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, or task) 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 the complete set of DNA instructions to encode for all possible identified neurons, and thus all human traits. As we are all 99.4% genetically alike, there’s not enough genetic difference to allow for the swapping in and out of entire swaths of DNA to select different traits, therefore we must each possess the DNA for all traits. 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?

How do identified neurons help explain human brain function? Because innate traits and emotions must know *a priori* where to send their messages, to execute their DNA scripts; having uniquely named identified neurons enables this. As an analogy, on the internet, unique IP addresses allow computers to route messages to any other computer in the world. You can’t send a message unless you know the name of the recipient in advance.

How might an identified neuron choose its name? Available names are likely listed in our collective DNA. A neuron randomly selects an available name, verifies (via broadcast messages) that no other neuron has already selected the name, and adopts 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 can adopt predefined names from our ancestral DNA. A strategy of generating and assigning unique 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 can execute its script and send messages to other identified neurons in the brain. Intervening neurons, in addition to their primary task, serve as repeater nodes to pass along and route messages. Messages travel from one neuron to the next until they reach their destination, similar to how data packets are routed on the 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 assigned section of DNA. Neurons are like little computers, with an ability to read code, process incoming messages, and perhaps they have more complex capabilities like the ability to execute Fast Fourier transformations on incoming signals to determine characteristic wave signatures. Neurons are dispassionate, carrying out their instructions efficiently, regardless of content or context.

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 using 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 are known by name *a priori* to allow this ancient DNA script to function – the single social\_anxiety neuron implements the trait. It acts like a general contractor, delegating tasks to subcontractor neurons via messages, which in turn delegate tasks to their subcontractors, in an epic cascade of activity. The task to determine whether you’re standing in a crowd is delegated to the in\_crowd\_setting neuron, which in turn delegates to other identified neurons (how do you define a crowd? how many people are actually 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. However, 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 newly named intervening neurons for fine tuning. However, any learned skill must (eventually) be linked back to a well-known, identified neuron, otherwise our innate traits (from our ancestral DNA) have no way to locate and leverage (exploit) them.

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

Memories fall into different categories. The simplest is recording the incoming sensory patterns (as a time series). For example, the buzzing sound of flying insects may have been encapsulated as a unique neural pattern (characteristic frequency) and stored in our collective DNA, millions of years ago. An identified neuron called “detect\_insects” constantly executes this DNA script, ever vigilant for the presence of flying insects, by sending inquiry messages to neurons associated with the senses (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 insects (or disgust at the sensation of insects crawling on our skin) is an innate trait, it must be that every human experiences the same feeling the same way (with the same identified neuron and the same neural signature of activity patterns). Identified neurons for the same trait carry the same name across all humans, 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 possibly send a confirmatory query (“is this a rare object?”) to another identified neuron (is\_rare\_object) unless it knew, *a priori* – in the scripts of our ancient DNA – the recipient’s name.

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. A new unique name must be generated and assigned to an unaffiliated neuron – creating a new identified neuron – to store memories of novel objects. However, we literally can’t recall a novel object (iPad) unless we link the new identified neuron to an *a priori* named identified neuron. In other words, to remember something (and to allow our innate feelings to interact with it), 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. New 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 “sensory signature” 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 invented 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 “who can I exploit to reach my goals?”

Each innate trait leverages learned traits that are stored in well-known locations in the brain. 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 what parents 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 that 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. With a few exceptions – such as a variant of the DRD4 gene that explains some of the variability in “novelty seeking” behavior – I don’t believe psychological traits are genetically determined. We humans are 99.4 to 99.9% genetically alike, which may be enough to account for some physical differences (Epstein 2014), but not mental ones. Again, there’s not enough genetic difference among us to allow for the swapping in and out of entire swaths of DNA to implement different traits. We each possess the DNA for all traits. Yes, mental traits are genetically specified (blueprinted), but our specific traits are not determined by our unique DNA.

How might post-conception trait selection work? Many potential traits, I believe, 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. (The roulette wheel may be seeded – or rigged – in some cases, to shift the probabilities slightly, as with traits that run in families.) 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 (by the trait assignment roulette wheel) according to highly-tuned, evolutionarily defined ratios across society 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 not so, because trait inequality leads to inequality in social outcomes, but I believe it is true nonetheless.

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

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