The Two-Second Advantage

How we succeed by anticipating the future – just enough

Vivek Ranadivé and Kevin Maney (2011)

Dwells on predictive models, both in the human brain and in computer systems.
The two-second advantage metaphorically refers to the ability of certain people or computer systems to predict what is going to happen a little better and faster than others.

Predictive models in the human brain

Research has brought to light a physical property of the brain called **Hebb's law** – named after the scientist Donald Hebb, considered the father of neuropsychology. The common shorthand version of the law is "*Neurons that fire together wire together*". Neurons that fire together nearly simultaneously wire that pattern together and then can replay the pattern equally simultaneously – building “chunks”.

The cycle of chunking, reinforcing, and predicting causes physical changes in the wiring of the brain – a characteristic called neuroplasticity.

Myelin, an electrical insulation that sheathes the nerve fibres (axons) which transmit electrical impulses around the brain, changes during learning. Myelin forms around axons that are excited over and over by experiences, and as myelin covers an axon, the speed of impulse transmission over that axon increases by up to 100 times compared to a bare axon.

The lowest layer of the neocortex collects raw information in granular detail from our five senses and passes it up to the next level, which starts to put the pieces together to form an image or sensation. As the information moves up to yet higher layers of the cortex, it's assembled into broader, more sophisticated, more creative concepts. At the highest working levels, the details are left behind, chunked into an efficient mental model that can process what's happening in a flash of recognition and anticipate the near future with incredible speed and accuracy.
As powerful as our brains are, they don't seem to be powerful enough to record and recall every tiny detail AND process high-level concepts. Since there is greater benefit in the high-level concepts, our brains focus on those, and essentially forgets the details.
In the brain of autistic people though, the details are not passed to higher levels; when combined with a high focus, this can produce individuals with exceptional visual memory for instance.

Predictive capabilities are the essence of talent.

Repetition builds predictiveness, and good predictions generate positive feelings that provide motivation to build yet more predictiveness.

The leading scientist studying exceptional talent, Anders Ericsson, edited The Cambridge Handbook of Expertise and Expert Performance (2006), a 900-page book presenting research done by more than 100 scientists. The conclusion was that natural talent is overrated, and that years of intense "deliberate practice" could turn almost anyone into a star in any field. Ericsson and his colleagues laid out the 10,000-hour rule made famous in Malcolm Gladwell's book Outliers (2008): almost anyone who intensely practices something for 10,000 hours will become an expert / achieve superior performance in that field.

Research has shown that language processing is an accurate indicator of future success in school and, later, in almost any intellect-based talent (as opposed to sports or other more physical talents). Complex chunking and being predictive with spoken language leads to chunking and predictiveness in reading, which leads to success in academics and most fields.

People who are talented don't just make predictions based on events; they also make predictions based on a *lack* of events.

Prediction capabilities can be classified into two categories: *Strategic intuition & Anticipatory thinking.*

Strategic intuition

William Duggan came up with the concept of strategic intuition while studying Napoleon. Napoleon had almost no battlefield experience, but he had studied military history extensively, especially details of how battles were won and lost. He would march his men off to fight without much of a plan; instead, he watched events unfold and had the presence of mind to see them from a high strategic level, and he'd wait for a flash of insight, or *coup d'oeil*. He was able to take in events and make instant predictions about what would happen if he took a certain action.
The idea of strategic intuition is the selective projection of past elements into the future, so as to be able to predict the result of a certain course of action, as a new combination of past and immediate events.

Anticipatory thinking

Gary Klein theorised that as one gains experience and thereby chunks things together in a given field – building a mental model of patterns – much of the standard operating process is then done on autopilot, thereby conferring heightened sensitivity to weak signals that would otherwise be ignored by those with less experience.

Theory of mind

Humans have the capability to infer a common reality from what senses perceive; they have an understanding of people and things which corresponds to a particular (predictive) model of the universe – out of the raw perceived arrangement of physical particles, humans group those together in conventional ways and assign them particular properties and relationships.
"The brain creates a model of the universe and projects this version like a bubble around us." (Henry Markram, neuroscientist)
By extension; our minds explain other people's behaviour thanks to an understanding of their beliefs and desires (properties, here assigned to people).
People with severe autism cannot model other people's minds, their intentions, actions, feelings - which leaves them stranded inside their own minds. Without a good implementation of the theory of mind, the person is handicapped when dealing with the broader world. Likewise, computers are for the moment “mindless”.

Futurist Ray Kurzweil and others refer to the singularity as the point in time when the world's connected computers collectively become smarter than humans. Without a theory of mind, computers might some day create their own version of reality, which might threaten human reality. But they won't take over our reality unless, somehow, they become human - sharing the representation of our real world.

Predictive models in computers

Computer scientists are building computer systems that operate in new ways borrowed from the human predictive model.

The aim is to find ways for systems to learn and build models that can quickly and efficiently react to events. These systems build memory chunks and generate behaviour based on predictions. Sensors can feed information back to the computers to both build patterns and test predictions.

Such systems would constantly categorise data, see relationships, and use that to build "chunks" and an ever-evolving model of how things work in a given domain. General streams of new data would come in and get sifted through the predictive model that the system constructed. The system could then react in real time to the events it is monitoring, drawing conclusions and potentially taking actions.

Generative models = internal models of the world that systems (whether computers or brains) develop during the course of their existence. These internal models enable a system to make predictions and constantly compare predictions to actual events that the system's sensory networks take in.

In the 2010s, a couple of technology trends are converging to help move computing systems towards Enterprise 3.0, where the pace is so fast that systems have to respond to events, not questions; one is real-time computing; another is predictive analytics.

Predictive analytics work by ploughing through past data to find trends and insights, and then building models/profiles of customers, setting event triggers (either static, such as a set action taken by the customer, or dynamic, i.e. based on predictions, like a probable future date of purchase of a specific item), and actions to take when event triggers occur.

"The system sees events in real time and can make accurate short-term predictions about what's going to happen and what action to take. <Company XYZ> still finds a great deal of value in deeply mining databases to discover large trends, but the two-second advantage is all about making small, intuitive predictions just a little bit ahead of tome based on events happening right then. (…) Knowledge of past behaviour gets chunked into some instantly recognizable patterns, while the vast majority of data gets pushed to the background. The model learns a customer's particular tendencies and preferences and watches for triggers."

The technology behind the two-second advantage tracks events from multiple types of sources (websites, sensors in the field, cameras, etc.) in real time, and runs those events through narrowly focused rules-based software that can instantly make a calculated prediction.
Events are collected through a software bus, which translates the data from the events into a format that can be processed by a software engine programmed using rules learned from mining the database. The idea is to avoid going back to search the old data in the database and instead process the events through the rules, coming to instantaneous conclusions. For example, rules can be set up to take into account a customer's preferences and tendencies by checking past data in the database.
To some extent, technology can tune the rules itself by watching outcomes and altering the rules based on those outcomes. The system starts out with rules programmed into it and creates concepts from those rules. If the rules expect X to happen but instead Y happens, the rules treat Y as the new expected outcome and move on to build a more refined concept - a step towards brain-like processing.

Yet, people still have to tell the machines what events to watch and what rules to follow. The machines can't yet really learn. They cannot decide what to remember and what to forget. The machines still operate like computers, processing information the same way they have since the 1940s, though of course much faster.

The von Neumann architecture, which is the way computers work, is based on the principle of serial, instructions-led, processing (in contrast with the kind of fuzzy, parallel, simultaneous processing that goes on in the brain), where memory is in one place and the processing elsewhere.
This architecture is now referred to as the von Neumann bottleneck; computers cannot work much faster using the same serial architecture, yet the flood of data and quicker pace of business demand faster processing.

Challenges to getting machines to work like fully functioning brains:

- density of the circuitry (transistors/neurons) -> raw processing capability
- storage capacity/density
- energy consumption
- adaptivity / dynamic linking of data; the synapses wire themselves together in a constantly evolving way. The brain formulates a lot of thoughts at the same time and then gravitates towards a solution or idea. The brain's programming is fuzzy and flexible (vs von Neumann architecture for computers)
- hardiness; the dynamic wiring of the brain means that it can still function after a bunch of neurons die, as it would rewire itself around the problem
- handling of emotion, which is an essential information cross-indexer, colouring every bit of information so as to determine its importance and how it relates to other information.
- implementing a theory of mind, a sense of the "real world"

Advances in the quest for brain-like computers, with a capability to build efficient models of how things work, absorb real-time events, and predict what will happen next:

- supercomputers (used for simulations, or the indexing of a vast quantity of data, like Watson)
- memristors (chips that would change their resistance when a voltage is applied across - both processing the information and remembering it)
- neuromorphic chips (chips able to create new connections based on input - learning)
- hierarchical software / Hierarchical Temporal Memory - HMT (method of processing data whose purpose is to build a prediction engine; involves building hierarchical layers, like in the neocortex of the brain, whereby inputs collected at the base layer get passed to a higher level and assembled into concepts, which in turn are passed up to another level looking for associations and the building of richer concepts, and so on up the line, until predictions and assessments can be made at the top layer)
- quantum computers