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The Mindful Learning Model

David W. Brooks
University of Nebraska - Lincoln, dbrooksne@gmail.com

Guy Trainin
University of Nebraska- Lincoln, gtrainin2@unl.edu

Khalid Sayood
University of Nebraska-Lincoln,, ksayood1@unl.edu

Abstract for DBER Group Discussion on 2014-10-23

Presenter(s), Department(s):
Dr. David Brooks
Professor
Dept. of Teaching, Learning, and Teacher Education
University of Nebraska-Lincoln

Dr. Guy Trainin
Associate Professor
Dept. of Teaching, Learning, and Teacher Education
University of Nebraska-Lincoln

Dr. Khalid Sayood
Professor
Electrical Engineering
University of Nebraska-Lincoln

Title:
The Mindful Learning Model

Abstract:
Earlier we published the Unified Learning Model which speaks to learning based on achieieving the "top slot" in working memory, repetition, and connections. The Mindful Learning Model accounts for more recent understandings of learning, and especially connections to "consciousness." The model has many parts. Inputs to the brain from sensors (eyes, ears) are not so much information about what is perceived but about discrepancies between that perception and one's mental model of the current context. The voices in our heads are after-the fact reports rather than realtime executives. Working memory is a series of detectable brain events taking place over a brief period (1.5-2.5 seconds). We are able to imagine ourselves "in the shoes of others," and we are ok to good at this skill in some situations. Whatever model one might choose to adopt, it needs to be consistent with what is known about information theory. Brooks will introduce three aspects of the model. Sayood will speak to how things "fit" in the context of information theory. Trainin is away on another assignment, and likely will deny any relationship with either Brooks or Sayood.

Mindful Learning Model

David Brooks, Guy Trainin & Khalid Sayood

DBER, 10/23/4

Working Memory

Working memory is the system that actively holds multiple pieces of transitory information in the mind, where they can be manipulated.

Working memory is generally used synonymously with short term memory, but this depends on how the two forms of memory are defined. (Wikipedia)

Unified Learning Model

Almost 10 years ago, Shell and I realized that a good operational way to think about working memory was in terms of motivation. Motivation means you are allocating working memory.

"Working Memory, Motivation, and Teacher-Initiated Learning," Brooks, D. W., & Shell, D. F. *J. Sci. Educ. Technology*, **2006**, *15*(1), 17-30.

This led to our book, *the Unified Learning Model*.

There are three parts to the *ULM* model. To be learned, something must reach the top slot of working memory. It (usually) must be repeated, and it needs to be connected to prior learning.

The *MLM* builds from the *ULM*. It does several other things.

The most important of these is to stake out some ground about working memory. We are now being explicit about what must happen in terms of what we used to call working memory. One can approach the *MLM* without ever using the term working memory.

Mind Models

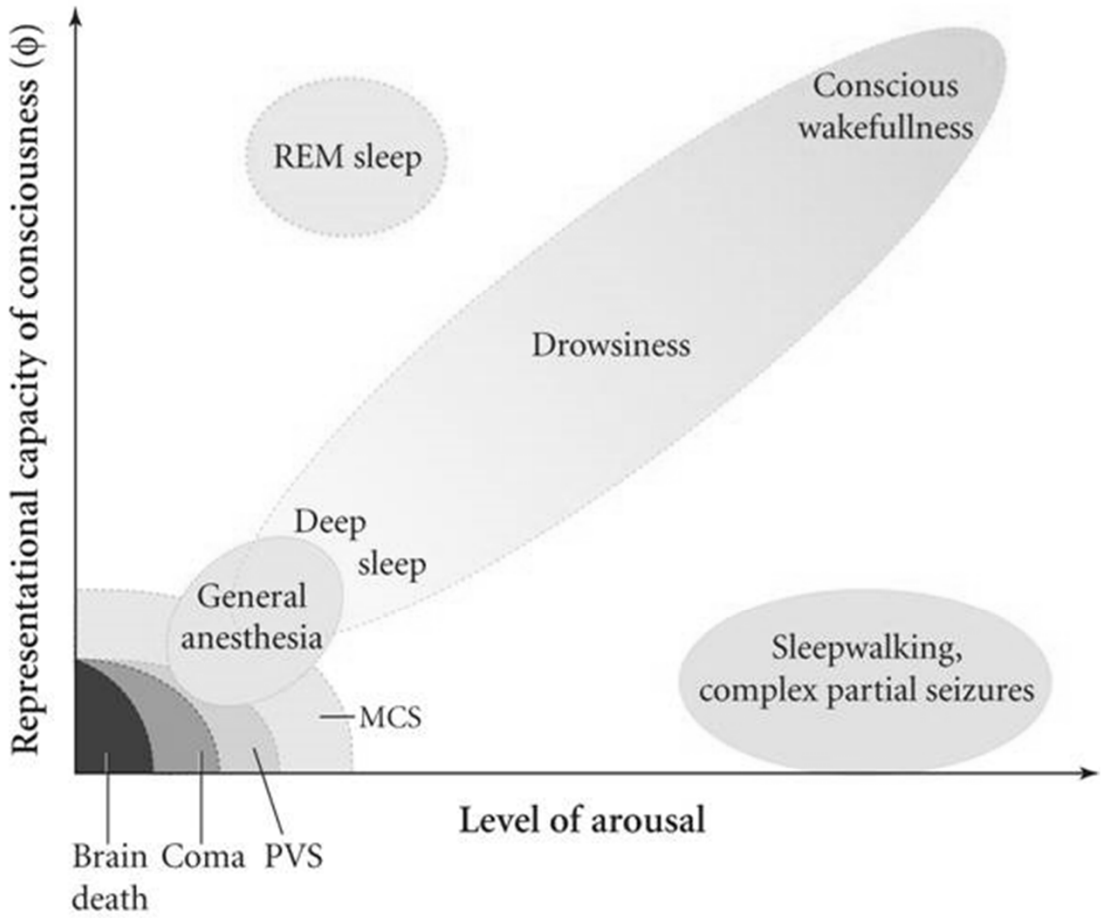
Today there are some really powerful models of mind (same word used in the *Wikipedia* definition just cited). These assert that we create models of our world in our minds and what we really do with sensory input is assess differences between the predication of the model and those inputs. The difference is measured in ***surprisal***.

From Clark:

The sheer breadth of application is striking. Essentially the same models here account for a variety of superficially disparate effects spanning perception, action, and attention. Indeed, one way to think about the primary “added value” of these models is that they bring perception, action, and attention into a single unifying framework. They thus constitute the perfect explanatory partner, I have argued, for recent approaches that stress the embodied, environmentally embedded, dimensions of mind and reason.

From Clark:

Perception, action, and attention, if these views are correct, are all in the same family business: that of reducing sensory prediction error resulting from our exchanges with the environment. Once this basic family business is revealed, longer-term environmental structuring (both material and socio-cultural) falls neatly into place. *We structure our worlds and actions so that most of our sensory predictions come true. (My emphasis.)*


Representational capacity of consciousness (ϕ)
REM sleep
Conscious wakefullness
Drowsiness
Deep sleep
General anesthesia
MCS
Sleepwalking, complex partial seizures
Level of arousal
Brain death
Coma
PVS

The second ‘big’ feature of the *MLM* is a lot harder to buy. We are NOT aware of our mental processes in real time. Instead, we become aware of them after they have operated.

Gazzinaga:

No doubt you will still feel pretty much in control of your brain, in charge, and calling all the shots. You will still feel that someone, you, is in there and making the decisions and pulling the levers. This is the homuncular problem we can't seem to shake: The idea that a person, a little man, a spirit, someone is in charge. Even those of us who know all the data, who know that it has got to work some other way, we still have this overwhelming sense of being at the controls.

The bottom line is that the voice in your head is acting as an after-the-fact reporter (the Presidential Press Secretary) rather than a real-time executive (the President).

So much so that, as in the case of press secretaries, some important pieces of information and not included as a part of their knowledge or message.

We authors have had to accept a lot as we developed the *MLM* for use by teachers. The most difficult thing for us to accept has been this after-the-fact rather than real time awareness of processing.

I, for one, have spent something like 67 years in the "old" model thinking I was a real time boss. All three of us have been very successful. For each of us, it's been one hell of a change. It's very much a work in progress for each one of us.

It should be pointed out, however, that this is not a new idea. It really was put forth in the 1970s by Libet based on EEG data.

The key feature for us to point out is that there is an electrophysiologically detectable event that Dehaene calls ***conscious access*** and Graziano calls ***awareness***.

We prefer awareness as a label for the event.

ALL of the processes compete:

The current in a 50.0 ohm resistor with an applied voltage of 6.50 volts is _____ amperes.

The best way to lower the price of Gleevec would be _____.

What will I get my wife for her birthday?

I’m hungry.

I’m horny.

One of these processes ***wins***, and that's the one we become aware of.

Put in simplest terms, that's why, when you are talking about how the theory of evolution explains some nuance of genetic drift, a kid in the back row is thinking about getting laid.

And that’s how ALL of us work, not just the kid in the back row!

The *ULM* was based on a model of working memory. How do we account for the working memory piece of learning in the *MLM*?

Each of us can hold (recall) a small number of ‘awareness’ events in sequence. In schools we end up getting learners to try to connect these.

While I’m extremely reluctant to ever identify “learning” with some specific brain tissue mass, this seems to happen in the front.

This may seem far too simplistic to accept. Let me offer a simple piece of evidence.

One “measure” of working memory capacity has been to recite digits (1-9) at a rate of one per second and then see how many a listener can recall. Typically we can hold about 7, but with a small amount of practice can build this to about 15.

The “record” reported in the literature is 79.

There are informal reports that the individual who did this got up to almost 120 before he died.

79 is darned impressive. That’s one digit per second for over one minute!

Suppose you have a deck of playing cards. It is shuffled. You are given the shuffled deck. You look at it. You then put it aside and take an unshuffled new deck and try to arrange the cards in the same order as the just shuffled deck. How long do you need to look at the shuffled deck in order to correctly order all of the cards in the second new deck?

The world record is less than 22 seconds!

How do people do this? We think that it's a matter of a sequence of "awareness" events being strung together. For the cards, it's a series of strategy-based events.

Consider recalling numbers. What effect should language have on that recall? Well, your first guess would be no effect. After all, a digit is a digit irrespective of the language.

Not so.

Ellis, N., & Hennelly, R. (1980). A bilingual word-length effect: Implications for intelligence testing and the relative ease of mental calculation in Welsh and English. *British Journal of Psychology, 71*(1), 43-51.

Chinese fastest, Welsh slowest. It takes less time to say the numbers in Chinese and more time in Welsh than English.

I guess you could argue that Chinese are smarter and Welsh dumber, but I think that your belief in that would reflect the fact that your momma raised a fool.

Today we *MLM* authors are trying to take all of this information and put it together. It's not easy.

AND, we are trying to keep in mind that whatever we come up with needs to be consistent with information theory. That's where my colleague Khalid comes in.

Mindful Learning Model

David Brooks, Guy Trainin & Khalid Sayood

DBER, 10/23/4

Tao Te Ching
(Translation by Stephen Mitchell)

- The tao that can be told
  is not the eternal Tao
  The name that can be named
  is not the eternal Name.
- The unnamable is the eternally real.
  Naming is the origin
  of all particular things.
- Free from desire, you realize the mystery.
  Caught in desire, you see only the manifestations.
- Yet mystery and manifestations
  arise from the same source.
  This source is called darkness.
- Darkness within darkness.
  The gateway to all understanding.

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Working Memory

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(*Wikipedia*)

We will try to quantify the "capacity" of working memory in terms of Shannon information and then use this to get some insight into approaches to learning and instruction.

Shannon entropy

$$H = \lim_{\rightarrow} \frac{1}{n} \sum P(X^{(1)}, X^{(2)}, \ldots, X^{(n)}) \log\left(\frac{1}{P(X^{(1)}, X^{(2)}, \ldots, X^{(n)})} \right)$$

If the events are independent and identically distributed

$$H = -\sum P(x_i) \log P(x_i)$$

To obtain these probabilities we need a model of the process.

- We only need a finite number of components.
- Isolate an item of interest.
- Lump all others into a complex event C.

$$P\left(X^{(1)}, X^{(2)}, \ldots, X^{(n)}\right) = P(X^{(1)}, C)$$

$$P\left(X^{(1)}, C\right) = P\left(X^{(1)} \mid C\right) P(C)$$

$$H = H(X^{(1)} \mid C) + H(C)$$

- We can treat H(C) as a fixed overhead and focus on H(X|C)

- Experiment to measure the span of working memory involves hearing and recalling a sequence of random digits.
- Let X be the random variable associated with the digits and N be the number of distinct digits.
- Let C be all other aspects of the experiment

$$H = \log N + H(C)$$

Working Memory Capacity

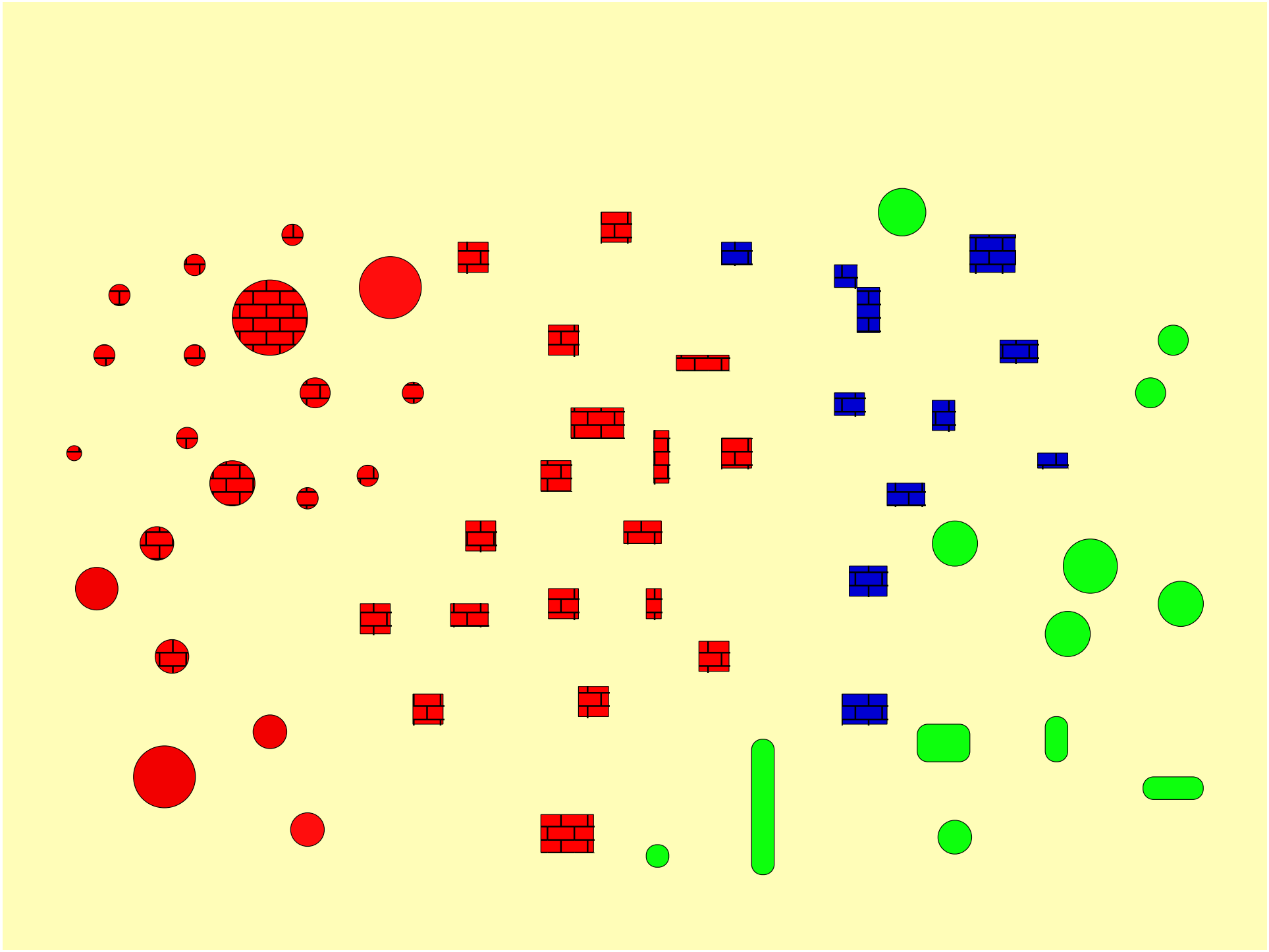
- If M is the average number of digits recalled, the working memory capacity in bits is MH
- Our hypothesis is that a concept can be taken into working memory when its “information size” is smaller than the working memory capacity.

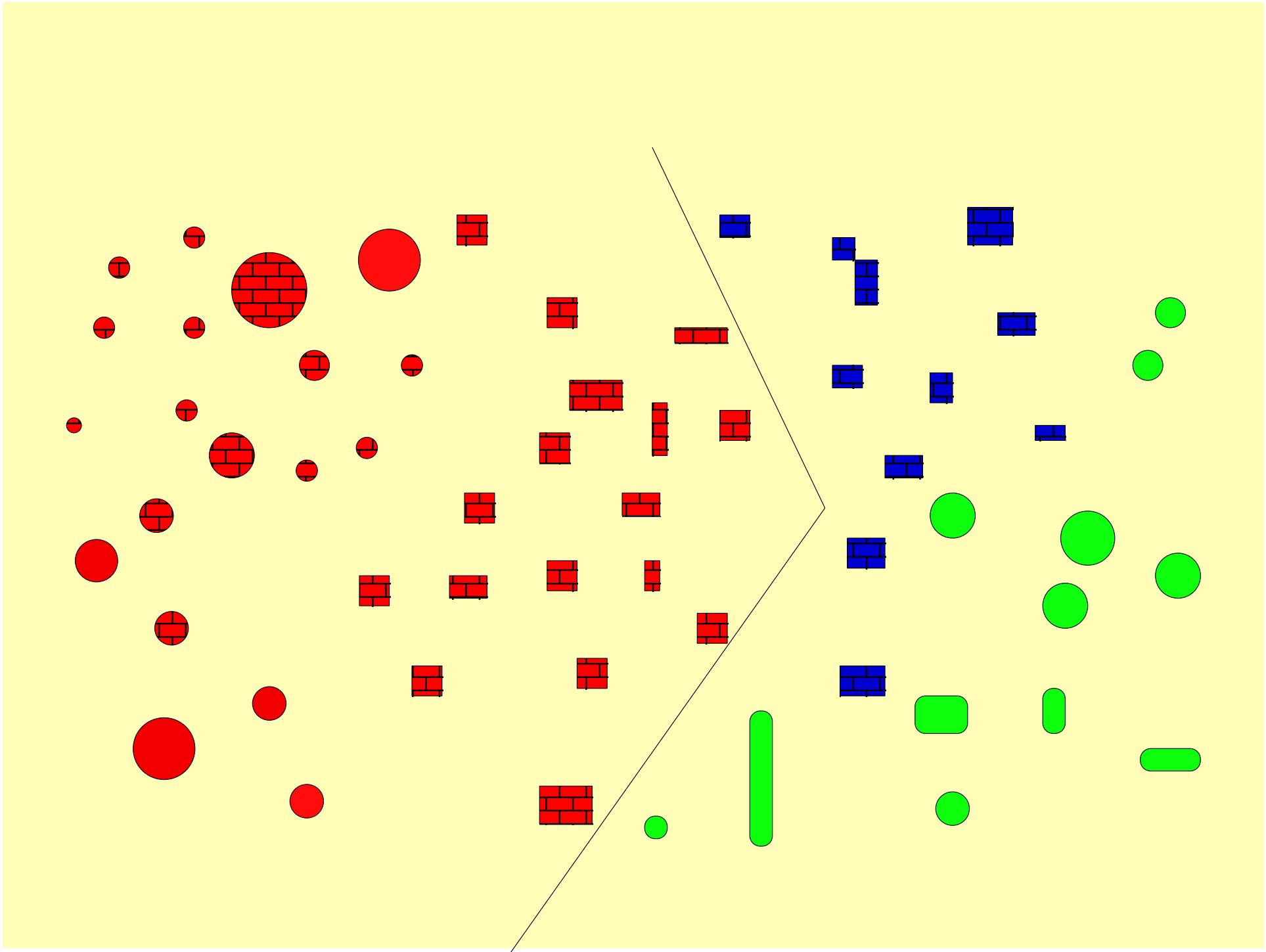
What is the Information Size of a concept?

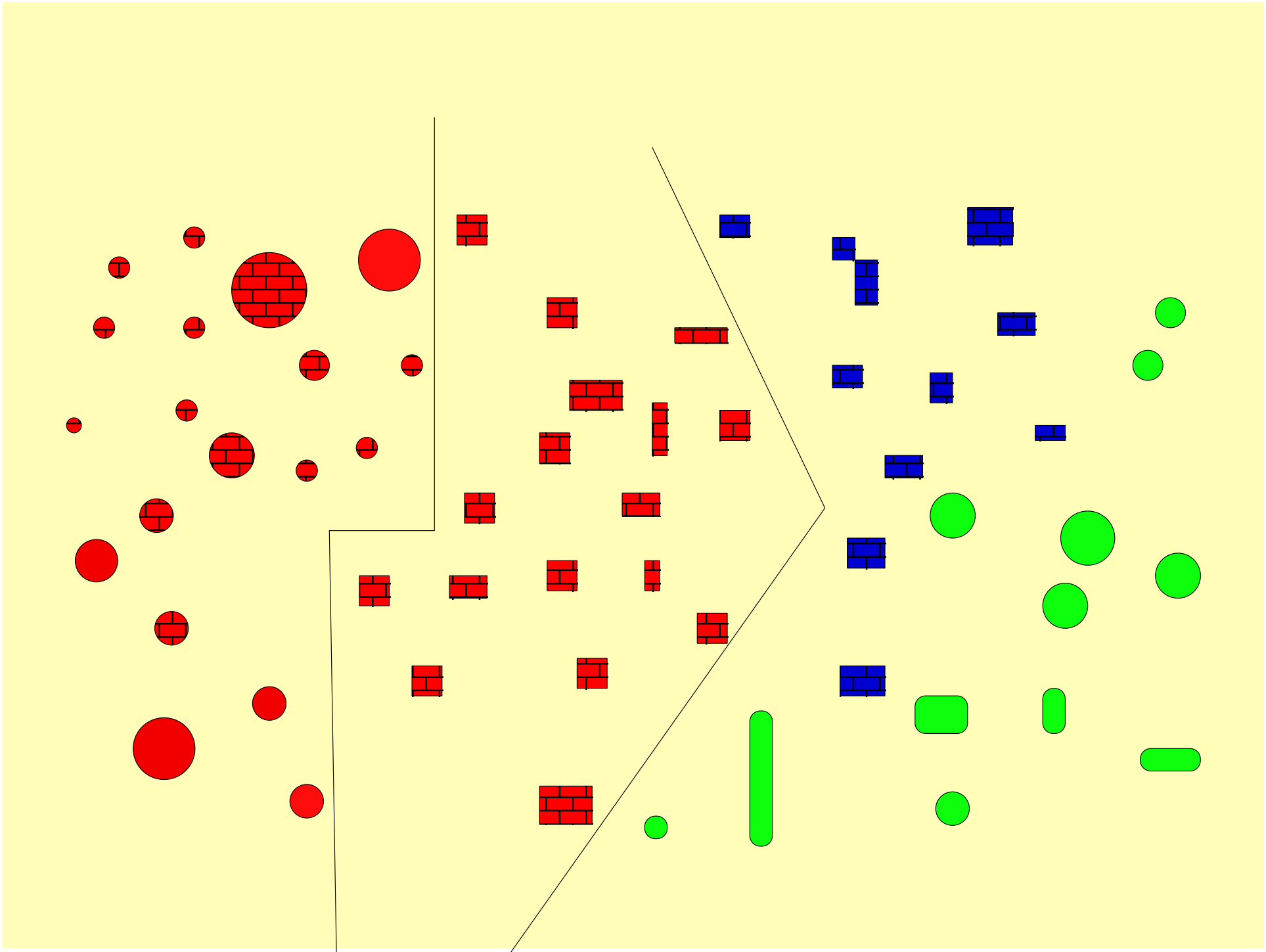
- Assume all concepts in the set of concepts under consideration are equally likely.
- If the size of the set is N, the average information corresponding to a concept from the set will be log(N).
- The set of concepts under consideration can be defined aposteriori by the outcome (Tonini).
- If I think of a red flower, the set of concepts is flowers of different colors.

How do we reduce the information size?

- The set of all possible concepts is vast.
- We can partition this set by using perceptual cues.







- If concepts are to be held in working memory they must belong to a set of concepts which has a small size.
- If the number of elements in the set is too big the information size is too large.
- To learn a concept it should be contained in a set with small cardinality. If this is not the case then additional cues need to be generated in order to reduce the size of the set.

- An impulse response h(t) is the response of a linear time-invariant system to an impulse at time t=0 and completely characterizes the system.

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- Boredom during mindfulness meditation

- Attending to a lecture versus attending to a lecture.

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Movies:

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