistic Rendering must play a central role in the scientific understanding of visual art and illustration

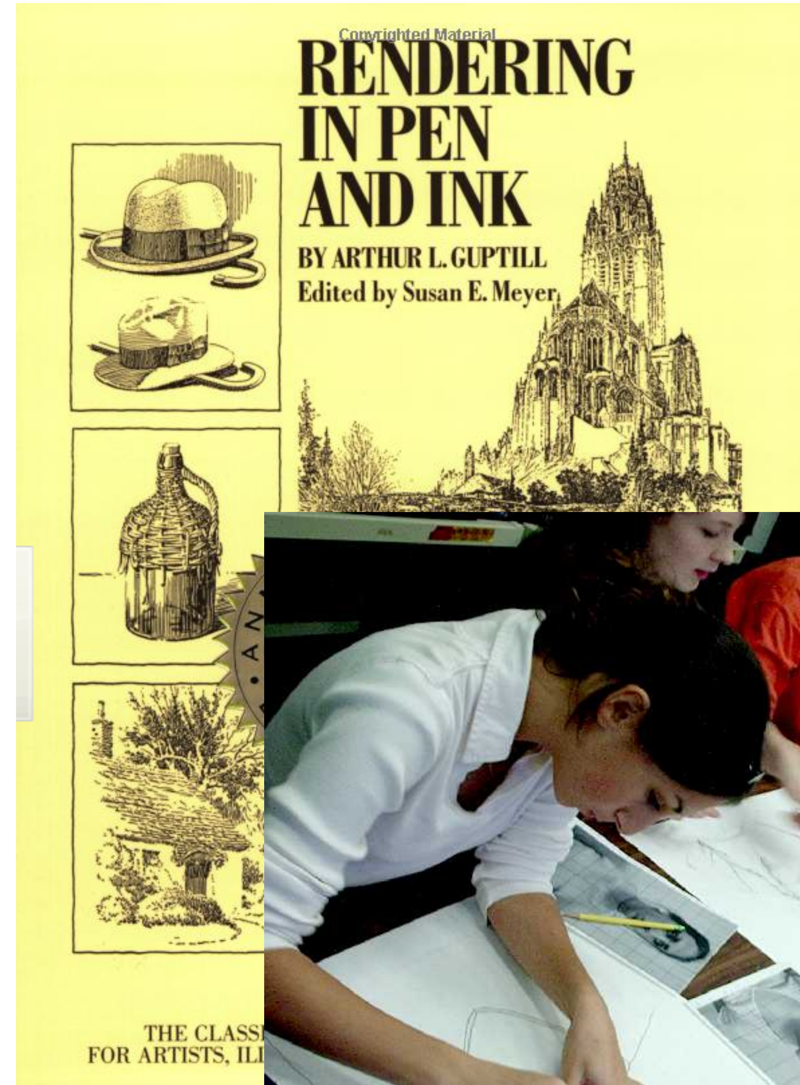
A scientific understanding of art could:

1. Further human knowledge
2. Lead to new tools
3. ... and new kinds of art and illustration

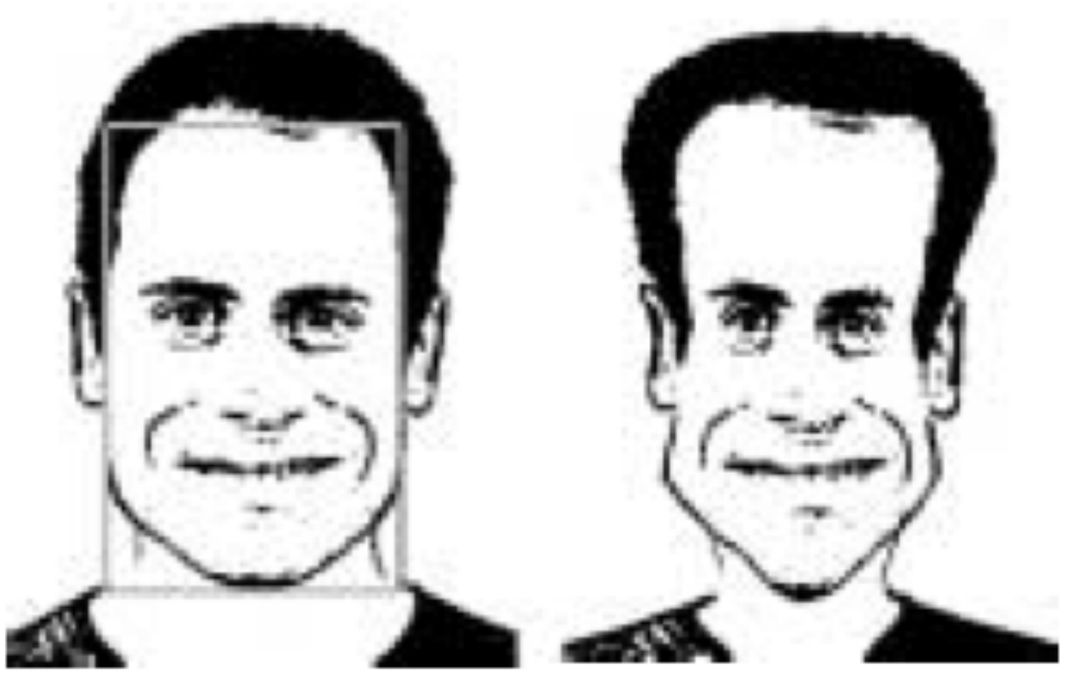




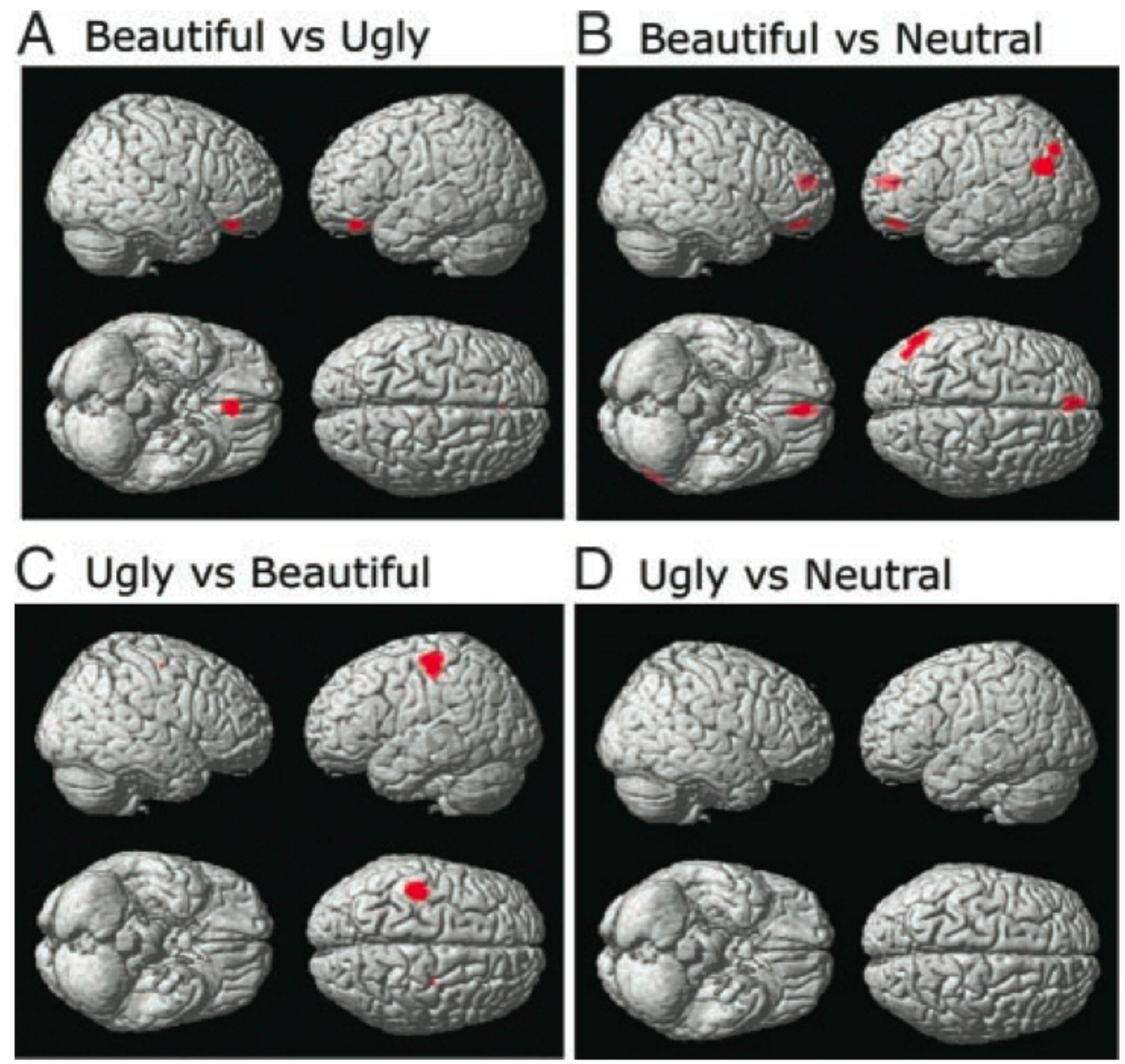
Art history
and criticism



Art instruction



[Gooch et al. 2004]



Peak-Shift
[Ramachandran and Hirstein 1999]

MRI data
[Kawabata and Zeki 2004]

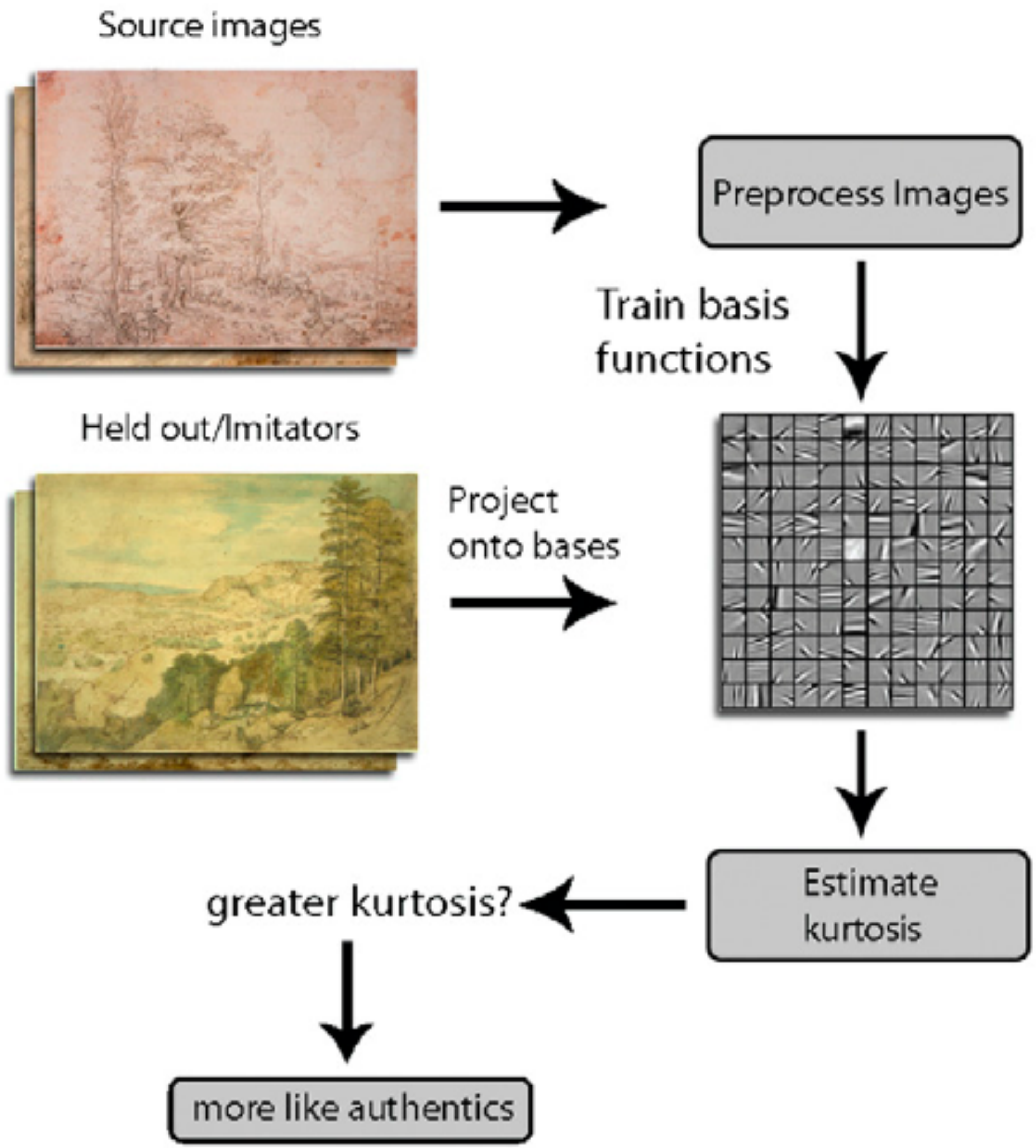
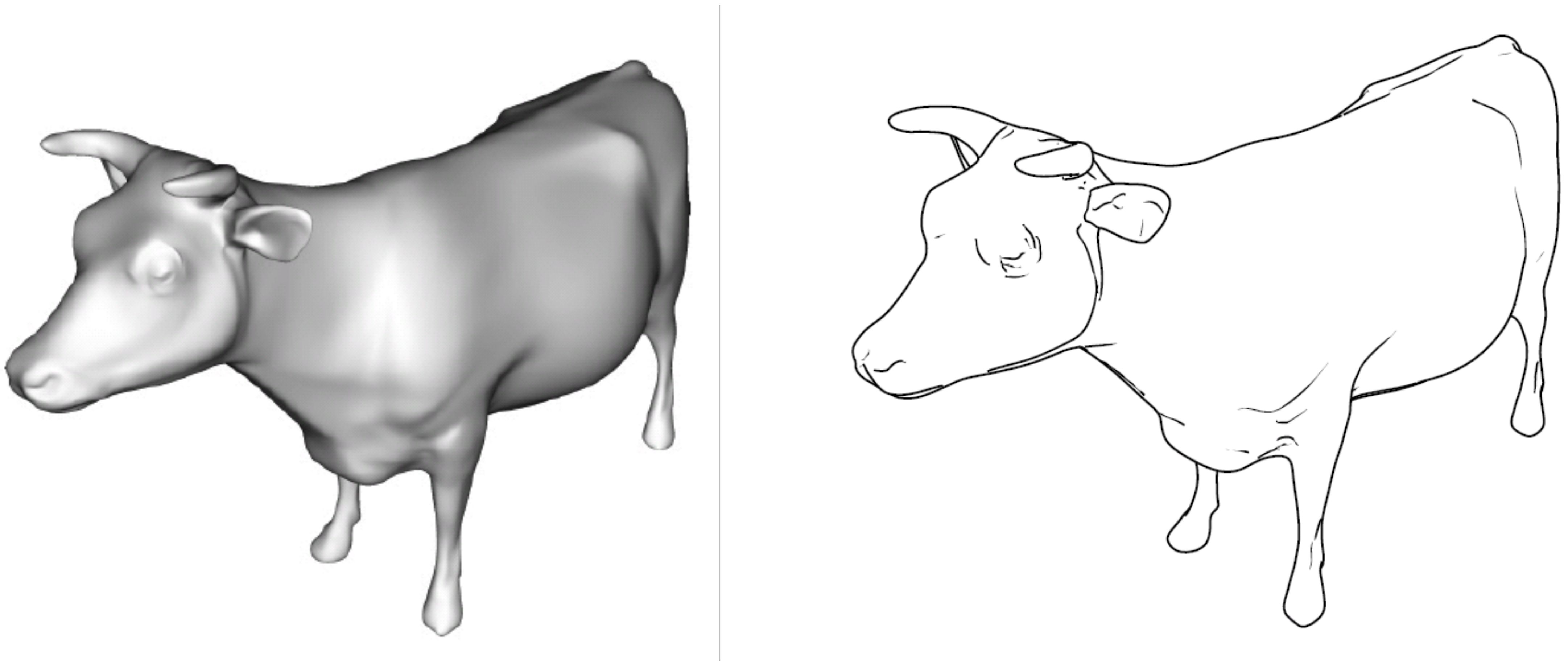


Image statistics [Hughes 2010]

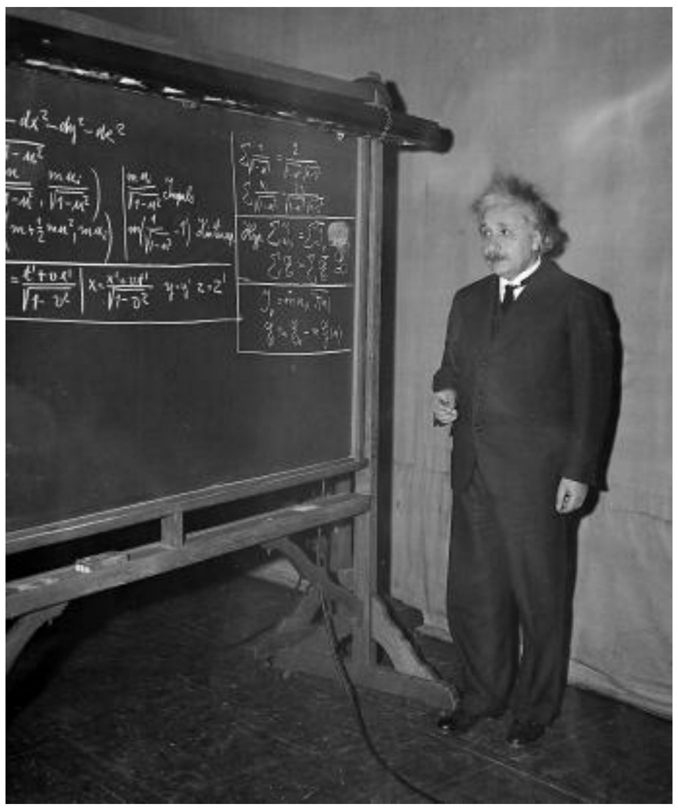
	Descriptive	Generative
Qualitative	Art history and criticism	Art instruction
Quantitative	Image statistics	NPR

[Haeberli 1990]



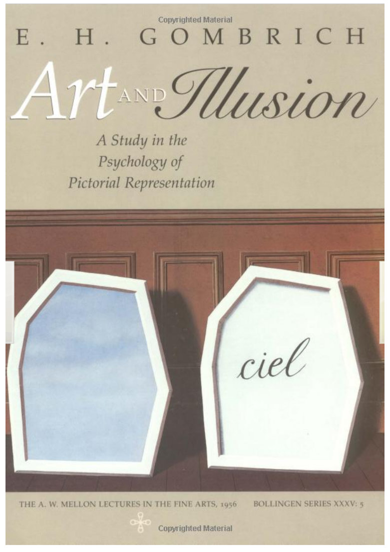
[DeCarlo et al. 2003]

The pillars of science

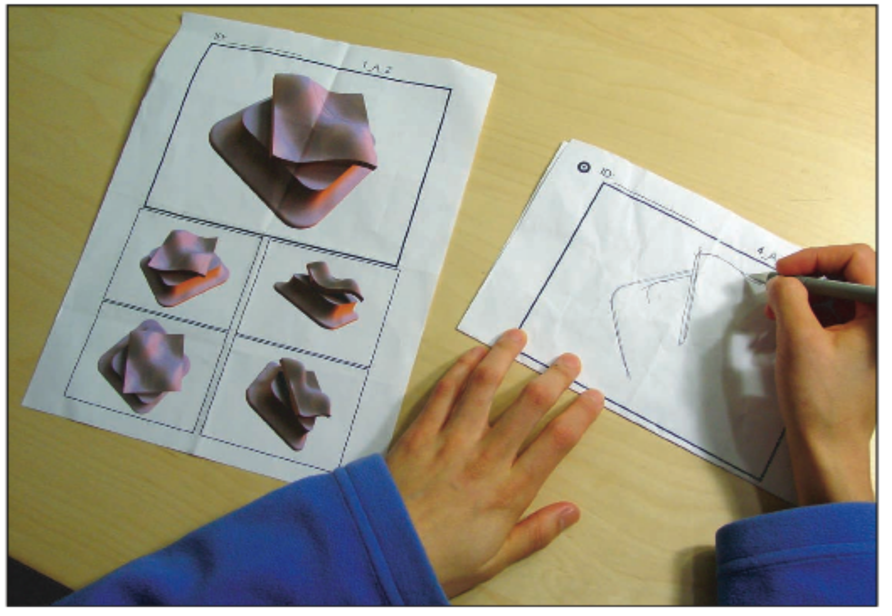

Theory


Experiment

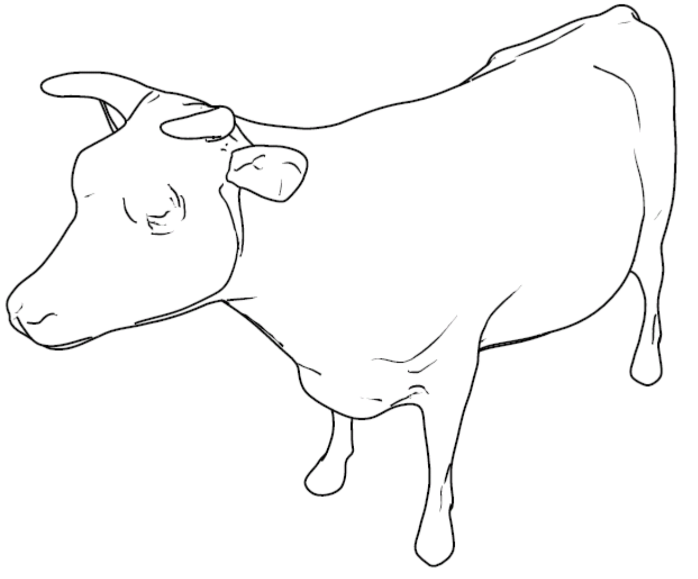
Computation



Theory



Experiment



Computation

[Cole 2008]

This work research experimental studies

- Current usage of studies is very haphazard
- We need a *new* methodology for NPR
- But many papers do not need any studies

See the paper for much more discussion

Some useful models for us:

1. Optimality theories in biology

2. Computational neuroscience and vision

Optimality theory in evolutionary biology

G. A. Parker & J. Maynard Smith

Optimization models help us to test our insight into the biological constraint
of evolution. They serve to improve our understanding about adaptations,
that natural selection produces optimal solutions.

IN recent years, optimization theory and game theory have been widely used, particularly by field biologists, to analyse evolutionary adaptation[1-7]. During the same period, originating with a classic paper by Gould and Lewontin[8], there has been continuing criticism of the optimization approach. This criticism seems to arise from the idea that those who adopt the approach assume either that animals and plants are optimally adapted, or that they are trying to prove that they are so. Hence any demonstration of the role of chance events—for example, that much molecular variation is selectively neutral, or that unpredictable events have had a major effect on evolution—has been seen as undermining the optimization approach. If, by this review, we could lay rest to the idea that the application of optimization theory requires either that we assume, or that we attempt to prove, that organisms are optimal, we would be well satisfied.

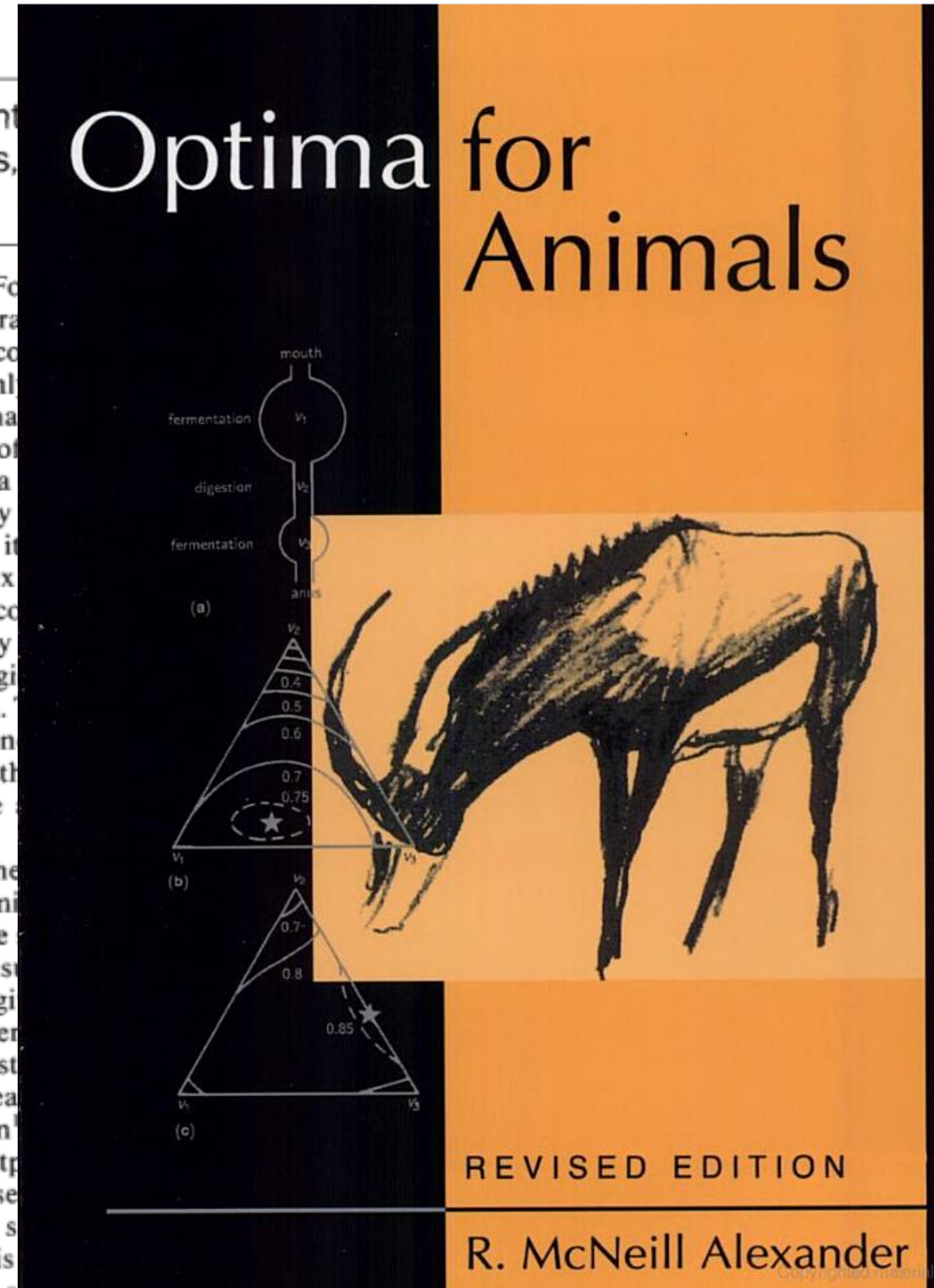
It is true that the optimization approach starts from the idea, already familiar to Darwin, Wallace and Weismann in the last century, that adaptation is a pervasive feature of living organisms, and that it is to be explained by natural selection. It is not our aim to add to this the claim that adaptation is perfect. Rather, the aim is to understand specific examples of adaptation, in terms of the selective forces and the historical and developmental constraints operating. This requires that we have an explicit model, in each specific case, that tells us what to expect from a given set of assumptions. The predictions are an inevitable consequence of the assumptions. A model cannot then be 'wrong' (unless analysed incorrectly), but it can certainly be inappropriate if it is based on assumptions that are not well founded.

We distinguish between general models and specific models[9], though in reality they form part of a continuum. General models have a heuristic function; they give qualitative insights into the

the question is defined. Fo
obvious strategy set (the ra
sider is all points in the co
offspring to producing onl
need not be continuous: ma
Thus, for a bird's choice of
might include nesting in a

The strategy set simply
given what we consider i
Often, as in the case of sex
strategy set that logically co
cases it is necessary to rely
feel for candidate strategi
existing range of variation.
define some obvious boun
but strategic possibilities th
are included unless there
them out.

In the construction of the
about what is being maximi
fitness is usually used. The
ted lifetime number of s
individual pursuing a gi
defined in units of gener
phenotype). Many life-hist
cumbersome rate of increa
the Euler–Lotka equation
relative reproductive outp
equate roughly with the se
population genetics) will s
are relatives, however, it is
'inclusive fitness'[15], which s



Optimality may arise from evolution, learning, or both

Much NPR research is *algorithmic*

Can we describe an art/illustration as optimizing an objective function?

For example, optimize viewer's response

Pros and cons of optimality

Optimality allows us to reason about *goals* without reasoning about *mechanisms*

Testable, reusable components (energy terms)

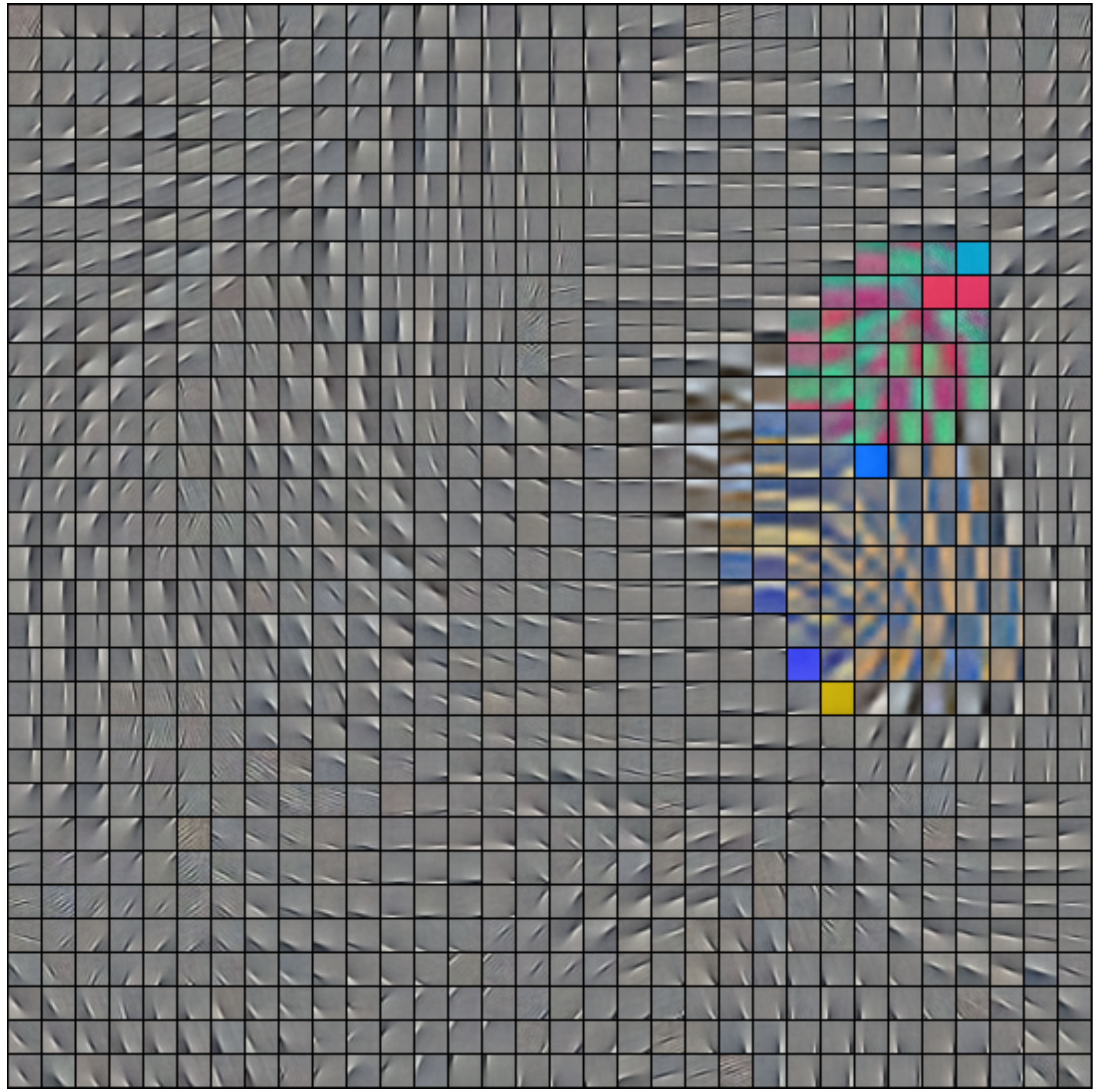
Usually very difficult to optimize

Deterministic (but see paper)

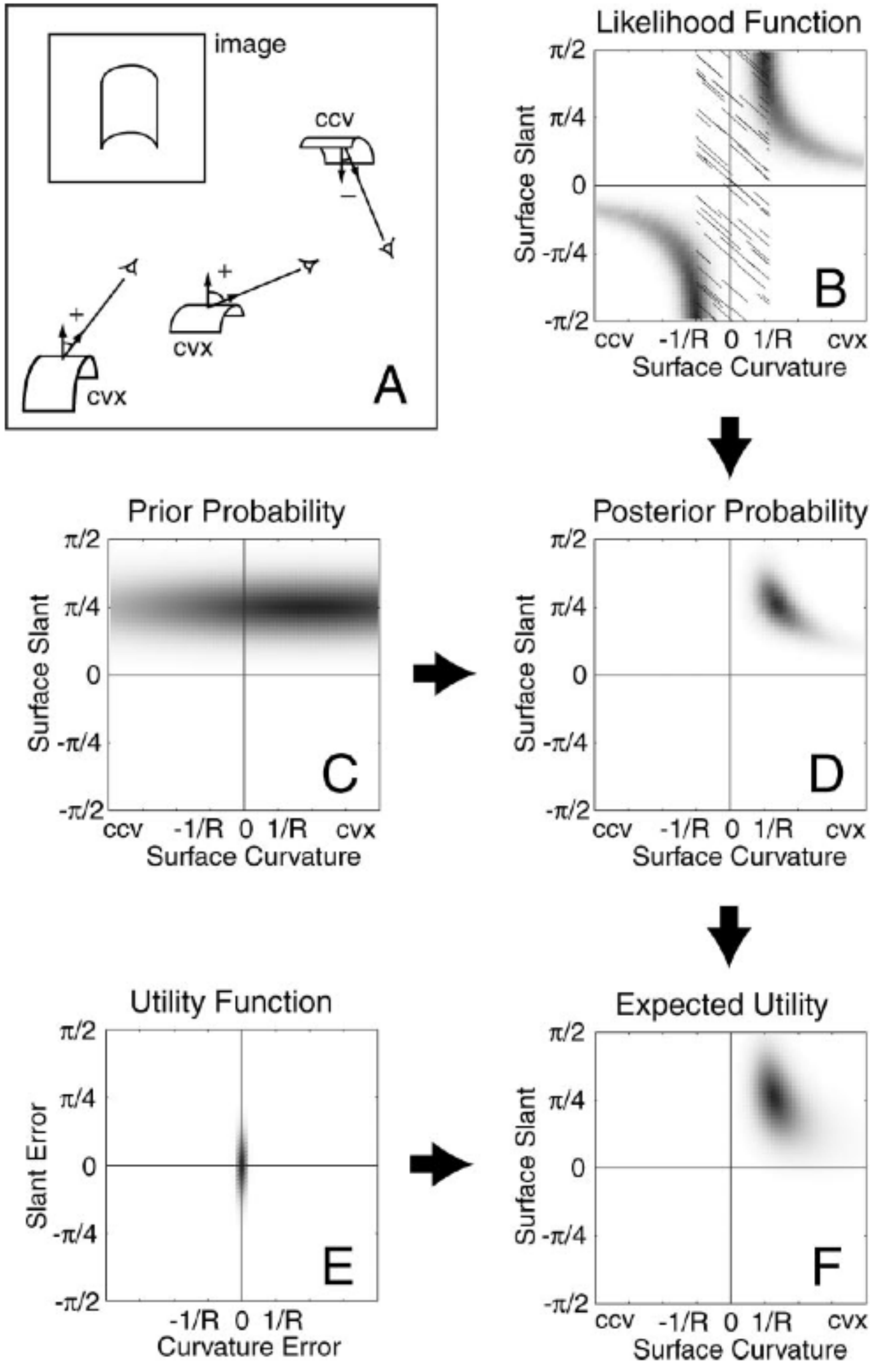
Computational neuroscience and vision

Computational models have played a role in building theories

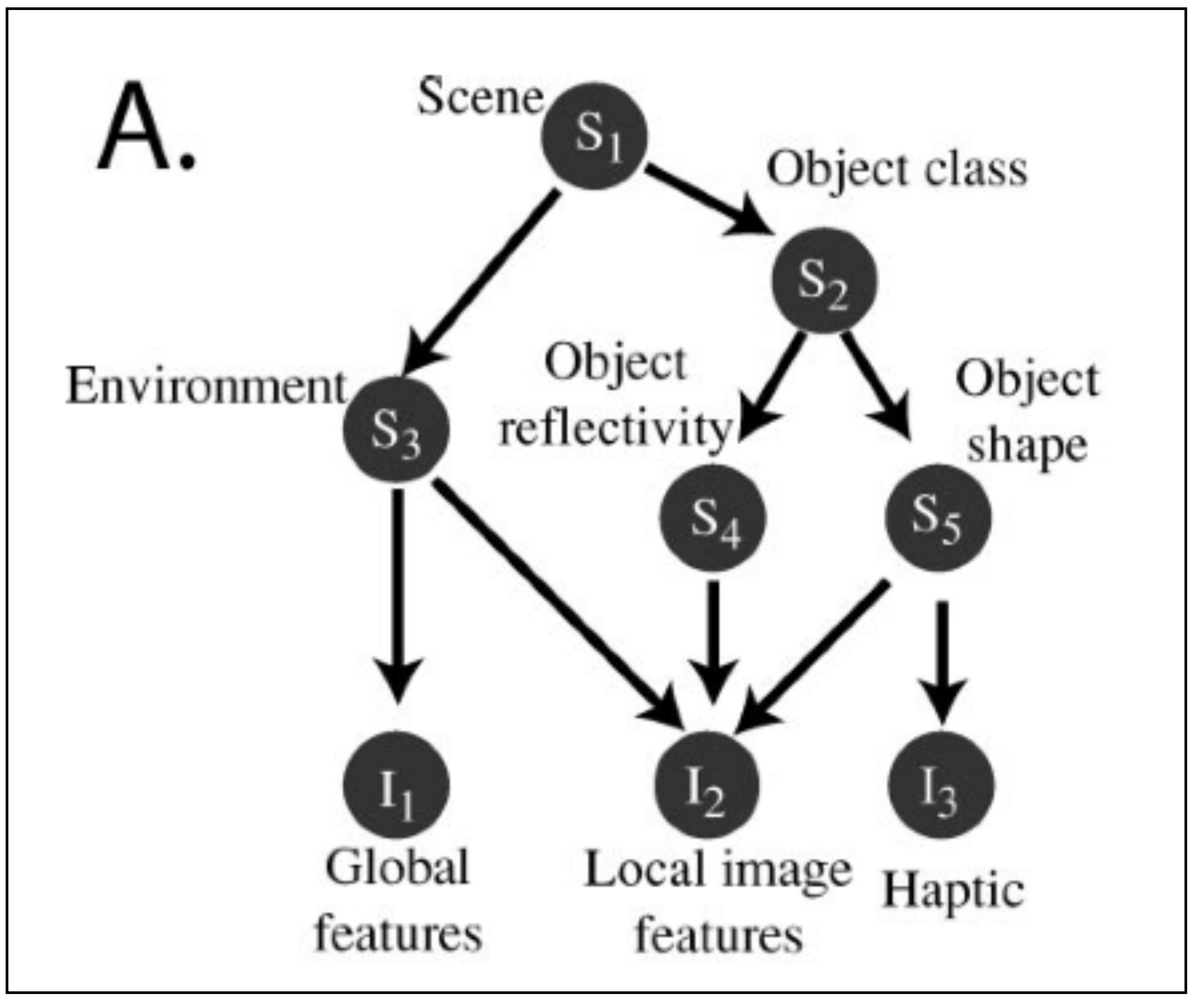
Reason about how something can be computed separately from how it is computed [Marr 1982]

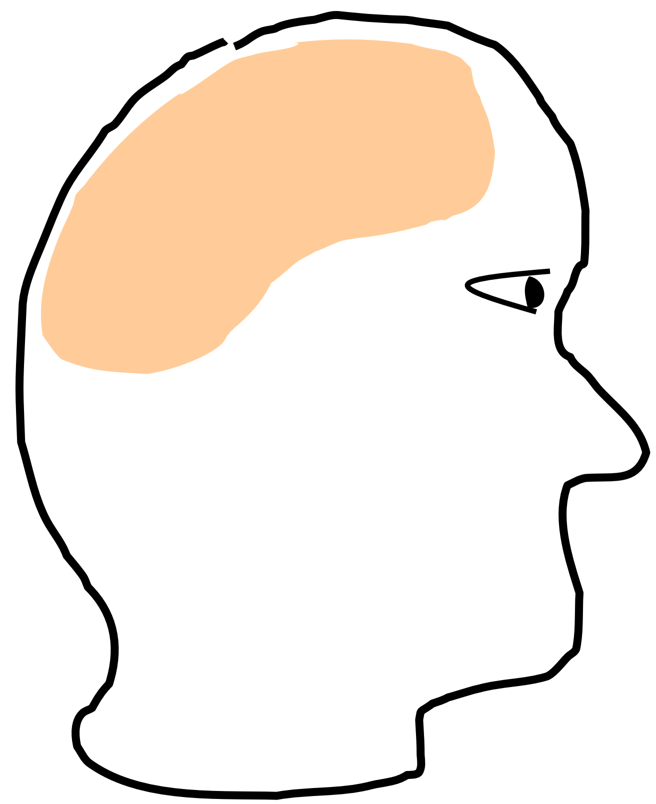


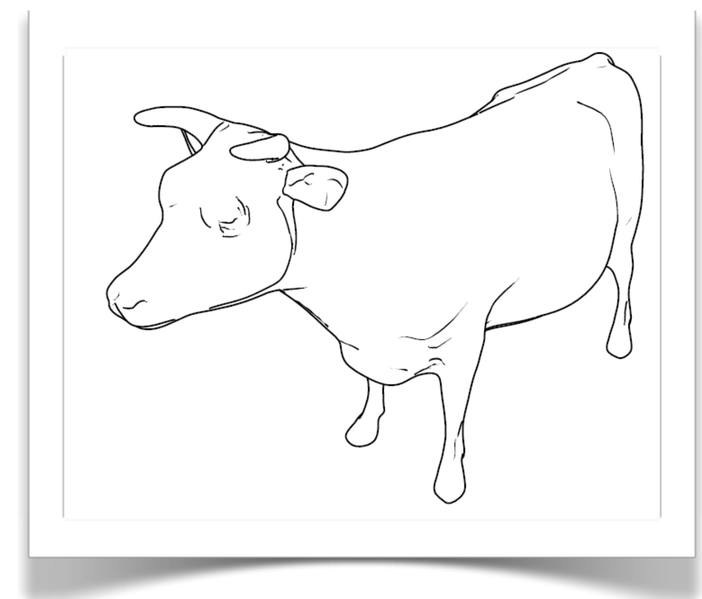
Optimal receptive fields match V1 [Field and Olshausen]
(image courtesy Geoff Hinton)



[Mamassian and Landy]







[Kersten et al. 2004]

Final thoughts

NPR will play a central role in the scientific understanding of visual art and illustration

We need to develop new experimental methodologies and perform more experimental work

This work must ultimately be interdisciplinary

This view of NPR leads to many new research ideas

Please read the paper:

www.dgp.toronto.edu/~hertzman/ScienceOfArt/

Acknowledgements: Maneesh Agrawala, Doug DeCarlo, David Fleet, Ryan Schmidt.
NSERC, CIFAR, Ontario MRI, Hebrew University of Jerusalem.