Decoding

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Coding

- is about how stuff outside the organism/ nervous system is "represented" by inside the nervous system
- outside is "sender" inside is "receiver", encoding transforms message into state "inside" CNS

Decoding

- Decoding:
  - given the code word, identify the message
  - given the inner state of the CNS, estimate the state outside the CNS

Decoding

- who does "decoding"?
  - us, the scientist: to learn about what information may be potentially "contained" in the inner state …
    - an assessment on how constraints may provide more or less power to a neural code
  - another part of the nervous system, e.g., down-stream of the system whose inner state is assessed…
    - an assessment of what is possible in principle, not on how it is actually done

Decoding

- Decoding becomes an interesting dimension on is own (that goes beyond simply inverting the code map) only because there is uncertainty about the inner state (neural noise) and the world, so that a probabilistic approach is needed

Decoding

- stimulus described by parameter s (in some set S)
  - =space of messages
- neuronal response described by a vector r={r_1, r_2, ..., r_N)
  - e.g, N=number of neurons, each r_i = firing rate
  - code space

Decoding

- probabilistic description: look at ensemble of possible stimuli as described by probability distribution
  - P(s): probability that stimulus s was applied (prior)
- and ensemble of possible responses as a probability distribution as well
  - P(r): probability that neuronal response r was observed

Decoding

- These two are not independent (or else there would be no coding), so
  - P(r,s): probability that stimulus s was applied and neuronal response r was observed
  - is NOT just P(r)*P(s)
- in other words, the conditional probability
  - P(r|s)=P(r,s)/P(s)
  - is NOT just P(r)
  - This probability P(r|s) is what is being measured: the tuning curve.

Decoding

- This conditional probability, P(r|s),is is what is being measured: the tuning curve.
- It is the probabilistic version of the encoding scheme
  - rather than map s onto r
  - map s onto a probability P(r|s)=probability density over r

Decoding

- The reverse conditional probability
  - $P(s|r)=P(r,s)/P(r)$
- is the basis of decoding: which stimulus s must have been presented given an observed neuronal response r
  - typically estimate s as value that maximizes $P(s|r)$

Decoding

- Bayes theorem links the two
  - P(s|r)=P(r|s)P(s)/P(r)
  - [P(r) can be obtained by summing P(r|s)P(s) over s, but often not needed if only maximum along r is needed]
  - more significant: decoding requires knowing the prior probability (space of messages and probability thereon)!
- => decoding is based on observed r, on encoding P(r|s) and on prior P(s)

Tutorial Bayes Theorem

- What is the probability of having AIDS is an AIDS test was positive?
  - s=have AIDS, r=test positive
  - Sensitivity P(r|s)=95% (true positives)
  - Specificity P(not r|not s) = of 90% (true negatives)
  - What is P(s|r)?

Tutorial Bayes Theorem

- P(r)=P(r,s)+P(r,not s) =P(r|s)P(s) +P(r|not s)P(not s)
- P(r)= P(r|s)P(s)+(1-P(not r|not S))(1-P(s))
  - =.95 * .02 + .1 *.98 =.117
- P(s|r)=P(r|s)*P(s)/P(r)
  - =.95*.02/.117 = .1624
- Prob to have Aids after a positive test =16%
- (if specificity = 99%: 66%)
- (if sensitivity=99%, specificity=99%: 67%)

critique

- decoding is about predicting the stimulus from the neural response
- but: perception is not describing the stimulus!

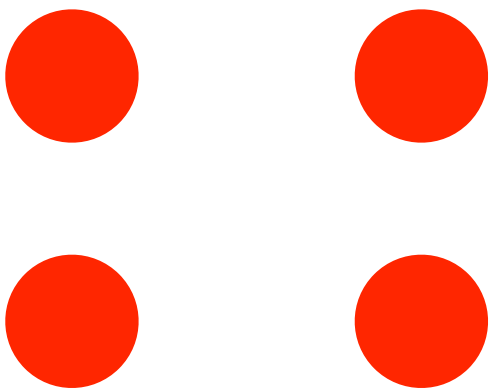
example: apparent motion

classical Gestalt idea

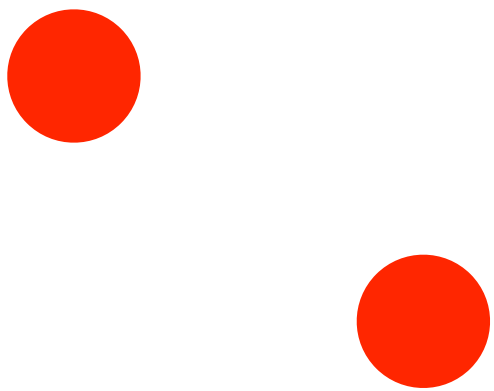
- percepts are not mere stimulus descriptions
- must be characterized by their own, perceptual variables (e.g., motion direction, motion speed, location of motion)

example: apparent motion

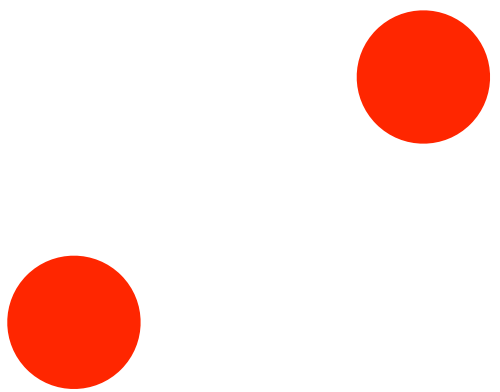
motion pattern



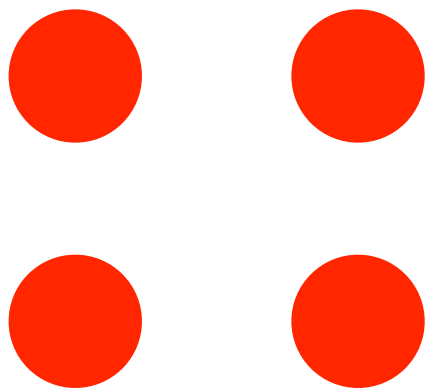
but why not see this motion?



or that motion?

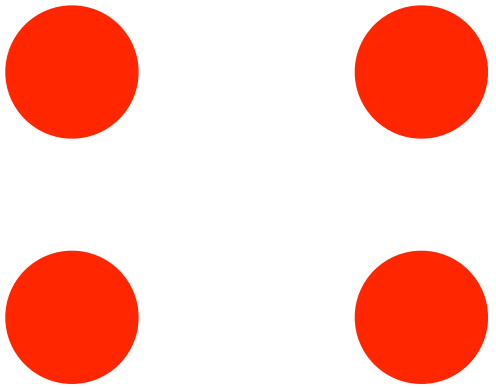


diagonal motions suppressed in motion pattern!

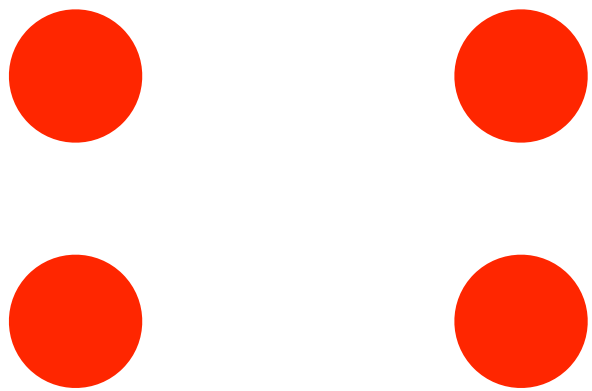


motion quartet

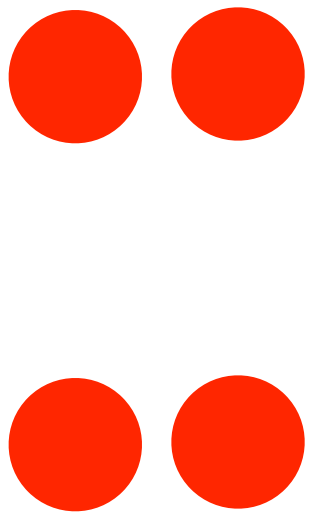
motion quartet

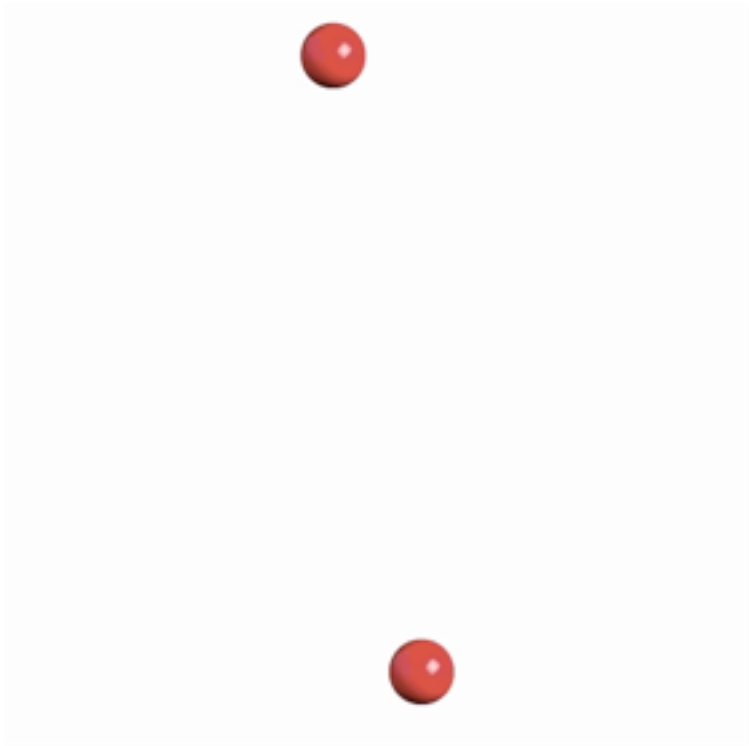


motion quartet



motion quartet





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conclusion

- percept does not stand in 1:1 relationship to the stimulus but depends on the inner state of the nervous system (induced by earlier stimuli)
- => decoding does not capture the essence of neural function

critique

- decoding does not provide a process account: how is decoding done, by whom, who “reads the code”
- in fact, could be viewed as circular: first encoding, then decoding...
- => neural dynamics

conclusion

- the concept of decoding is useful to formalize different qualities of "dependence" of neural activity on stimuli
- decoding helps understand that prior information about the world is important in evaluating neural states
- but does not necessarily capture the essence of neural function