Merging Race Models and Adaptive Networks:

A Race Network

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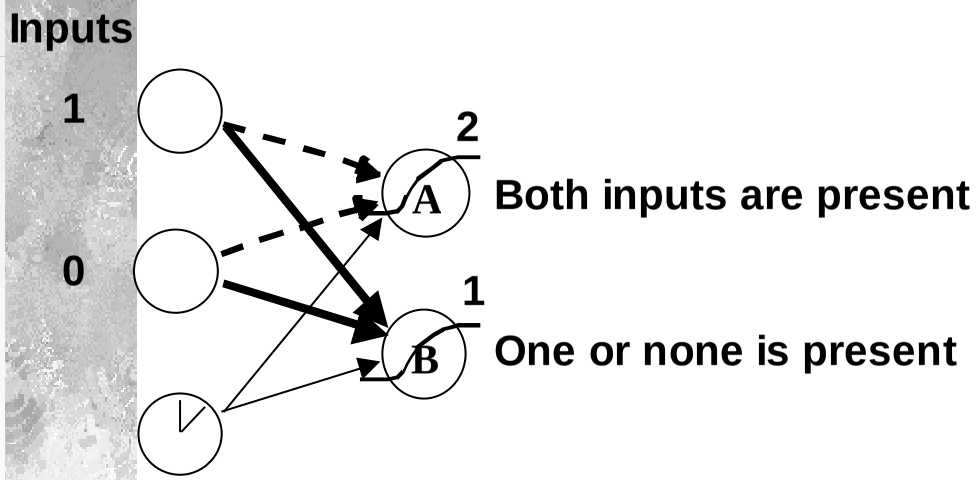
Connectionist Networks **VS.** Race Models

- Connectionist Networks **have a hard time predicting RT, both the means and the whole distributions.**

- Race Models **can't learn to associate multiple-feature inputs (integration) to various responses (discrimination).**

Race Network **is a totally new solution that combines strength of both approaches.**

Functioning a) Decision rule

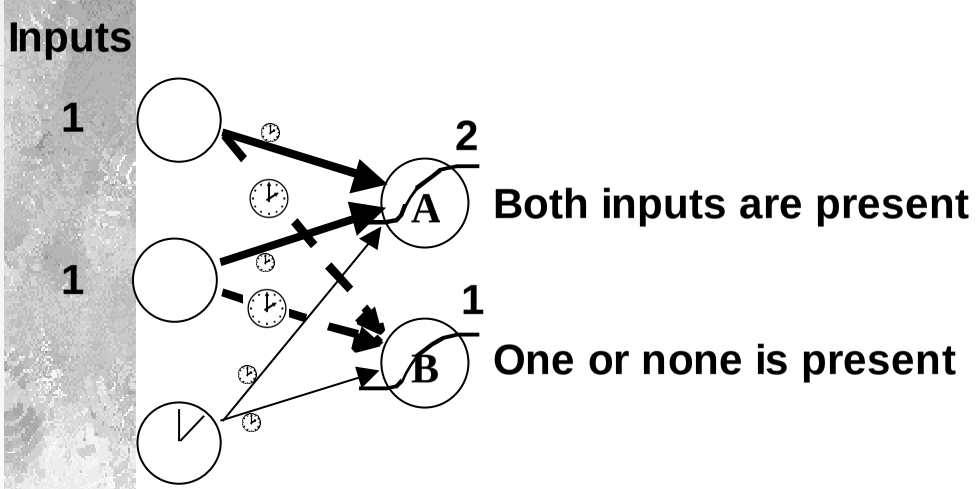


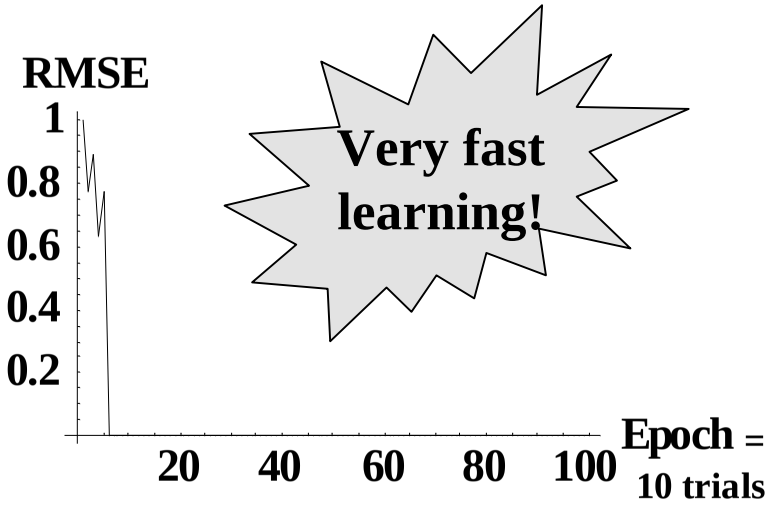
- You must see the inputs as signals traveling along the paths, with some traveling time.
- It is a race for a response: the fastest wins!

Example learning a "AND" problem:

- The threshold indicates how many signals (evidence) are needed;
- The first output to reach its threshold makes a response.

Functioning b) Learning rule





Two learning rules:

- An output node that reacted too soon (False alarmed) sees one of its input slowed down.
- An output node that didn't react (missed) sees his threshold readjusted.

The mathematics is simple

Connectionist networks uses matrix multiplication:

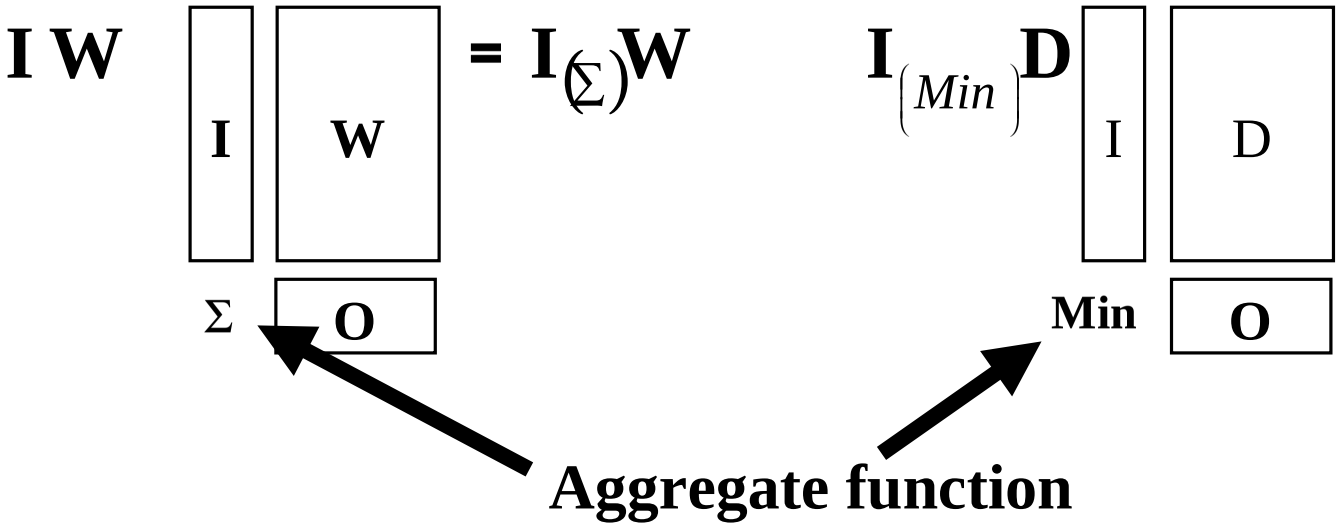
Simple, compact, and compute a weighted sum of the inputs;

Race network is not based on sum

based on the fastest, or equivalently, on the minimum

Solution: Let's redefine matrix multiplication !

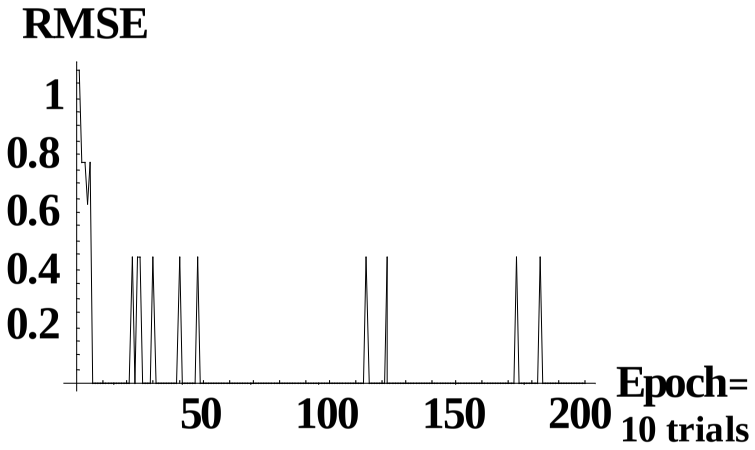
so that the aggregate function be explicit.



If noise exists

Noise can be either in the inputs $\mathcal{I}$, the delays $\mathcal{D}$, or both.

a) Can still learn easily $\Rightarrow$



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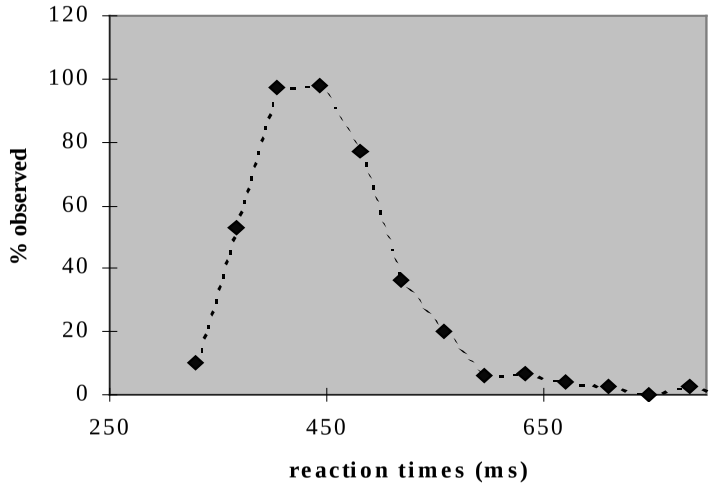
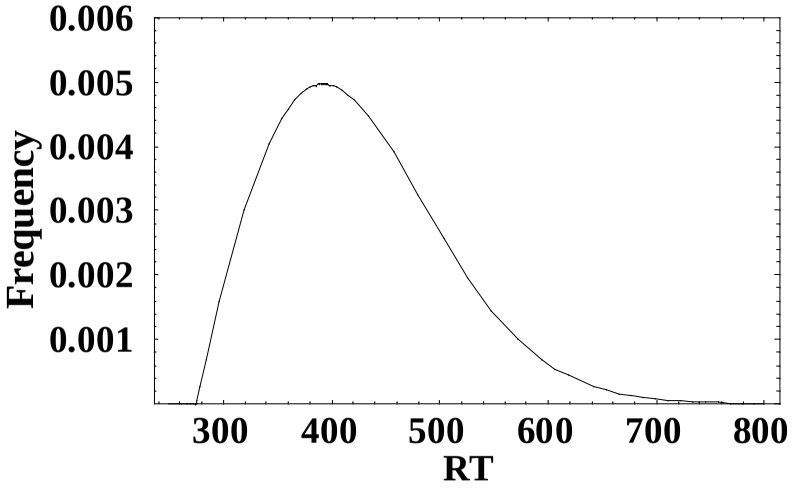
b) Predicts a Weibull distribution with no transforms, no filters, no *ad hoc* mechanisms...



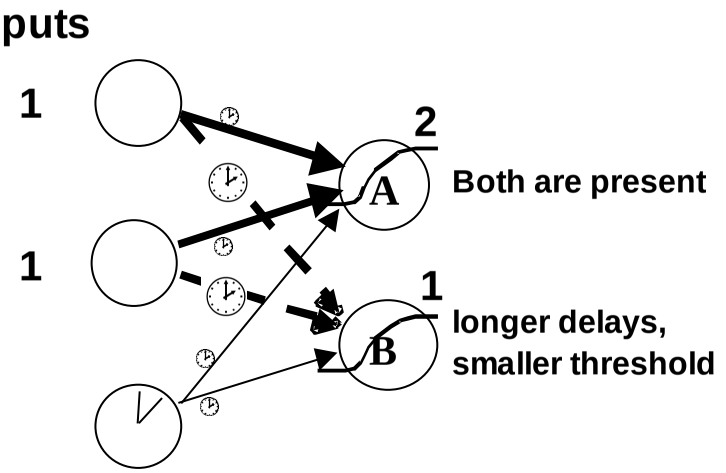


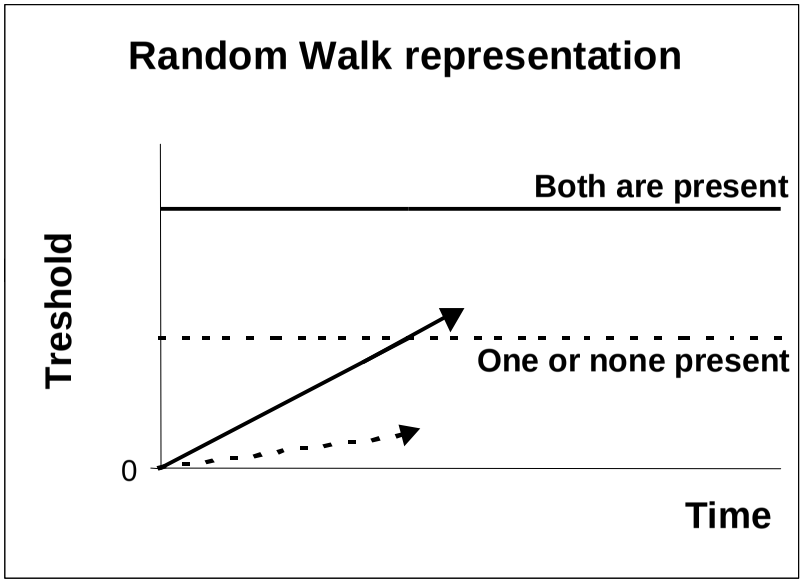
Race Network Accumulator model

Delays 🕑 leading to a response = "drift rate" toward a response.

Each response has its own drift rate and threshold.

Race networks are a subset of Accumulator models.





- **Free parameters**:
  - Distribution of the noise in the input $\mathcal{I}$ or i the delays $\mathcal{D}$, or both
- **Learned parameters**:
  - Accumulation rates (delays 🕑) and
  - Boundary (thresholds T)

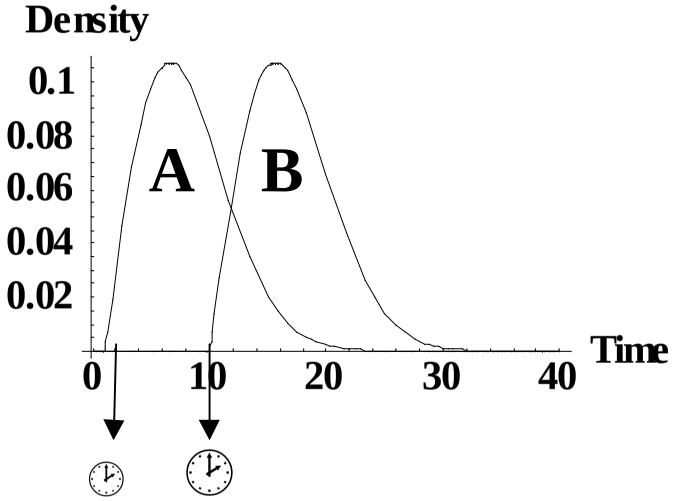
Race Network Priority learner

Race Networks learn rules:

- "- Say A as soon as two evidences are perceived,

  or else

- Say B after a while."



If responses uses partly the same info, they must be ordered, so that one signal does not release both responses at once.

"Seriality effect" produced by a parallel network.

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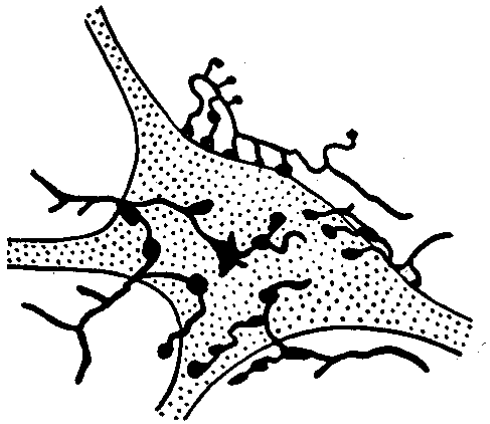
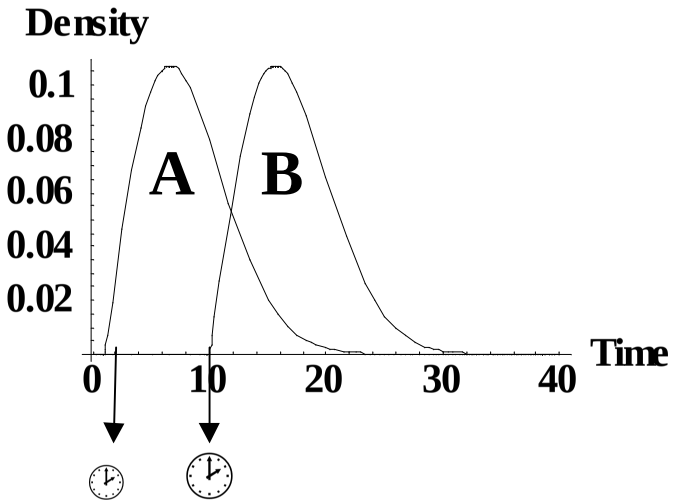
Race Network Variability reducer

Redundancy is likely to exist.

In a Race Networks, slow redundant signals are ignored (arrived too late).



Extracted from D. Hebb, Textbook of psychology



Reduces variability,

Speed-up responses,

Reduces errors.

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Conclusion (1)

- **Race Network manipulates times and predicts times.**

- **The stars:**
  - **Equivalent to an accumulator model;**
  - **(and a random walk if signal is stochastic = spikes);**
  - **Produce serial effect within a parallel architecture;**
  - **Predict the RT distributions;**
  - **(as well as ROC curves);**
  - **Has built-in controls over variability (through redundancy)**
  - **and noise (by manipulating delays 🕑).**

Conclusion (2)

- **Integration: Race Network does not take extra time to integrate multiple sources of evidence**
  (e.g. Ward, Duncan, and Shapiro, 1997, where subject can report ALL features).

- **Discrimination: Race Network does give priority to more "complex" stimuli, stimuli defined by the presence of more features, vs "simple" stimuli with less features**
  (e.g. Fournier, Eriksen, Bowd, 1998, on triple conjunctions,
  Trabasso, Rollins, Shaughnessy, 1971, on XOR problems).

For more, contact the author at Decousin@Indiana.edu.

This talk is available at: http://Prelude.Psy.UMontreal.CA/~cousined/talks