

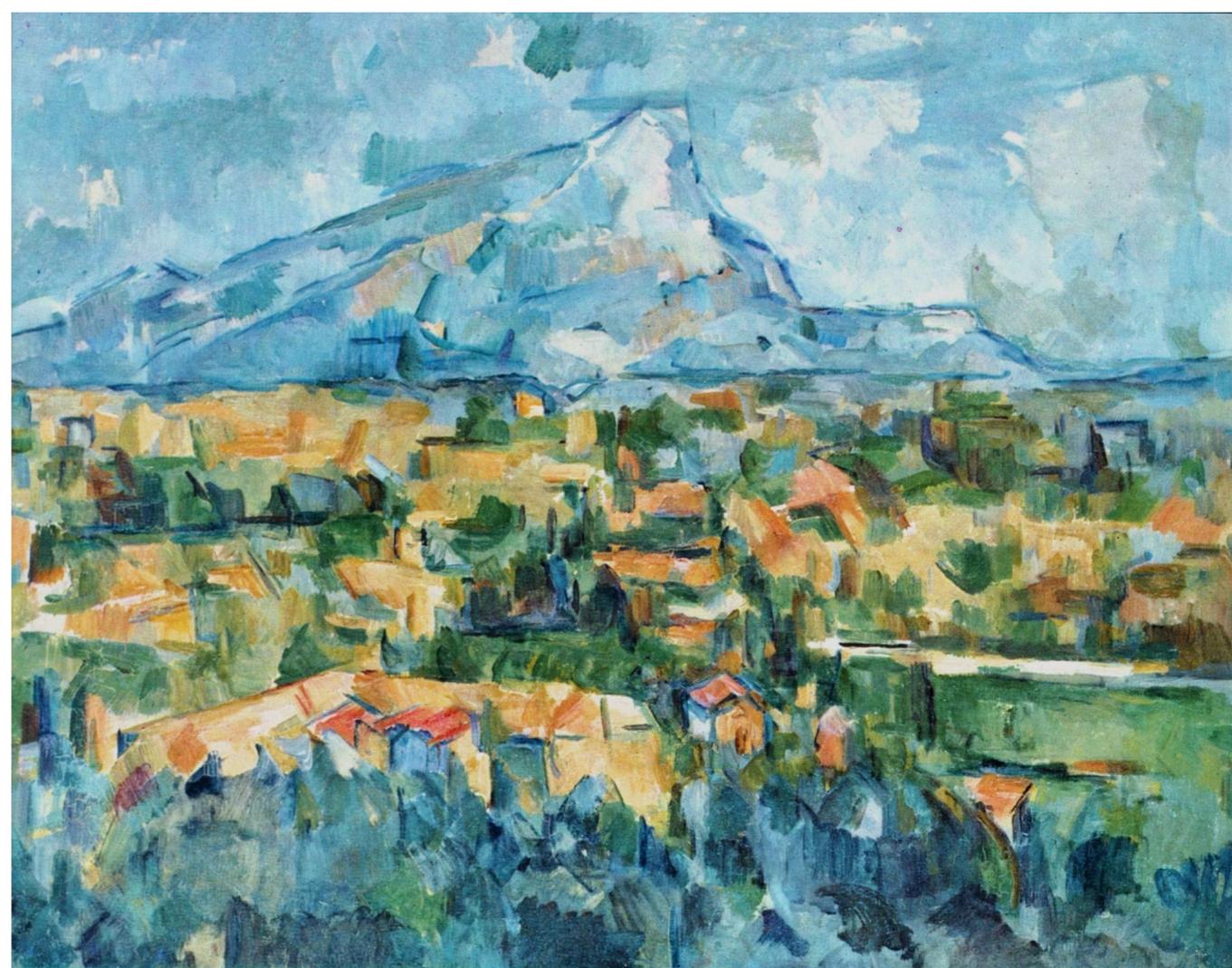
Towards a computational account of art cognition

*Unifying perception, visual art, and
music through Bayesian inference*

Jorge Aurelio Menéndez

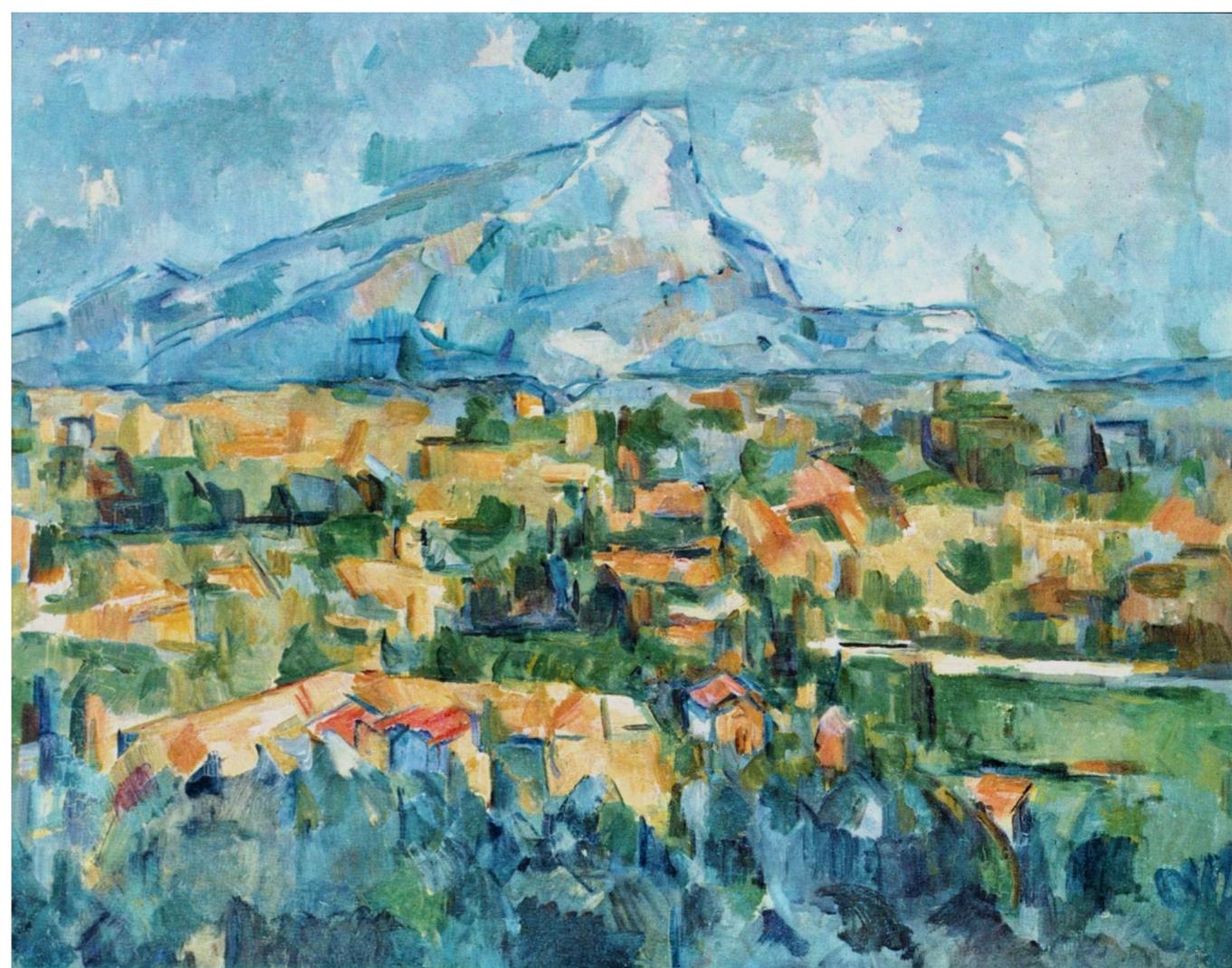
Centre for Mathematics, Physics and Engineering in the Life Sciences and Experimental Biology
University College London

What is art?



What is art?

**What are the computations
that give rise to art?**



Art perception =
computing & evaluating
predictions

Predictions in **Music**

Predictions in **Music**

do re mi fa so la ti ...

{**do**, di, re, me, mi, ...}

Predictions in **Music**

do re mi fa so la ti ...

{**do**, di, re, me, mi, ...}

Predictions in **Music**

do re mi fa so la ti ...

I - IV - ii - I64 - V - ...

{**do**, di, re, me, mi, ...}

{**I**, ii, iii, IV, ...}

Predictions in **Music**

do re mi fa so la ti ...

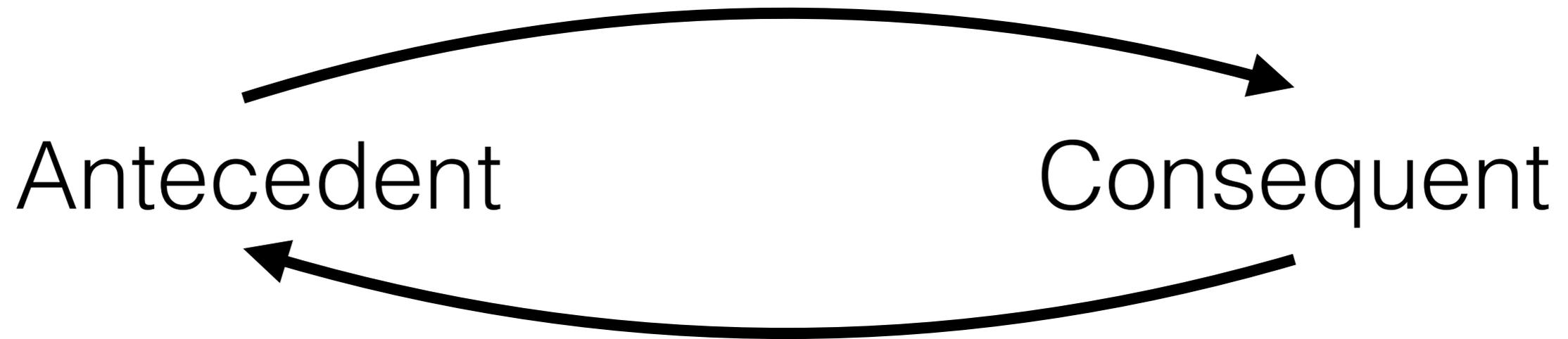
I - IV - ii - I64 - V - ...

{**do**, di, re, me, mi, ...}

{**I**, ii, iii, IV, ...}

Predictions in **Music**

Leonard Meyer (1957)



do re mi fa so la ti ...

I - IV - ii - I₆₄ - V - ...

{**do**, di, re, me, mi, ...}

{**I**, ii, iii, IV, ...}

Predictions in **Music**

Evidence?

Predictions in **Music**

Evidence?

phenomenology

Predictions in **Music**

Evidence?

phenomenology

style

Predictions in **Music**

Evidence?

phenomenology

style

universals

Predictions in **Music**

Evidence?

phenomenology

style

universals

individual differences

Predictions in **Music**

Evidence?

phenomenology

style

universals

individual differences

history of Western music

Predictions in **Music**

Evidence?

phenomenology

style

universals

individual differences

history of Western music

20th century music

Predictions in **Visual Art**

Predictions in **Visual Art**

Interpretation

Predictions in **Visual Art**

Interpretation

“this painting is
about sadness”

Predictions in **Visual Art**



prediction

Interpretation

“this painting is
about sadness”

Predictions in **Visual Art**

[there should be a lot of blue]

prediction



Interpretation

“this painting is
about sadness”

Predictions in **Visual Art**

[there should be a lot of blue]

prediction

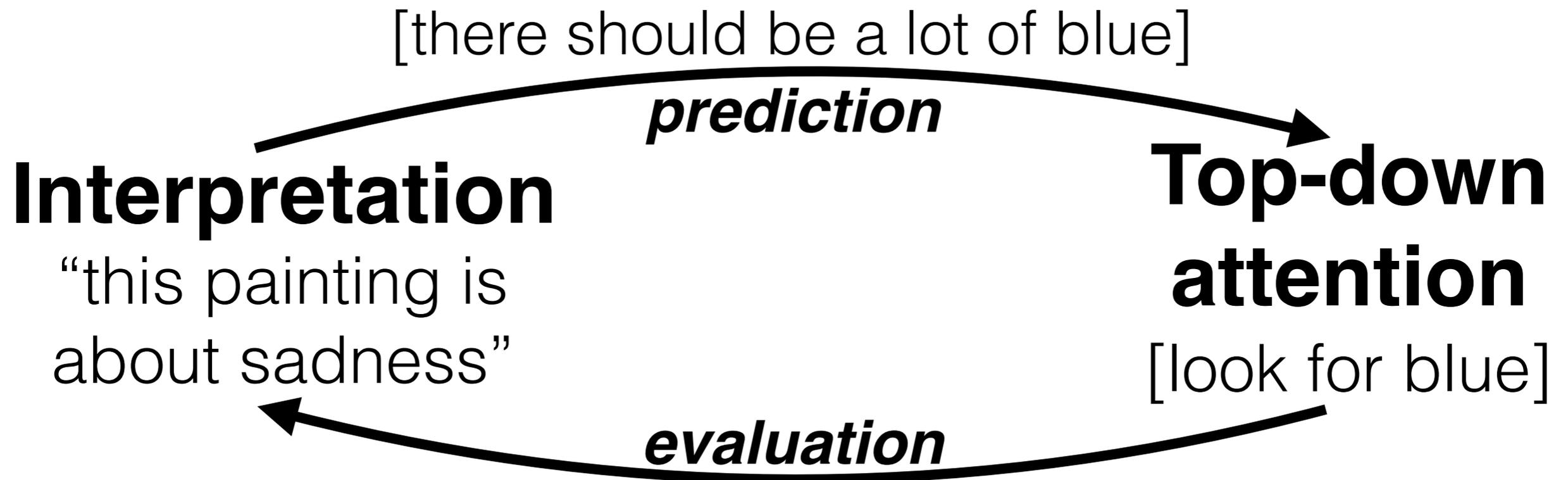
Interpretation

“this painting is
about sadness”

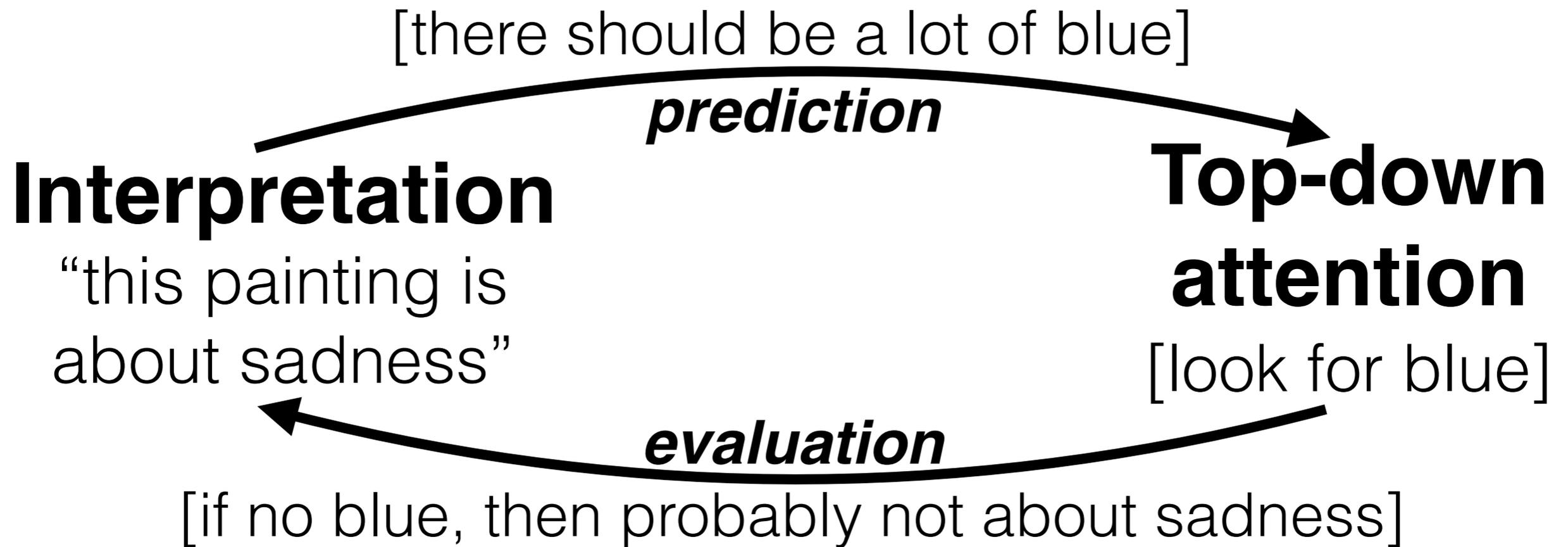
**Top-down
attention**

[look for blue]

Predictions in **Visual Art**



Predictions in **Visual Art**



Predictions in **Visual Art**

Evidence?

Predictions in **Visual Art**

Evidence?

individual differences

Predictions in **Visual Art**

Evidence?

individual differences

top-down effects

Predictions in **Visual Art**

Evidence?

individual differences

top-down effects

Western art history



Art perception =
computing & evaluating
predictions

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computing & evaluating
predictions

Art perception =
computing & evaluating
predictions

Bayesian inference

$$p(H|D)$$

probability of the hypothesis,
given the observed data

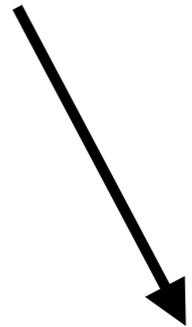
Bayes' theorem

$$\underbrace{p(H|D)} = \frac{p(D|H)p(H)}{p(D)}$$

probability of the hypothesis,
given the observed data

Bayes' theorem

[it is a box]



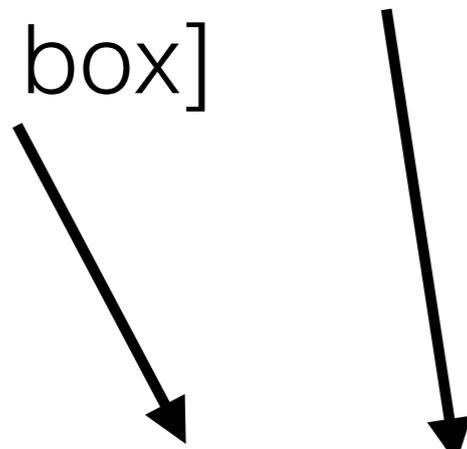
$$\underbrace{p(H|D)} = \frac{p(D|H)p(H)}{p(D)}$$

probability of the hypothesis,
given the observed data

Bayes' theorem

retinal input

[it is a box]


$$p(H|D) = \frac{p(D|H)p(H)}{p(D)}$$

probability of the hypothesis,
given the observed data

Bayes' theorem

retinal input
[it is a box]

Probability of a box
generating this
retinal input

$$\underbrace{p(H|D)} = \frac{\overbrace{p(D|H) p(H)}}{p(D)}$$

probability of the hypothesis,
given the observed data

Bayes' theorem

retinal input
[it is a box]

Probability of a box
generating this
retinal input

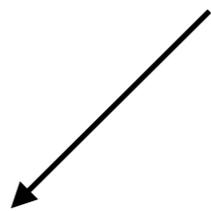
“prior” probability
of a box

$$\underbrace{p(H|D)} = \frac{\overbrace{p(D|H)} \overbrace{p(H)}}{p(D)}$$

probability of the hypothesis,
given the observed data

{do, di, ...}

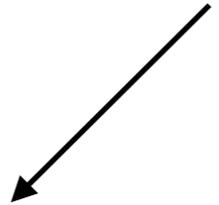
do re mi fa so la ti



$$p(\textit{consequent} | \textit{antecedent}) = \frac{p(\textit{antecedent} | \textit{consequent}) p(\textit{consequent})}{p(\textit{antecedent})}$$

{do, di, ...}

do re mi fa so la ti



$$p(\textit{consequent} | \textit{antecedent}) = \frac{p(\textit{antecedent} | \textit{consequent}) p(\textit{consequent})}{p(\textit{antecedent})}$$

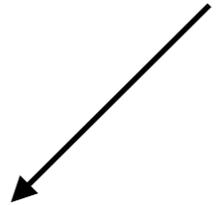
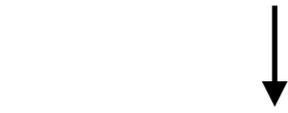
$$p(I_k | \{f_i\}) = \frac{p(\{f_i\} | I_k) p(I_k)}{p(\{f_i\})}$$

{sadness, happiness, ...}

{blueness, curved edges, ...}

{do, di, ...}

do re mi fa so la ti



$$p(\textit{consequent} | \textit{antecedent}) = \frac{p(\textit{antecedent} | \textit{consequent}) p(\textit{consequent})}{p(\textit{antecedent})}$$

style

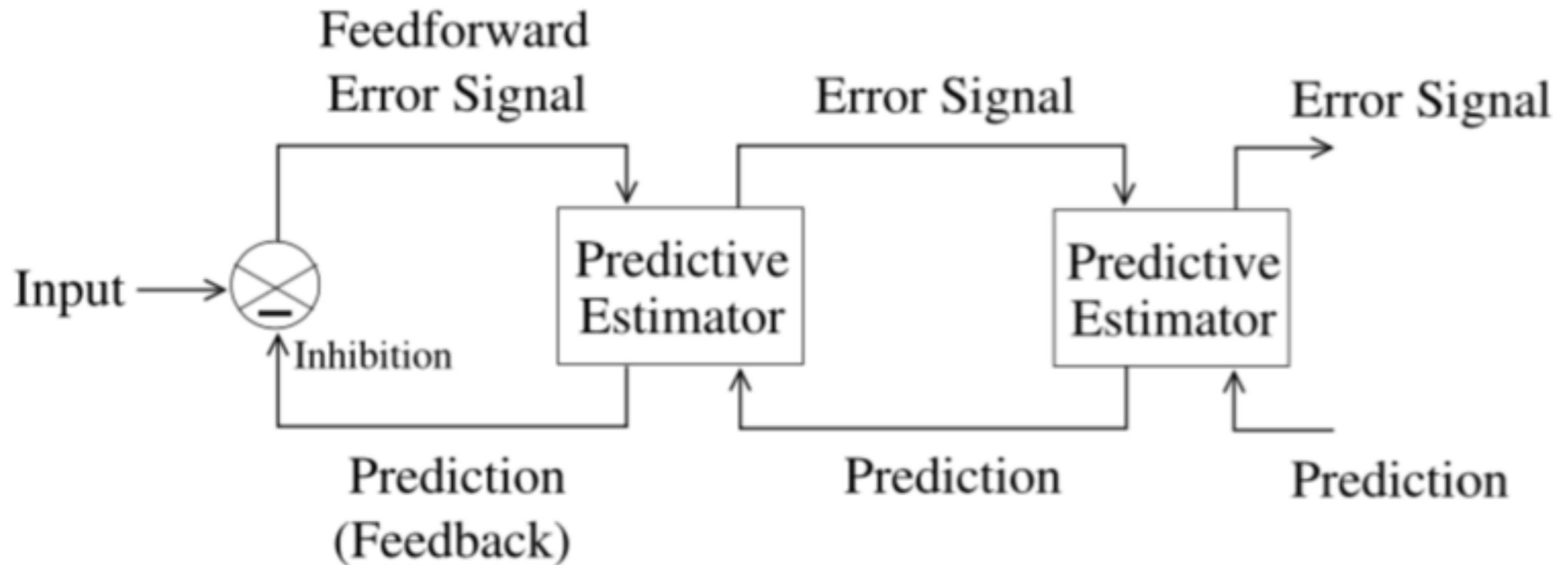
{sadness, happiness, ...}

{blueness, curved edges, ...}

$$p(I_k | \{f_i\}) = \frac{p(\{f_i\} | I_k) p(I_k)}{p(\{f_i\})}$$



Predictive Coding



Rao & Ballard (1999)

Evolutionary rationale

Uncertainty

- noisy environment
- noisy internal signals
- learning
- decision outcomes

Spans all Marr's levels!

Spans all Marr's levels!

Computational: *why do we enjoy art?*
because our brains are built to compute predictions

Spans all Marr's levels!

Computational: *why* do we enjoy art?
because our brains are built to compute predictions

Algorithmic: *how* do we enjoy art?
Bayesian inference, predictive coding

Spans all Marr's levels!

Computational: *why* do we enjoy art?
because our brains are built to compute predictions

Algorithmic: *how* do we enjoy art?
Bayesian inference, predictive coding

Implementational: how does our *brain* do it?
neural pathways encoding predictions and prediction error

Art perception =
computing & evaluating
predictions

Art perception =
computing & evaluating
predictions
...through ***Bayesian
inference***

Art perception =
computing & evaluating
predictions
...through ***Bayesian
inference***

(...via predictive coding?)

*Need to build
computational models!!*

Thank you!

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