Identified Neurons: what if every neuron in the human brain has its own identity?

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Recent research suggests that human memories are stored not between neurons as synaptic weights, but within individual neurons themselves (Bédécarrats et al, 2018). This opens the possibility to replace the dominant paradigm of brain function – neural networks – with a new one. In this article, I explore how “identified neurons” could explain how memories are stored, and how human traits are implemented in the brain.

Every human brain contains 100 billion neurons. Each neural cell has a complete, private copy of human DNA, two meters long, containing a library of 23 books (chromosomes) with 3.2 billion genetic letters, e.g., AGATTCAG… Only a small percentage of our DNA (1%) accounts for the 22,000 genes that express proteins, construct the body and regulate metabolism, and another 7% of our DNA helps to regulate that gene expression. So what does the other 92% of our “junk DNA” actually do? Is it involved in mental traits?

In this article, I propose several hypotheses, all highly speculative:

1. Each neuron in the brain is identified by a unique name. This allows other identified neurons to find it.
2. Each identified neuron is assigned a unique section of our shared “junk” DNA to act as its code (or script) to execute. This “ancient code” provides the instruction set for identified neurons to implement human traits and serves as a reference library of patterns and templates, which can be consulted at any time.
3. To carry out its instructions, each identified neuron communicates with other identified neurons via messages (routed from one neuron to the next). The role of axons, dendrites, synapses and neurotransmitters is limited to the routing of these messages, likely over a carrier frequency of brain waves
4. “Modern memories” are also stored within identified neurons. Incoming messages and patterns are serialized and stored to their local DNA/RNA “tape”. Memories that assist human survival can be eventually transferred from local DNA to reproductive cells and transmitted to the next generation.
5. All humans possess a complete set of DNA instructions that encode for all potential identified neurons (as we are all 99.4% genetically alike). However, after conception, some DNA scripts are epigenetically de-activated by lottery. In this way, the diversity of human traits is established.

What evidence do we have that identified neurons exist in humans? For one, other organisms have them. For example, every Aplysia sea slug has 20,000 identified neurons, each having precisely the same function across the species. So why not in humans?

Why are identified neurons needed to explain human brain function? Because innate traits must know *a priori* where to send their messages, to execute their DNA scripts. As an analogy, on the internet, unique IP addresses are assigned to computers to allow them to route information packets to any other uniquely identified computer, anywhere in the world. You can’t send a message unless you know the IP address of the recipient in advance.

How would an identified neuron choose its name? Available names are likely listed in our collective DNA. A neuron, then, would randomly select an available name, verify (via broadcast messages) that no other neuron had already selected the name, and adopt the name as its own. (For efficiency, some names may be brain-region specific.)

However, as there are 100 billion neurons in the human brain and only 3 billion genetic letters in our DNA, not all neurons will adopt predefined names from our ancestral DNA. A strategy of assigning “anonymous” names must exist, similar to how recombination in the immune system is used to “name” hundreds of thousands of unique antibodies.

Once named, an identified neuron executes its script and sends messages to other identified neurons in the brain, addressing recipients by their unique name. Intervening neurons, in addition to their primary task, would serve as repeater nodes to pass along and route messages. Messages would travel from one neuron to another until they reach their destination, similar to how packets are routed on the public internet. If messages travel too slowly, the network (dendrites, axons, synapses) is optimized and reconfigured to increase transmission performance. One can imagine both point-to-point communications as well as broadcast messages being supported over a substrate of brain waves.

An identified neuron bootstraps itself by reading instructions (script, code) from its uniquely assigned section of DNA. Neurons are like little computers, with an ability to process incoming messages, and perhaps have more complex capabilities like the ability to execute Fast Fourier transforms on incoming signals to determine characteristic wave signatures.

How might an identified neuron implement a trait like social anxiety? (Certainly, it’s not a trait you can teach someone, and no one voluntarily suffers from social anxiety, so it must be innate.) A single identified neuron (let’s call it “social\_anxiety”) could implement this trait with the following DNA code:

*if msg(in\_crowd\_setting) = Yes and msg(in\_family\_setting) = No then msg(flight\_behavior)*

(This is translated from the original DNA-speak – ATGTGACGGTC etc. – for easier reading.) The IF-THEN-ELSE statements resemble a computer language. LOOPs and recursion could be added for the acquisition of human language, with its production rules and universal generative grammar (Chomsky 1956). I realize that this proposed language of thought (LOT) resembles so-called “expert systems” from the 1980’s, with all the caveats and fragility that implies (Dreyfus et al, 1984).

By sending messages to three named neurons (in\_crowd\_setting, in\_family\_setting, flight\_behavior) – all of which must be known by name *a priori* for this ancient DNA script to work – the single social\_anxiety neuron can implement the trait. It acts like a general contractor, delegating tasks to subcontractor neurons, which in turn delegate tasks to their subcontractors, in an epic cascade of activity. The task to determine whether you’re in a crowded setting is delegated to the in\_crowd\_setting neuron, which in turn delegates to other identified neurons (how many people are here? are they really people? are those eyes? etc.)

Our actions are also controlled by identified neurons. The “flight\_behavior” neuron (above) triggers a series of muscle movements or saccades, to flee. That might work for a sea slug, but not for humans; we need to learn to walk first, and then to run. Obviously, infants have a strong (innate) drive to learn to walk, and the development of that skill may require the establishment of new intervening “anonymous” neurons for fine tuning. However, any learned skill must (eventually) be linked to a well-known, identified neuron, otherwise our innate traits (from our ancestral DNA) have no way to locate and leverage (exploit) them.

Memories can also be implemented by identified neurons, which store incoming messages (or anything else) to local RNA/DNA tape. (If this process proves too slow, temporary memories could be stored to an “abacus” using epigenetic tags or protein beads before being translated to RNA.) Most likely, identified neurons would cache incoming message payloads to their local DNA/RNA store, to avoid resending messages (unless the cache has expired).

Memories fall into different categories. The simplest is a record of incoming sensory patterns (as a time series). For example, the characteristic sensory signature of flying insects buzzing about may be encapsulated as a pattern (from millions of years ago) and stored to our collective DNA. An identified neuron called “detect\_insects” constantly executes this DNA script, ever vigilant for the presence of flying insects, by sending messages to neurons associated with the retina (or perhaps those messages are pushed/published automatically to any identified neuron that expresses an interest).

Assuming that our irritation at the sound of buzzing flies is an innate trait, every human must experience the buzzing of flies the same way (the same neural signature of activity patterns, the same identified neuron). Identified neurons for the same trait must have the same name across all humans (e.g., is\_buzzing\_fly), to allow shared human traits to be coherently passed down from one generation to the next. For example, if a trait like “jealousy toward rare objects” is implemented by a genetic script – *if msg(is\_rare\_object) then msg(jealousy\_behavior)* – the identified neuron implementing this trait couldn’t send a confirmatory query (“is this a rare object?”) to another identified neuron (is\_rare\_object) unless it knew, *a priori*, the name of that recipient.

Clearly, not every object we perceive and remember is innately pre-defined in our DNA. iPads didn’t exist when we last evolved, so there’s no ancestral DNA memory of them. Unique names must be generated for newly assigned identified neurons to store memories of novel objects. However, we can’t remember any object unless we can associate it with an *a priori* named identified neuron. In other words, to remember something, with must establish an innate (emotional) connection with it first. Humans who lack emotional affect suffer from memory problems. If we can’t associate an iPad with an innate predisposition (e.g., greed or envy or status) then we can’t remember it. Newly assigned identified neurons store the memory of novel objects and link themselves back to the innate emotion that established the interest in the object in the first place (e.g. envy, etc.), which allows for memory retrieval. The unique and characteristic “signature” (from the senses) of an iPad can thus be recorded to the local RNA tape of the “iPad neuron”. If iPads turn out to be crucial for human survival, this RNA signature can eventually be conveyed back to DNA in reproductive cells.

Each human emotion and trait is implemented by an identified neuron. Desires, cravings, hungers, fears, compulsions, ambitions, motivations, etc. These are all innate, and it’s unlikely that evolution would invent novel ways to implement each of them as brain circuitry. An ambitious person possesses an “ambition” identified neuron that executes a specific evolutionary DNA script (agenda) which sends a cascade of messages back and forth to thousands of other identified neurons to determine things like “what are the opportunities for ambition these days?” and “which introverts can I exploit to reach my goals?” (sorry!) and “how can I recognize an introvert”? Again, each innate trait leverages learned traits.

The learning process is itself innate. It’s as if our DNA issues the command: “Please go out and learn how to walk, and once you do, link your skill back to an identified neuron called walk\_behavior so I know where to find it for later exploitation.” General instructions (mental recipes) on how to learn to walk and run are kindly provided by our DNA reference library.

If you’re unconvinced that human traits are specified in our DNA, consider the extremes. I like the example of psychopathy because it’s foreign to (most) people’s experience, and thus easier to study objectively. In the modern world, psychopaths are often successful CEOs at large corporations due to their single-minded vision, talent for sizing up and motivating people, ability to hide their agenda, and willingness to cut human ties quickly (e.g., firings and corporate layoffs). Obviously, psychopathy is innate, because which parents would willingly raise their children to be psychopaths? Typically, psychopaths have normal parents and weren’t mistreated as children (contrary to what the movies would have you believe) although clearly there are exceptions.

Psychopaths, by this theory, have a single identified neuron which implements their highly complex, evolutionarily-tuned traits. And if psychopathy is innate, then any trait (gambling compulsion, social anxiety, ambition, narcissism, thin skin, low threshold to anger, etc.) can also be innate.

Each human is born with the potential for all human traits (we all carry essentially the same DNA). With a few exceptions (such as a variant of the DRD4 gene that explain some of the variability in “novelty seeking” behavior), I believe psychological traits are not genetically determined. We humans are 99.4 to 99.9% genetically alike, which might be enough to account for physical differences (Epstein 2014), but not mental ones. All mental traits are genetically specified (blueprinted), but trait variability itself is not genetically determined (associated with genetic variability). Many potential traits, even when specified in our DNA, are clamped shut (deactivated) by epigenetic tags added to the corresponding DNA by an internal “trait assignment” roulette wheel (*in utero*, post-conception), establishing human trait diversity. If your DNA for “ambition” is deactivated, you won’t develop an ambition neuron. If your psychopath DNA is switched off by an epigenetic tag (which it is in most of us), then you won’t develop a psychopath’s identified neuron and traits.

Humans are specialized actors. The diversity of traits is necessary for long term human survival. Personality traits are allocated according to evolutionarily defined and highly-tuned ratios across society (by the trait assignment roulette wheel) to enforce a division of labor. For example, 7% of people have social anxiety, some are introverts, some are extroverts, some crave to be leaders, etc. Having 1% of the population as psychopaths (not 0.1% and not 2%) is “just right,” according to our evolutionary past. In times of war or conflict (say, with the Neanderthals), we needed psychopaths, who don’t suffer from PTSD, to carry on the fight. Not everyone has this capability. Social anxiety, on the other hand, keeps followers in line, which allows leaders to establish dominance hierarchies that allow society to scale. I wish it were otherwise, because trait inequality leads to inequality in social outcomes.

In summary, I have proposed a series of (falsifiable) hypotheses on identified neurons and human memories and traits. With the recent discovery that human memories are not stored in neural networks, the current paradigm is fast crumbling and needs a credible replacement.

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