Thinking

The conscious actor ("Being") complex:

1. Input (e.g. sensing, downloading)
2. Processing (e.g. thinking, conscious & unconscious)
3. Output (e.g. having a body or otherwise acting on the world)

Thinking is that which takes place between sensing and action, input and output. In the same manner as with those elements, it exists purely to realize the actors teleology.

- Action without thinking is not conscious. Not that thinking (read: processing) is (necessarily) sufficient for consciousness, but it is *necessary*.
- Thinking without sensing is pure fantasy. It has no relation to reality.
- Sensing without processing is meaningless. It serves no purpose, and arguably, is impossible.

Thinking is information processing. In our case, thinking happens within the brain. It happens in the context of a cognitive architecture, and the abilities and limits of our wetware brains. Even simple organisms process information, though we often call instinct or automatic behavior. If there is output selection on input (external or internal), there is information processing.

1 CONTENTS

2 MAPPING THE BRAIN

This text is an effort to map out what happens in the brain, especially concerning the process of conscious thought. Such an effort requires a blend of psychological theory, introspection, neurobiology. Science do not have a complete blueprint of how to build and program a human brain, i.e. perfect knowledge about our hard- and software. I am mainly interested in how to best utilize the brain in thinking in everyday and life issues, and generally in maximizing the utility from our brains. This includes diet, exercise, cognitive algorithms and strategies.

Introspection requires the encoding of our own thoughts and mental phenomena. This again requires concepts about our mental contents; A mental vocabulary, if you will. The process of encoding once own thoughts adds to one's cognitive load (see self-reflective limit).

The psychological theory on memory works like this:

1. Do experiments that give data
2. Create theoretical constructs (e.g. working memory)

What we're trying to describe is the software of the brain, and we do that by looking at its behavior. Working memory is a concept. It is a description of the behavior of a system. It is not something that can ever be seen or measured directly with our eyes or with measuring equipment. It can only be seen inferentially. It is analogous to a computer program. To understand the computer program, you must look at its behavior, its effects. If you could read code (and some can, maybe you to), you wouldn't need to run it, but the code would still only be meaningful with reference to the behavior it implies.

The neurobiology of the brain can tell us about its workings. Understanding hardware lets us understand the limits of software. For instance, myelination and synaptogenesis are two neurobiological processes that are very involved in learning. Knowing about these processes lets us know that becoming proficient at something requires lots of repetition. We could reach the same conclusion through observation and introspection as well, i.e. we could go from data to conclusion without going through the layer of neurobiological theory, but neurobiology is a nice addition that might have predictive power.

E.g. if the brain cannot sustain concentrated attention for more than 30 minutes at a time, this tells us that there is some form of accumulation of waste or depletion of reserves somewhere in the brain mechanism that allows sustained attention. And conversely, If we knew that there was some form of accumulation of waste or depletion of reserves somewhere in that mechanism, we would know the sustained attention couldn't be sustained indefinitely.

3 Statistics

3.1 How long does it take to think a thought (e.g. an argument)?

Factors that affect thought speed:

- Thought Complexity
- Subject Familiarity
- Circadian & Homeostatic Sleep Components
- Digestion (Parasympathetic Activation)
- Short-Term Attention Burn-Out

Depends upon how you define "a thought". What I'm referring to is the period you will be unreceptive toward your surroundings, the time your "spaced out", conscious, motivated, self-directed thinking. You probably drift in and out of that state while doing intense brain work. At other times, you probably stay in a half-external, half-internal state while doing other things and resting in the default mode network. You could also go on autopilot where you are perceptive, but you know the task so well that you can think relatively intensively about something totally different at the same time, e.g. while driving home from work. Obviously, thinking is a very broad term, and even answering simple questions is technique is thinking. E.g. “where is the Eiffel tower located?”.

It feels comfortable to think about things you already have familiarity with, because you can relatively easily have intelligent thoughts. By doing so you feel smart og secure. If you try to step outside your areas of expertise you are in risk of being stupid or ignorant, which doesn’t feel very good. By staying with what you already know, you might also build incrementally on it, which will make you even smarter on that subject and trigger flow states. As a matter of strategy, you should seek to learn new things and try yourself out in new areas you deem to be worthy of consideration, but at the same time not always think about new stuff. Repeating things you already know is very important as well. Strike a balance.

For these reasons it is hard to put a number on how long it takes to think a thought. The question is further complicated by the very unclear definition of “a thought”. The brain is really doing computation all the time at various levels, in various modules and systems. Not all of this is conscious, per se, but the brain never sleeps (it is almost as active during the night as in the day). We could ask a more specific question, “how long does it take to make a syllogistic inference?” Well, it still depends, because you must do the apprehension and judgement (see logical view of mental operations) which will be associated with differing speeds based on subject matter. The inference step should take approximately the same amount of time invariably. The last step probably takes a couple seconds. The first two are kind of hard to pin down, since they happen semi-unconsciously. My best, but still taken out of nearly thin air, attempt to pin down the time it takes to make one syllogistic inference is from 1 – 45 seconds. As with everything brain related, it also depends on module specialization and myelination (see chunk/domain familiarity and evo-psych).

Thoughts are usually connecting pieces of mental content that is already there in memory, parts present in the vast neural network of the brain. By a spark of intelligence, they are assembled into something greater, a new, more complex, and hopefully useful or illuminating thought. You’re rarely thinking very complex thoughts from the ground up in one sitting. Complex thoughts usually come to life incrementally, and often uses the thinking of others to some degree. Our minds is to a large extent a reflection of the ideas and minds we have come in contact with throughout our lives.

All mental actions:

- require some time to occur
- create some amount of tiredness
- consume some amount of the available energy & attention

Examples:

Cognitive Switching Penalty is the cost to switching focus from one task to another. It says that it is better to focus one only one task instead of multitasking.

Remembering complex information requires that one “packs it out”, or in other words, retrieving the information schema gradually, in a somewhat logical, stepwise fashion. Depending upon the memory strength of all the information, it can take multiple minutes to recall everything. You may need to take a break from everything you're doing, to find all the memory traces and to puzzle them together into a logical whole. This process is quite a bit of mental work. The speed at which you do this probably depends on your working memory. You also need to consider that there might be things missing, and that they're being gone isn't obvious.

3.1.1 Signal Transmission Speed

To say that the speed of thinking is fast or slow doesn't make sense if you can't compare it to something else. There isn't really anything else in the world that can do what a human brain can do, *yet*, so there is really nothing to compare it too directly in terms of speed (at the high level of mind we operate on). Let's then just compare the signal transmission speed.

The brain is a complex organ. Processing happens at the level of the neuron and the module system level. We have often heard the metaphor that the brain is a computer. I personally use it all the time. And we have also heard that the brain is NOT like a computer, because it is paralleled while a CPU is serialized. Well, there exists parallel computing, and I guess the brain is much like that, with the neurons and higher-order logical systems being a kind of CPU. That is not a very precise statement, because science really doesn't have the full picture yet. The point it that the brain does computation, it processes information from input and produces output. This necessitates an underlying logic and a formal computational architecture. So, when saying that the brain is NOT like a computer, or not like a *specific* computer, you're not stating that it doesn't compute information at all, but that it is not made of silicone and metal wires, and that it doesn't run Windows operating system – Yes, Sherlock, you are perfectly right.

The signal transmission speed of the brain is SLOW compared to signal speed on metal wires with electricity. There is truly no competition. The limits on thought speed and total number of daily thoughts come from the limitations of our wetware. If the same logical architecture could be implemented in silicone, speed would be increased by very much.

Our nerve signals travel at various speeds:[1]

- Muscle position signal: 119 m/s
- Pain signals: 0.61 m/s
- Touch signals: 76.2 m/s

Ultimately, conduction velocities are specific to each individual and depend largely on an axon's diameter and the degree to which that axon is myelinated.[1] Electrical circuits can transfer information at extreme speeds, 50%-90% of the speed of light.[2]

Assuming we could upgrade our brains with silicone based hardware or upload all our memories to a computer with the same or very similar architecture, we could reach much better thinking speeds and avoid all sorts of quicks and limitations of biological wetware. Imagine having your new silicone based brain stored inside a secure mountain complex, exercising control and perceiving through robots (also other sensors and mechanisms). We would hopefully still be "human" in some meaningful sense, but with better stats.

Our consciousness could, possibly, not be uploadable without losing some of the humanity we're so attached to. Our life goals, purposes and what we find meaningful ultimately come from our genes and from our memes. It is easy to imagine that improvements to the logical architecture of our minds will be proposed in this migration/translation process. Our brains could be found to do things inefficiently, as it is an imperfect, evolved mechanism. I.e., we could make qualitative, not just quantitative changes. To some degree, we probably will have to. In the end, it is either *we* who must be upgraded with better hardware and software, or an artificial intelligence doing all the thinking for us. In the last case, if we wanted to derive all the value the A.I. produced for us, we would need to interface with it effectively, making brain upgrades very appealing. Anyways, this is a hypothetical, placed in the far future. In the meantime, we need to do the best with what we got.

3.1.2 Chunk Familiarity

Practice and concept consolidation will increase thinking speed. This is due to myelination of axons, which insulate them, allowing for faster signal transmission and lower activation bleed.[2] E.g. calculating 18x14 is much easier, quicker, and more accurate if you have spent considerable time practicing a technique for doing so.

If the facts, theories or methods used in thinking have very strong memory traces, then thinking becomes faster, easier and more accurate. There are many reasons why something would have a stronger memory trace; It could be emotionally salient, had been memorized thoroughly, it has many access routes (pegs).

When you first begin to learn about an entirely new field of knowledge, it is just a thematic blob in your mind, and you have disproportionate confidence in your own understanding. As you begin to learn more and more, the blob starts to fill out with concrete stuff. This process takes time. The more you know, the more of the true complexity emerge. It is like a layered cake. The top layer is an image, a very pixelated image. The more you dig into the cake, you find more and more detailed images. But your only discovering one pixel at a time, so the longer down you go, the more time it takes to progress further. The process of building a true to life, highly detailed, interactive mental model of some aspect of the world follows a graph the displays diminishing returns per unit of effort.

3.2 How tiering is it to think a thought?

A thinking session can be very tiering, or not so tiering.

3.2.1 Short Term Energy Consumption

The brain ordinarily uses approximately 20%, but under hard thinking this could increase up to 30%.

How does it affect your need for a mental rest period? Thinking requires concentration, and even after 30 minutes of intense concentration, you could be pretty tired. But a short rest period can refresh your mind. The Pomodoro technique leverages this asymmetry. You study for 25 minutes, take a 5-minute break, and repeat. This is much better than just working continually for hours.

3.2.2 Homeostatic Sleepiness

Brain work adds to homeostatic sleepiness. The more you think across your day, the sleepier you become. Probably, the harder you think relative to the amount, the greater increase in homeostatic sleepiness.

Sources:

1. https://en.wikipedia.org/wiki/Nerve_conduction_velocity
2. https://en.wikipedia.org/wiki/Speed_of_electricity

4 THE PROCESS OF THINKING

Thinking is hard, and not always pleasurable. People generally avoid having to do so. When thinking through an issue, you're bound to think something stupid and to not think everything through, or even just go entirely blank. That doesn't exactly build confidence or motivation. But thinking is the ability that separates us from the animals, and which backs our promised technological future, so we better do it and we better do it well.

4.1 WAYS THINKING COULD BE WRONG:

1. Using wrong facts
2. Not having all information
3. Drawing false inferences
4. Not drawing all possible inferences from available data
5. Using meaningless or non-reality corresponding concepts

1: You could satisfy point 3 and 4, i.e. only drawing valid inferences and drawing all the relevant ones, but still not have sound thinking – Meaning that they don't correspond to reality.

2: You never really have all information, perhaps only in a few corner cases. You always must keep this in the back of your mind. You must employ systematic search and efficient heuristics to gain good information breath (while retaining information quality). Also, drawing inferences leads to new facts. Thinking therefore is a process that feeds itself. If you happen upon a contradiction in your thinking, you know that either you have drawn a false inference (3), or you have been using wrong facts (1).

3: Here, learning all the valid inference rules is important. The study of valid inference rules is logic. Relying on your own intuition can take you far, but not all the way. Logic has been developed formally over a long time, and by careful thinking. You just can't match that with drive-by intuition.

4: Even if you have a lot of information, you could still not draw all possible relevant conclusions from them. This could be due to not realizing they are there, or not having enough time or energy.

All thinking is probably always partially wrong or incomplete or self-contradictory. If you never wanted to say anything that wasn't true or didn't give misleading or incomplete answers, you would have to be very cautious. A better approach is possibly to just state "to the best of my knowledge, analytic powers and time and energy constraints, my thoughts on the subject is X, Y, Z." This can be appropriate in formal and scientifically literate conversation and publication, but otherwise it could lead people to doubt your knowledge on the subject, as people use apparent certainty as a proxy for correctness, and it might seem quite awkward.

4.1.1 Uncertainty Considerations

Thoughts carry uncertainty with respect to all these points. You should then ideally have an idea of what the probability of (1) your facts being right, (2) that you have all the necessary information to get a perfect picture, (3) that all your inferences are valid, and (4) that you have drawn all possible relevant inferences from that pool of facts. Now, the purpose of noting these uncertainties is to ascertain the expected utility from acting upon these beliefs.

How do you weight the relative impact of being right on these four points? A very rough set of numbers could theoretically be calculated if we had all this data about every person alive's utility from acting upon thoughts and their personal uncertainties on these four points when acting. Now, we will never be able to collect that information, and even if we could it would probably be a very rough estimate. We could probably get better estimates by being domain specific. Anyways, the best solution is probably to just spread the estimated impact out evenly, 25% to each of them.

1: Your facts could be wrong. Should you (i) state your credence for each individual fact and take the mean of those, or should you (ii) just state the credence you have in that all facts are correct? The first will probably be a moderately high number, or at least should be, while the latter probably would be significantly lower (unless using few facts).

2: Not having all the information. Should you (i) state your best estimate for many percent of the total information you have, or should you (ii) state the credence you have in having all the information?

3: Drawing false inferences. As with point 1, should you state (i) the mean of the credence in each individual inference, or the (ii) the credence that all your inferences are valid?

4: Not drawing all inferences. As with point 2, should you (i) estimate all inferences drawn as percentage of all possible (relevant inferences), or (ii) credence in having drawn all possible ones?

Deciding on all these are not very easy and causes high cognitive load. You just can't do this for everything you think. This goes to illustrate how limited we really are. Reflecting on our own thoughts quickly leads to cognitive overload. The point where our self-reflection grinds to a halt is called our “**self-reflective limit**”. We can split the self-reflective limit into two parts: The “**absolute self-reflective limit**” and the “**average running self-reflective limit**”. The absolute self-reflective limit is the point at which no meta-thought can be produced. The average running limit comes from the fact that we can selectively switch between having thoughts of 1^{st}, 2^{nd}, 3^{rd}, 4^{th} order, and so on, but when trying to do so all at once we quickly lose steam. The act of thinking a thought itself produces high cognitive loads. For instance, systematically determining all the 8 elements of thought of our own thoughts would probably be more time and energy demanding than just thinking the thought itself.

We are using our bounded rationality to live our lives, and does so to a reasonable degree. The modern world supplies more correct facts (1 & 2), more free time to draw inferences from those facts (4), and the internet, television and printing press allows for quick dissemination of facts, inferences, counter-inferences, and inference overviews (write-ups, documentaries, articles, books, etc.) But we are still very much in the position that we must balance the reward of being right with the risk of being wrong. So long as the punishments are tolerable to some extent, we can tread forward with some confidence that it will end well. In theory, a limited being cannot ever satisfy at least point 2, arguably the other points as well, perhaps especially point 1 and 4.

The introduction of any fact can theoretically require you to update *all* your beliefs. There are multiple things that makes sure that you don’t thoroughly go through this process. First, your active beliefs are very limited in time by memory decay. To have many beliefs you must take extra steps to secure them; Keeping write-ups on subjects and lists of beliefs can help you do so. Secondly, there are time and processing constraints. Luckily, there is at least some “automatic” updating of beliefs, although it’s limited.

Ideally, we would be self-programming Turing machines; but we are not. We’re noisy, slow, fault-ridden biological computers with severely bounded rationality. This is something that can be disappointing to discover, and even hard to reconcile with ones’ self-image as a rational being. Turing machines are theoretical constructs with infinite memory and processing power, which ether must compute infinitely fast or have infinite time to compute, to fulfill its promises of being able to compute everything that can theoretically be computed. Of course, nothing real is infinite, so such a machine will never exist. Minds are always on a spectrum of quantification, so don’t be to bummed out, since there is nothing we know of yet that can do what the human brain can do. The only thing that could hurt your confidence in this respect is other humans.

4.2 Internal vs External

Thinking internally only is problematic, and will only work for simple subjects. This is because everything must be stored and accessed in the brain. In addition, an index must be built to keep track. This is a fault ridden process. Loading, storing and reloading will consume much brain resources compared to thinking on paper. Even the thinking part (creating and critiquing arguments and models) quickly run out of working memory. The brain must also refresh all contents of working memory constantly, making it more tiering. These are things that happen automatically/unconsciously most of the time, unless your forcing it, but they do require concentration and volition. By thinking on paper, you can store it for the rest of your life without worrying about forgetting it. Remember to store it in a logical way in a folder system, name it something descriptive and tag it.

Thinking in the brain is a noisy process. It's best to think through complex subjects on paper. You jot down whatever nuggets of ideas or thoughts you might have. This frees up new working memory, and insulates you from forgetting them. Now you can work of what you have written down. You can remove, add, change, rearrange, rewrite etc. Thinking happens incrementally. This is crucial to understand. If you are like me, it can happen anytime and anywhere. When I think an interesting thought that is complex enough or that I feel has potential to become something more, then I write it down or record it with a smartphone. I do not trust my own memory to remember it exactly is I thought it, or remember it at all. You can probably relate to forgetting something and then going back to where you thought of it, trying to regain the associative network you had then, so the memory can be retrieved again. All thinking happens within a priming environment that is always changing. In other words, thinking is often highly contextual. Also, by externalizing it, I remove the need to keep it refreshed in memory, as I feel strained by doing so. This leaves more mental space for new thoughts. Also, the act of writing it down usually consolidates it in memory*.

When reading or otherwise consuming information, you might suddenly get new ideas on which subject you have previously written. It can happen anytime probably, that you get new ideas or think new thoughts. The brain may be connecting information while you are in default mode network. Thoughts might just pop out of thin association. Then depending upon salience, and other things, it might disappear, even forever. What thoughts you can have depends upon the facts, perspectives, models, theories and experiences you have. When an interesting thought pops up, you should take out the document and add the new information. You should ideally keep sources and annotations for all facts and input that is not obvious or well-known. This is easy with writing.

* If the act of verbalizing (turning into words) consolidates the memories, why not just do it in the head? Well, it is harder. You don't get visual feedback. It's harder to keep on track.

We do not think complex thoughts in words. The process of converting thought to words is time consuming and tiering as well. I can spend hours writing down a couple of pages. You usually must go over a couple of times before it becomes somewhat well written. My philosophy is first to just get the ideas down in an understandable and quick way, not being overly concerned with how it is written. Then spelling, flow, structure is improved over time. The best thing is to work in an incremental fashion. There is always more to add, things to clarify and things to just remove.

4.3 What happens when we read or listen?

Much of our mental energies goes toward the process of reading or listening itself, and to superficially judge the facts and arguments presented. When reading, we obviously do not need to generate any arguments. At most we must remember relevant information and look out for inconsistencies and faults. It is much easier to read, judge and critique than to write something ourselves.

4.4 Record keeping

Keeping all documents for later use is very important. It doesn't have to be your own creation. You can copy another person's work. I implore you to abridge - crop and edit - articles you find online. The process of removing useless or distracting information requires you to read it and then decide to ignore it. Doing this just once will save you over the long run if you are to view the source of information multiple times. By giving it a descriptive name and appropriate tags, you make more accessible as well. Accessibility is important, because it lowers the barrier for using information in thinking and for shared with others.

4.5 Forgetting

Memory is a crucial part of all information processing. There can be no computation without memory. The brain has multiple memory systems. Memory supplies thinking with information not immediately available to the senses, and serves as a work bench on which to manipulate that information (facilitating processing). The first case includes long-term, short-term and sensory memory. The second case refers to working memory.

Stages of memory:

1. Encoding
2. Storage
3. Retrieval

Memory can fail at all these stages. Memories must be encoded in the first place. One might be distracted or erroneously believe that it will automatically be encoded subconsciously. While in storage, the memory trace decays over time. It must be recalled for its strength to refreshed, and this must of course happen before it is forever lost. Retrieval happens either automatically, or because you remember to remember something. The brain set's up an associative network, whose purpose is to make available relevant information to the process of thinking when it needs it. This process is far from perfect, and can be helped with mnemonic techniques. Some specific retrieval failures are *cue-dependent forgetting* and *interference*. In any case, all steps are of equal importance.

You might protest the idea that you forget important or interesting thoughts. You might believe that your brain stores everything of value automatically. You would be correct to some degree. It is very likely an illusion that it remembers all the important and interesting stuff, because when you forget something, in most cases, you never notice that you did, and if you don't notice, you don't factor it into the ratio of things you remember to those you forget. We do have a propensity of remembering core ideas or general themes more than remembering details, which can also contribute to a skewed image of how much we remember. Those core ideas or themes are the main peg on which related details would be hung. You sort of have the roots of the tree, but not the tree itself, but it feels like you have the whole thing.

There are two ways you can access something you thought earlier:

1. Accidentally (You happen to stumble on it associatively.)
2. You remember to remember it
    a. You also remember the content
    b. You don't remember the content

The lost value from forgetting is easy to miss, because it is hypothetical. It is for the untrained mind something flimsy and non-Important. It is not likely something that they will ever think about. When you don't remember that you didn't remember to remember something, you won't concern yourself with it.

Each time you forget something that is of value you lose out. The value from each thought can range from insignificant to major, with a probable average somewhere in the low range. Many small losses will however accrue to a large one. Also, when it comes to good ideas, there are exponential factors involved, so it can conceivably add up to a huge loss of value in the end. Analogously, imagine someone having $1000 left over each month. They spend this money on stuff immediately. They could instead have invested the money and earned interest. That interest could earn interest. The person never thinks about all the interest they lose out on. Can't see it, and they don't force themselves to think about it to avoid losses, so they just don't think about it. The loss is real nonetheless. The cost of whatever the person spent the money on is equal to the money itself, plus all the interest he could have earned.

Each thought you *have* produces some amount of value; That's what thoughts are for. Thus, we want to maximize the value from each thought, and maximize the frequency of thought (up to a point). Still, we should not spend all our time thinking; The lot of man is also to sense, and to act.

- Increase value of thought
- Increase frequency of thoughts
- Increase retention of thoughts

4.6 Memory

The brain has very limited memory capacity, contrary to what is sometimes uttered. The brain stores as little information as possible. It abstracts away physical features and leaves only the points of interest for you. You don't remember exactly the interior of houses you visit, or the faces of the people you meet. You remember themes and salient features. You don't even remember these exactly. When you are asleep, the brain removes a lot of memories it deems useless. Everything to preserve the "space" available.

When trying to remember a complex issue, situation or argument, the brain must retrieve it from memory bit by bit, because it is to large to be held in memory all at once, and because unless previously processed and turned into some personally meaningful conclusion or resolution, then it is stored in bits and pieces. Once it is processed and compactified into a conclusion or resolution, then the few details you possess doesn't need to be recalled again. They can still be, if you find the need to do so, but if they are not, they will quickly decay forever. For instance, you sit through the trail of a person accused of murder. You hear the case for and against, and whilst it is going on you manage to follow the argumentation with relative ease. But you don't store all the arguments in their full detail in memory. You only store the theme and impact of each line of argumentation. Then after the trial, when the man is found guilty, you don't find the details important or salient anymore, so you just store the verdict. Now, you could force yourself to go back to the details, and you would with some effort and time in concentration find some of them, mostly in their abstracted form, and that most of them are gone.

Thinking can occur without one specific memory, but thinking cannot happen without memory at all, and memories without thinking is impossible. Information is not physical, it is logical interpretation of patterns. It does not exist without thought.

4.7 THE BRAIN'S LOGICAL CONNECTIVE TISSUE

The brain has an architecture. Whether it is serial, parallel, quantum or whatever, we can be certain that it does computation, and that computation requires a logic and physical mechanism.

5 WHAT THE BRAIN CAN DO

The brain can do many things. I'm going to focus on the things related to this topic.

- Defining (e.g. concepts, terms, categories)
- Language
- Planning (first X, then Z, then Y)
- Sequential Mechanistic Thinking (if X, then Y)
- Sequential Probabilistic Thinking (if X, then Y or Z)
- Attention (i.e. concentration, focus)
- Memory (e.g. explicit, implicit)
- Volition
- 3D Visualization (not sustained)
- Hypothetical Thinking (if X was the case, then ?? Imagination based)
- Creating Arguments (e.g. syllogisms; formal or informal reasoning; incl. counter-arguments)
- Imagination

Volition is when we intend to do something and sustain that intent. It can be driven by emotions, reason, or whatever. You will have a hard time doing it when tired, you're not motivated, and easy when you are. When writing, long term volition is important. You must expect to be dissatisfied and to come up dry (not having any interesting thoughts.) It is a blend of disappointing emptiness and engaging flow states, mixed together. It is driven by a feeling that there is more to say, and that there are ways to say them well.

All thinking involves these 8 elements:

1. Purpose (e.g. goal, objective)
2. Question (e.g. problem, issue)
3. Information (e.g. facts, experiences)
4. Interpretation & Inference (e.g. conclusions, solutions)
5. Concepts (e.g. theories, models, definitions, laws, principles)
6. Assumptions (e.g. presuppositions, axioms)
7. Implications and Consequences
8. Point of View (e.g. perspective, frame of reference, orientations)

5: All information is given meaning when filtered through the lens of concepts, theories, models, definitions, laws and principles. Concepts can be useful to you or not, don't be afraid to modify them or scrap them entirely. You want to treat your mind as a garden you care for. You want it to be free from elements that do not serve your interests. By controlling which concepts, theories, models, laws and principles that are included, which are excluded and how they are used, people can control to some degree which thoughts are reached.

8: Everybody has a point of view. It can be based on their personal experiences (ideological, emotional basis) or purely an informational viewpoint, meaning that it has limited information. Alternatively, it just means that people can think through the same subjects with entirely different aims, concepts and assumptions, leading to very different inferences and interpretations.

5.1 REASONING

Reasoning, e.g. **creating arguments**, as a logical process. To do it right you need to know the valid inference rules, which are the laws of correct thought. You will have an intuitive feeling about the logical correctness of arguments, but this feeling will only take you so far. Study logic. Converting natural language into symbolic expressions and vice versa should ideally be a natural, fluent thing.

1. Formal Logic
2. Informal Logic
3. Cognitive Biases

There are three categories of inference:

1. Deductive
2. Inductive
3. Abductive

5.2 DEDUCTIVE LOGIC

Deductive logic is true logic. All necessarily valid inference rules are deductive in nature. All deductive logic cares about is how to create good arguments. If you care about the truth and rationality, then you must know logic. And it forms the basis for all computation.

Logic as field of formal science started with Aristotle (everything started with Aristotle, or what?). He created the classical categorical syllogistic system.

5.2.1 Classical

A syllogism is a valid inference rule. It consists of two premises and one conclusion.

9. - Premise
10. - Premise
11. :: Conclusion

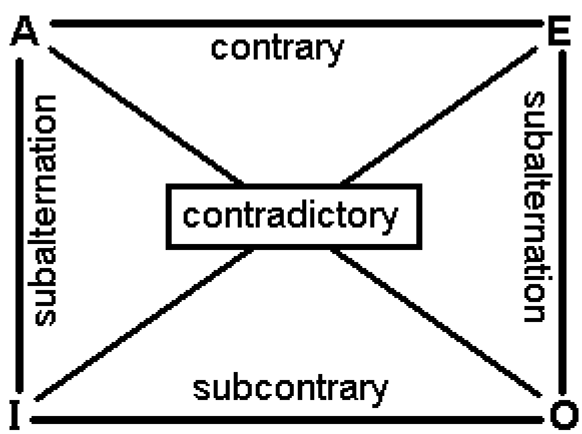
The premises are categorical propositions. A proposition consists of a subject and a predicate. The subject is further sub-divided into *a kind of thing* and a *quantifier*. The quantifier is either *all* or *some*. So, for example, “all people are mammals” & “no penguins are mammals”.

12. - All people are mammals
13. - No penguins are mammals
14. :: No penguins are people

There are 256 unique syllogisms, 24 valid ones, and only 15 are unconditionally valid. That is right, there are only 15 non-controversial inference rules over categorical propositions. So, if you make an inference that does not correspond to one of them, you are wrong.

5.2.1.1 Square of Opposition

The square of opposition is a chart that was introduced within classical (categorical) logic to represent the logical relationships holding between certain propositions in virtue of their form. The square, traditionally conceived, looks like this:



The four corners of this chart represent the four basic forms of propositions recognized in classical logic:

A propositions, or *universal affirmatives* take the form: *All S are P*.
E propositions, or *universal negations* take the form: *No S are P*.
I propositions, or *particular affirmatives* take the form: *Some S are P*.
O propositions, or *particular negations* take the form: *Some S are not P*.

Given the assumption made within classical (Aristotelian) categorical logic, that every category contains at least one member, the following relationships, depicted on the square, hold:

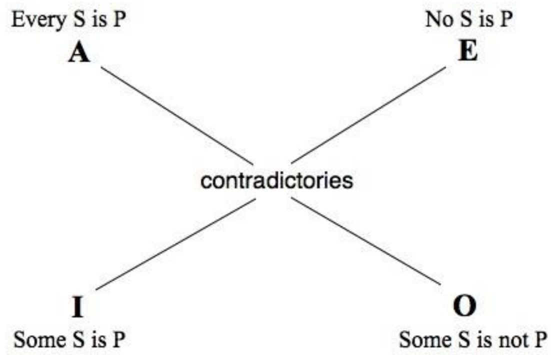
Firstly, A and O propositions are ***contradictory***, as are E and I propositions. Propositions are contradictory when the truth of one implies the falsity of the other, and conversely. Here we see that the truth of a proposition of the form *All S are P* implies the falsity of the corresponding proposition of the form *Some S are not P*. For example, if the proposition "all industrialists are capitalists" (A) is *true*, then the proposition "some industrialists are not capitalists" (O) must be *false*. Similarly, if "no mammals are aquatic" (E) is *false*, then the proposition "some mammals are aquatic" must be *true*.

Secondly, A and E propositions are ***contrary***. Propositions are contrary when they cannot *both* be true. An A proposition, e.g., "all giraffes have long necks" cannot be true at the same time as the corresponding E proposition: "no giraffes have long necks." Note, however, that corresponding A and E propositions, while contrary, are not contradictory. While they cannot both be true, they *can* both be false, as with the examples of "all planets are gas giants" and "no planets are gas giants."

Next, I and O propositions are ***subcontrary***. Propositions are subcontrary when it is impossible for both to be *false*. Because "some lunches are free" is false, "some lunches are not free" must be true. Note, however, that it is possible for corresponding I and O propositions both to be *true*, as with "some nations are democracies," and "some nations are not democracies." Again, I and O propositions are subcontrary, but not contrary or contradictory.

Lastly, two propositions are said to stand in the relation of ***subalternation*** when the truth of the first ("the superaltern") implies the truth of the second ("the subaltern"), but *not* conversely. A propositions stand in the subalternation relation with the corresponding I propositions. The truth of the A proposition "all plastics are synthetic," implies the truth of the proposition "some plastics are synthetic." However, the truth of the O proposition "some cars are not American-made products" does not imply the truth of the E proposition "no cars are American-made products." In traditional logic, the truth of an A or E proposition implies the truth of the corresponding I or O proposition, respectively. Consequently, the falsity of an I or O proposition implies the falsity of the corresponding A or E proposition, respectively. However, the *truth* of a particular proposition does not imply the truth of the corresponding universal proposition, nor does the falsity of a universal proposition carry downwards to the respective particular propositions.

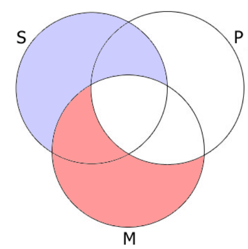
The presupposition, mentioned above, that all categories contain at least one thing, has been abandoned by most later logicians. Modern logic deals with uninstantiated terms such as "unicorn" and "ether flow" the same as it does other terms such as "apple" and "orangutan". When dealing with "empty categories", the relations of being contrary, being subcontrary and of subalternation no longer hold. Consider, e.g., "all unicorns have horns" and "no unicorns have horns." Within contemporary logic, these are both regarded as true, so strictly speaking, they cannot be contrary, despite the former's status as an A proposition and the latter's status as an E proposition. Similarly, "some unicorns have horns" (I) and "some unicorns do not have horns" (O) are both regarded as false, and so they are not subcontrary. Obviously then, the truth of "all unicorns have horns" does not imply the truth of "some unicorns have horns," and the subalternation relation fails to hold as well. Without the traditional presuppositions of "existential import", i.e., the supposition that all categories have at least one member, then only the contradictory relation holds. On what is sometimes called the "modern square of opposition" (as opposed to the traditional square of opposition sketched above) the lines for contraries, subcontraries and subalternation are erased, leaving only the diagonal lines for the contradictory relation.



5.2.1.2 Unconditionally Valid Syllogisms

BARBARA, AAA-1

All M are P. All S are M. Therefore, All S are P.



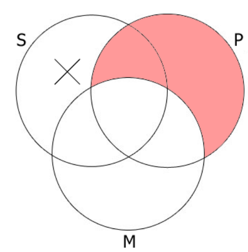
If you wish to formulate a valid argument with a UNIVERSAL NEGATIVE conclusion from a mix of AFFIRMATIVE/NEGATIVE and UNIVERSAL/PARTICULAR premises, the you have TWO to choose from.

BAROCO, AOO-2

All P are M.

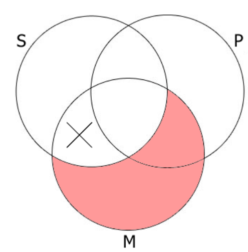
Some S are not M.

Therefore, Some S are not P.



BOCARDO, OAO-3

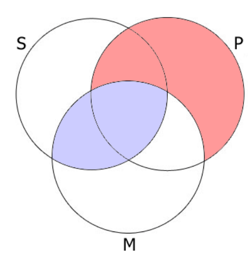
Some M are not P. All M are S. Therefore, Some S are not P.



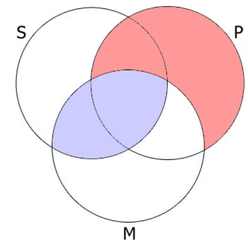
If you wish to formulate a valid argument with a UNIVERSAL NEGATIVE conclusion from ONLY universal premises (only one of which is affirmative), then you have four to choose from:

CAMENES, AEE-4

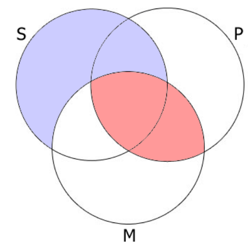
All P are M. No M are S. Therefore, No S are P.



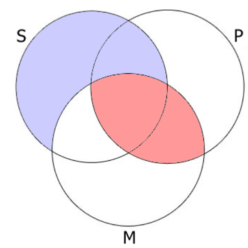
CAMESTRES, AEE-2
(by converting the minor premise of CAMENES)
All P are M. No S are M. Therefore, No S are P.



CELARENT, EAE-1
No M are P. All S are M. Therefore, No S are P.

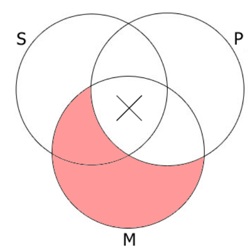


CESARE, EAE-2
(by Converting the major premise of CELARENT)
No P are M. All S are M. Therefore, No S are P.

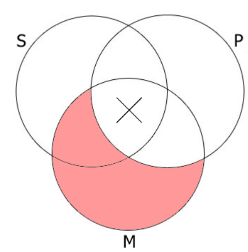


If you wish to derive a PARTICULAR AFFIRMATIVE conclusion from only AFFIRMATIVE premises using both UNIVERSAL AND PARTICULAR then choose from these four valid forms for your syllogism

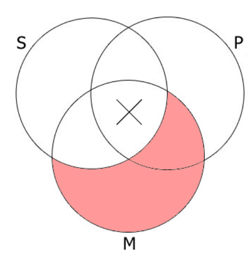
DARII, AII-1
All M are P. Some S are M. Therefore, Some S are P.



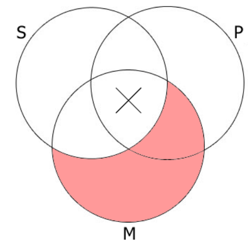
DATISI, AII-3
(by converting the minor premise of DARII)
All M are P. Some M are S. Therefore, Some S are P.



DISAMIS, IAI-3
Some M are P. All M are S. Therefore, Some S are P.

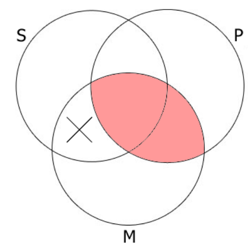


DIMARIS, IAI-4
(by converting the major premise of DISAMIS)
Some P are M. All M are S. Therefore, Some S are P.

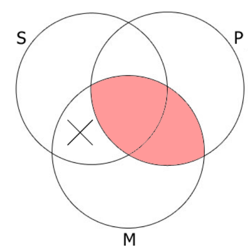


If you want to formulate an argument with a PARTICULAR NEGATIVE conclusion from one UNIVERSAL NEGATIVE and one PARTICULAR AFFIRMATIVE without worry about how the FIGURE of the MIDDLE TERM will affect your argument, then choose any MOOD & FIGURE of EIO arguments. Regardless of FIGURE, they are all valid. To understand why this is the case merely recall that only Type E and Type I propositions are valid immediate inferences by conversion.

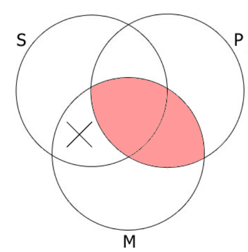
FERIO, EIO-1
No M are P. Some S are M. Therefore, Some S are not P.



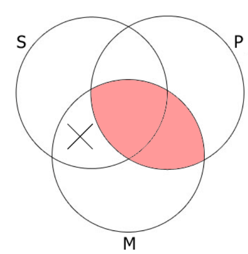
FESTINO, EIO-2
(by converting the major of FERIO)
No P are M. Some S are M. Therefore, Some S are not P.



FRESISON, EIO-4
(by converting the minor of FESTINO)
No P are M. Some M are S. Therefore, Some S are not P.



FERISON, EIO-3
(by converting the major of FRESISON)
No M are P. Some M are S. Therefore, Some S are not P.
(Note: Converting the minor of this syllogistic form, FRESISON will return you to FERIO)



5.2.1.3 Overview

5.2.1.3.1 Unconditionally valid

Figure 1	**Figure 2**	**Figure 3**	**Figure 4**

AAA **EAE** **AII** **EIO**	**EAE** **AEE** **EIO** **AOO**	**IAI** **AII** **OAO** **EIO**	**AEE** **IAI** **EIO**

5.2.1.3.2 Conditionally valid

Figure 1	Figure 2	Figure 3	Figure 4	Required condition
AAI **EAO**	**AEO** **EAO**		**AEO**	*S* exists
		AAI **EAO**	**EAO**	*M* exists
			AAI	*P* exists

Source:

http://markmcintire.com/phil/validforms.html

http://www.poweroflogic.com/cgi/Venn/venn.cgi?exercise=6.4B

https://en.wikipedia.org/wiki/List_of_valid_argument_forms

5.2.2 Propositional

5.2.2.1 Valid Propositional Forms

MODUS PONENS

One valid argument form is known as modus ponens, not to be mistaken with modus tollens which is another valid argument form that has a like-sounding name and structure. Modus ponens (sometimes abbreviated as MP) says that if one thing is true, then another will be. It then states that the first is true. The conclusion is that the second thing is true.[3] It is shown below in logical form.

If A, then B

A

Therefore B

Before being put into logical form the above statement could have been something like below.

If Kelly does not finish his homework, he will not go to class

Kelly did not finish his homework

Therefore, Kelly will not go to class

The first two statements are the premises while the third is the conclusion derived from them.

MODUS TOLLENS

Another form of argument is known as modus tollens (commonly abbreviated MT). In this form, you start with the same first premise as with modus ponens. However, the second part of the premise is denied, leading to the conclusion that the first part of the premise should be denied as well. It is shown below in logical form.

If A, then B

Not B

Therefore not A.[3]

When modus tollens is used with actual content, it looks like below.

If the Saints win the Super Bowl, there will be a party in New Orleans that night

There was no party in New Orleans that night

Therefore, the Saints did not win the Super Bowl

HYPOTHETICAL SYLLOGISM

Much like modus ponens and modus tollens, hypothetical syllogism (sometimes abbreviated as HS) contains two premises and a conclusion. It is however, slightly more complicated than the first two. In short, it states that if one thing happens, another will as well. If that second thing happens, a third will follow it. Therefore, if the first thing happens, it is inevitable that the third will too.[3] It is shown below in logical form.

If A, then B

If B, then C

Therefore if A, then C

When put into words it looks like below.

If it rains today, I will wear my rain jacket

If I wear my rain jacket, I will keep dry

Therefore if it rains today, I will keep dry

DISJUNCTIVE SYLLOGISM

Disjunctive syllogism (sometimes abbreviated DS) has one of the same characteristics as modus tollens in that it contains a premise, then in a second premise it denies a statement, leading to the conclusion. In Disjunctive Syllogism, the first premise establishes two options. The second takes one away, so the conclusion states that the remaining one must be true.[3] It is shown below in logical form.

Either A or B

Not A

Therefore B

When used A and B are replaced with real life examples it looks like below.

Either you will see Joe in class today or he will oversleep

You did not see Joe in class today

Therefore Joe overslept

Disjunctive syllogism takes two options and narrows it down to one.

CONSTRUCTIVE DILEMMA

Another valid form of argument is known as constructive dilemma or sometimes just 'dilemma'. It does not leave the user with one statement alone at the end of the argument, instead, it gives an option of two different statements. The first premise gives an option of two different statements. Then it states that if the first one happens, there will be a particular outcome and if the second happens, there will be a separate outcome. The conclusion is that either the first outcome or the second outcome will happen. The criticism with this form is that it does not give a definitive conclusion; just a statement of possibilities.[3] When it is written in argument form it looks like below.

When content is inserted in place of the letters, it looks like below.

Bill will either take the stairs or the elevator to his room

If he takes the stairs, he will be tired when he gets to his room

If he takes the elevator, he will miss the start of the football game on TV

Therefore Bill will either be tired when he gets to his room or he will miss the start of the football game

There is a slightly different version of dilemma that uses negation rather than affirming something known as destructive dilemma. When put in argument form it looks like below.

If A then C

If B then D

Not C or not D

Therefore not A or not B [4]

5.2.3 Logical Systems

1. Classical (Syllogistic)
2. Propositional (Sentential)
3. Predicate
4. Modal
    a. Alethic
    b. Epistemic
    c. Doxastic
    d. Temporal
    e. Deontic
15. Mathematical
16. Binary

5.2.4 Connectives

17. Conjunction (And)
18. Inclusive Disjunction (X, Y or Both)
19. Exclusive Or (X or Y, not Both)
20. Negation (Sign reversal; Not)
21. Conditional (If-Then, Implication)
22. Bi-Conditional (Bi-Directional Conditional)

5.2.5 Quantifiers

23. All X are Y
24. Some X are Y (1 or more)

5.2.6 Arguments

Syllogisms are inferences/arguments. They always have the same basic form.

25. 2 premises
26. 1 conclusion

5.2.6.1 Syllogism Properties

27. Valid Inference (Valid Inference Rule)
28. Sound Inference (Valid & True)

5.3 Inductive Logic

Inductive logic is the logic of making general rules (or “facts”) from a limited set of observations. Universal physical laws are assumed to exist because of specific observations that confirm the same cause-effect relationships at different places and different times. Inductive and abductive logic are not necessary. We use them because it feels like they are useful, and I wholly support that.

According to PUSR, all inductive arguments will never be guaranteed to necessarily be correct, given that you can never repeat an experiment infinitely many times or guarantee that a sample process is purely random. Inductive inferences might tend to work, but you have no guarantee that they will continue to tend to work. Is that disheartening? Well, it's just the way it is. Deal with it!

Generalization

A generalization (more accurately, an *inductive generalization*) proceeds from a premise about a sample to a conclusion about the population.

> The proportion Q of the sample has attribute A.
>
> Therefore:
>
> The proportion Q of the population has attribute A.

Example

There are 20 balls—either black or white—in an urn. To estimate their respective numbers, you draw a sample of four balls and find that three are black and one is white. A good inductive generalization would be that there are 15 black and five white balls in the urn.

How much the premises support the conclusion depends upon (a) the number in the sample group, (b) the number in the population, and (c) the degree to which the sample represents the population (which may be achieved by taking a random sample). The hasty generalization and the biased sample are generalization fallacies.

Generalizations are not necessary. Even if we knew with absolute certainty that our sample was chose perfectly at random, we could only support the conclusion if the generalization by modifying it. We would need an infinite number of samples from the target population. Q would need to be the average proportion with attribute A in those samples. In practice, a generalization can never be perfectly necessary. This is called the *Principle of Uniformity-Sampling-Random* (PUSR).

Statistical syllogism

Main article: Statistical syllogism

A statistical syllogism proceeds from a generalization to a conclusion about an individual.

> A proportion Q of population P has attribute A.
>
> An individual X is a member of P.
>
> Therefore:
>
> There is a probability which corresponds to Q that X has A.

The proportion in the first premise would be something like "3/5ths of", "all", "few", etc. Two dicto simpliciter fallacies can occur in statistical syllogisms: "accident" and "converse accident".

According to PUSR, the conclusion is only necessary when X is drawn an infinite number of times, and Q is the average times that X has A.

Simple induction

Simple induction proceeds from a premise about a sample group to a conclusion about another individual.

> Proportion Q of the known instances of population P has attribute A.
>
> Individual I is another member of P.
>
> Therefore:
>
> There is a probability corresponding to Q that I has A.

This is a combination of a generalization and a statistical syllogism, where the conclusion of the generalization is also the first premise of the statistical syllogism. Therefore, it is also subject to PUSR.

Argument from analogy

Main article: Argument from analogy

The process of analogical inference involves noting the shared properties of two or more things, and from this basis inferring that they also share some further property:[15]

> P and Q are similar in respect to properties a, b, and c.
>
> Object P has been observed to have further property x.
>
> Therefore, Q probably has property x also.

Analogical reasoning is very frequent in common sense, science, philosophy and the humanities, but sometimes it is accepted only as an auxiliary method. A refined approach is case-based reasoning.[16]

This line of reasoning is not necessarily true, because you can (metaphysically) have thing that share properties a, b and c, but while differ in a 4th property. Thus, the conclusion depends upon the reference class and the epistemic physical world the reasoner inhabits. If a world only contains 10 things which share 3 properties, and you know that 7 of those things share a 4th property, while the rest do not, then you can to some degree support the conclusion. But this still depends on PUSR, in that the conclusion only is true in the limit, as the number of draws approaches infinity, and when P and Q are selected perfectly uniformly randomly.

Prediction

A prediction draws a conclusion about a future individual from a past sample.

> Proportion Q of observed members of group G have had attribute A.
>
> Therefore:
>
> There is a probability corresponding to Q that other members of group G will have attribute A when next observed.

This also depend on PUSR. For the conclusion to be necessary, you would have had to draw an infinite number of samples from G, and taken the average proportion of observed members who had attribute A.

5.4 Abductive Logic

Abductive reasoning is going from an effect back to it likely cause. You feel that the grass is wet, so you think that it has rained. There are many metaphysically possible reasons for the grass to be wet, and only one likely one. Most likely it rained, but it could have been the sprinklers. It is a probabilistic framework.

1. The grass is wet
2. Rain causes wet grass
3. Therefore, it is likely that it has rained

If you didn't include the probability element, it would be a formal fallacy (affirming the consequent; *Post hoc ergo propter hoc*). E.g. thinking:

1. The grass is wet
2. Rain causes wet grass
3. Therefore, it has rained

Alternatively, and probably more correctly, we could remove the probability element, and just reason backward in a deductive manner.

1. The grass is wet
2. Rain causes wet grass
3. Therefore, rain is one possible cause of (1)

https://en.wikipedia.org/wiki/Abductive_reasoning

5.5 Logic as Fabric of Thought (Theory of Banal Truth-Bearing Propositions)

When we think about logic, we often think about debates and whatnot. But logic is much more fundamental than that. Logic is the basis of computation, and all thinking is computation. Not just thinking in words, but the unconscious processing in the brain also. Deduction, induction and abduction are integral elements of the operation of our minds.

The brain is not the same everywhere. It consists of specialized modules that communicate with each other. E.g. the back of the brain processes visual stimuli from the eyes and produces sight. Then that information is transmitted to other parts of the brain for further consideration, e.g. to make a coherent model of our surroundings. These modules are plastic to some degree, meaning that they can take over for other modules if the latter have been damaged (e.g. stroke). They do, however, cannot really be made to perform to the same standard, which is only natural.

6 THE LOGICAL VIEW OF MENTAL OPERATIONS

According to most logicians, the three primary mental operations are apprehension (understanding), judgement, and inference.

Apprehension is the mental operation by which an idea is formed in the mind. If you were to think of a sunset or a baseball, the action of forming that picture in your mind is apprehension. The verbal expression of apprehension is called a term.

Judgment is the mental operation by which we predicate something of a subject. Were you to think, "That sunset is beautiful," or "Baseball is the all-American sport" is to make a judgment. The verbal expression of judgment is the statement (or proposition).

Inference (or reasoning) is the mental operation by which we draw conclusions from other information. If you were to think, "I like to look at that sunset, because I enjoy beautiful things, and that sunset is beautiful" you would be reasoning. The verbal expression of reasoning is the logical argument.

They proceed in a step by step fashion, the first enabling the second, and the second the third.

7 BELOW THE WATER-LINE

Despite all this talk about domain-general logical thought expressed verbally and symbolically as logical arguments on premises according to valid inference rules, there is more to the picture. MOST of our mental content is NOT this kind of domain-general logico-verbal thought.

Our minds are made of goal-specific modules that process different information and which sets bodily functions and other mental processes in motion. We have danger-monitoring modules that scans our surroundings and trigger apprehension or fear if the right stimulus is present. E.g. if we’re walking in a dark forest, every sound can make us jump, our eyes scan the shadows and briefly see monsters before they disappear the next moment. While our domain-general logical thought is somewhat slow and requires conscious effort, our specialized modules can act very fast and without conscious involvement.

There really is no such thing as an unconscious mind, or unconscious intelligence; There is only intelligence. In other words, there is just computation of various sorts in the brain. What we normally call "conscious" is that computation that is involved in the "reflective function", a function that is involved in self-concept, cooperation and arbitration with others, and language, i.e. self-reference within a unified system.

We can separate **conscious information** and **conscious control**. Conscious information is the information about your own bodily and brain states that can be accessed directly from the brain by an individual at will without using external senses, e.g. looking in a mirror or taking a blood test. Conscious control is the processes or functions that a person can start, stop or modify at will directly in the brain by willing it. Unconscious information and unconscious control are automatic sub-processes that cannot be accessed or controlled directly willfully. Our nervous system does very many things automatically, in closed systems, including digestion, hormone regulation, heart-beat, breathing (2 modes, conscious and automatic). We do this with the brain itself, the brainstem, the sympathetic & parasympathetic nervous system.

7.1 Evolved psychological mechanisms

Main article: Evolved psychological mechanisms

Evolutionary psychology is founded on several core premises.

1. The brain is an information processing device, and it produces behavior in response to external and internal inputs.[2][14]
2. The brain's adaptive mechanisms were shaped by natural and sexual selection.[2][14]
3. Different neural mechanisms are specialized for solving problems in humanity's evolutionary past.[2][14]
4. The brain has evolved specialized neural mechanisms that were designed for solving problems that recurred over deep evolutionary time,[14] giving modern humans stone-age minds.[2][15]
5. Most contents and processes of the brain are unconscious; and most mental problems that seem easy to solve are actually extremely difficult problems that are solved unconsciously by complicated neural mechanisms.[2]
6. Human psychology consists of many specialized mechanisms, each sensitive to different classes of information or inputs. These mechanisms combine to produce manifest behavior.[14]

Evolutionary psychology is based on the hypothesis that, just like hearts, lungs, livers, kidneys, and immune systems, cognition has functional structure that has a genetic basis, and therefore has evolved by natural selection. Like other organs and tissues, this functional structure should be universally shared amongst a species, and should solve important problems of survival and reproduction.

Evolutionary psychologists seek to understand psychological mechanisms by understanding the survival and reproductive functions they might have served over the course of evolutionary history.[citation needed] These might include abilities to infer others' emotions, discern kin from non-kin, identify and prefer healthier mates, cooperate with others and follow leaders. Consistent with the theory of natural selection, evolutionary psychology sees humans as often in conflict with others, including mates and relatives. For instance, a mother may wish to wean her offspring from breastfeeding earlier than does her infant, which frees up the mother to invest in additional offspring.[26][27] Evolutionary psychology also recognizes the role of kin selection and reciprocity in evolving prosocial traits such as altruism.[26] Like chimpanzees and bonobos, humans have subtle and flexible social instincts, allowing them to form extended families, lifelong friendships, and political alliances.[26] In studies testing theoretical predictions, evolutionary psychologists have made modest findings on topics such as infanticide, intelligence, marriage patterns, promiscuity, perception of beauty, bride price and parental investment.[6]

7.1.1 Products of evolution: adaptations, exaptations, byproducts, and random variation

Not all traits of organisms are evolutionary adaptations. As noted in the table below, traits may also be exaptations, byproducts of adaptations (sometimes called "spandrels"), or random variation between individuals.[30]

Psychological adaptations are hypothesized to be innate or relatively easy to learn, and to manifest in cultures worldwide. For example, the ability of toddlers to learn a language with virtually no training is likely to be a psychological adaptation. On the other hand, ancestral humans did not read or write, thus today, learning to read and write require extensive training, and presumably represent byproducts of cognitive processing that use psychological adaptations designed for other functions.[31] However, variations in manifest behavior can result from universal mechanisms interacting with different local environments. For example, Caucasians who move from a northern climate to the equator will have darker skin. The mechanisms regulating their pigmentation do not change; rather the input to those mechanisms change, resulting in different output.

	Adaptation	**Exaptation**	**Byproduct**	**Random variation**
Definition	Organismic trait designed to solve an ancestral problem(s). Shows complexity, special "design", functionality	Adaptation that has been "re-purposed" to solve a different adaptive problem.	Byproduct of an adaptive mechanism with no current or ancestral function	Random variations in an adaptation or byproduct
Physiological example	Bones / Umbilical cord	Small bones of the inner ear	White color of bones / Belly button	Bumps on the skull, convex or concave belly button shape
Psychological example	Toddlers' ability to learn to talk with minimal instruction	Voluntary attention	Ability to learn to read and write	Variations in verbal intelligence

One of the tasks of evolutionary psychology is to identify which psychological traits are likely to be adaptations, byproducts or random variation. George C. Williams suggested that an "adaptation is a special and onerous concept that should only be used where it is really necessary."[32] As noted by Williams and others, adaptations can be identified by their improbable complexity, species universality, and adaptive functionality.

7.1.2 Sensation and perception

Many experts, such as Jerry Fodor, write that the purpose of perception is knowledge, but evolutionary psychologists hold that its primary purpose is to guide action.[65] For example, they say, depth perception seems to have evolved not to help us know the distances to other objects but rather to help us move around in space.[65] Evolutionary psychologists say that animals from fiddler crabs to humans use eyesight for collision avoidance, suggesting that vision is basically for directing action, not providing knowledge.[65]

Building and maintaining sense organs is metabolically expensive, so these organs evolve only when they improve an organism's fitness.[65] More than half the brain is devoted to processing sensory information, and the brain itself consumes roughly one-fourth of one's metabolic resources, so the senses must provide exceptional benefits to fitness.[65] Perception accurately mirrors the world; animals get useful, accurate information through their senses.[65]

Scientists who study perception and sensation have long understood the human senses as adaptations.[65] Depth perception consists of processing over half a dozen visual cues, each of which is based on a regularity of the physical world.[65] Vision evolved to respond to the narrow range of electromagnetic energy that is plentiful and that does not pass through objects.[65] Sound waves go around corners and interact with obstacles, creating a complex pattern that includes useful information about the sources of and distances to objects.[65] Larger animals naturally make lower-pitched sounds as a consequence of their size.[65] The range over which an animal hears, on the other hand, is determined by adaptation. Homing pigeons, for example, can hear very low-pitched sound (infrasound) that carries great distances, even though most smaller animals detect higher-pitched sounds.[65] Taste and smell respond to chemicals in the environment that are thought to have been significant for fitness in the EEA.[65] For example, salt and sugar were apparently both valuable to the human or pre-human inhabitants of the EEA, so present day humans have an intrinsic hunger for salty and sweet tastes.[65] The sense of touch is actually many senses, including pressure, heat, cold, tickle, and pain.[65] Pain, while unpleasant, is adaptive.[65] An important adaptation for senses is range shifting, by which the organism becomes temporarily more or less sensitive to sensation.[65] For example, one's eyes automatically adjust to dim or bright ambient light.[65] Sensory abilities of different organisms often coevolve, as is the case with the hearing of echolocating bats and that of the moths that have evolved to respond to the sounds that the bats make.[65]

Evolutionary psychologists contend that perception demonstrates the principle of modularity, with specialized mechanisms handling particular perception tasks.[65] For example, people with damage to a particular part of the brain suffer from the specific defect of not being able to recognize faces (prosopagnosia).[65] Evolutionary psychology suggests that this indicates a so-called face-reading module.[65]

7.1.3 Emotion and motivation

Main article: Evolution of emotion

Motivations direct and energize behavior, while emotions provide the affective component to motivation, positive or negative.[67] In the early 1970s, Paul Ekman and colleagues began a line of research which suggests that many emotions are universal.[67] He found evidence that humans share at least five basic emotions: fear, sadness, happiness, anger, and disgust.[67] Social emotions evidently evolved to motivate social behaviors that were adaptive in the *environment of evolutionary adaptiveness* (EEA), e.g. mainly the African savanna, but also elsewhere.[67] For example, spite seems to work against the individual but it can establish an individual's reputation as someone to be feared.[67] Shame and pride can motivate behaviors that help one maintain one's standing in a community, and self-esteem is one's estimate of one's status.[26][67] Motivation has a neurobiological basis in the reward system of the brain. Recently, it has been suggested that reward systems may evolve in such a way that there may be an inherent or unavoidable trade-off in the motivational system for activities of short versus long duration.[68]

7.1.4 Cognition

Cognition refers to internal representations of the world and internal information processing. From an evolutionary psychology perspective, cognition is not "general purpose," but uses heuristics, or strategies, that generally increase the likelihood of solving problems that the ancestors of present-day humans routinely faced. For example, present day humans are far more likely to solve logic problems that involve detecting cheating (a common problem given humans' social nature) than the same logic problem put in purely abstract terms.[69] Since the ancestors of present-day humans did not encounter truly random events, present day humans may be cognitively predisposed to incorrectly identify patterns in random sequences. "Gamblers' Fallacy" is one example of this. Gamblers may falsely believe that they have hit a "lucky streak" even when each outcome is actually random and independent of previous trials. Most people believe that if a fair coin has been flipped 9 times and Heads appears each time, that on the tenth flip, there is a greater than 50% chance of getting Tails.[67] Humans find it far easier to make diagnoses or predictions using frequency data than when the same information is presented as probabilities or percentages, presumably because the ancestors of present-day humans lived in relatively small tribes (usually with fewer than 150 people) where frequency information was more readily available.[67]

7.1.5 Personality

Evolutionary psychology is primarily interested in finding commonalities between people, or basic human psychological nature. From an evolutionary perspective, the fact that people have fundamental differences in personality traits initially presents something of a puzzle.[70] (Note: The field of behavioral genetics is concerned with statistically partitioning differences between people into genetic and environmental sources of variance. However, understanding the concept of heritability can be tricky – heritability refers only to the differences between people, never the degree to which the traits of an individual are due to environmental or genetic factors, since traits are always a complex interweaving of both.)

Personality traits are conceptualized by evolutionary psychologists as due to normal variation around an optimum, due to frequency-dependent selection (behavioral polymorphisms), or as facultative adaptations. Like variability in height, some personality traits may simply reflect inter-individual variability around a general optimum.[70] Or, personality traits may represent different genetically predisposed "behavioral morphs" – alternate behavioral strategies that depend on the frequency of competing behavioral strategies in the population. For example, if most of the population is generally trusting and gullible, the behavioral morph of being a "cheater" (or, in the extreme case, a sociopath) may be advantageous.[71] Finally, like many other psychological adaptations, personality traits may be facultative – sensitive to typical variations in the social environment, especially during early development. For example, later born children are more likely than first-borns to be rebellious, less conscientious and more open to new experiences, which may be advantageous to them given their particular niche in family structure.[72] It is important to note that shared environmental influences do play a role in personality and are not always of less importance than genetic factors. However, shared environmental influences often decrease to near zero after adolescence but do not completely disappear.[73]

7.1.6 Cultural universals

Main article: Cultural universal

Evolutionary psychologists hold that behaviors or traits that occur universally in all cultures are good candidates for evolutionary adaptations.[5] Cultural universals include behaviors related to language, cognition, social roles, gender roles, and technology.[34] Evolved psychological adaptations (such as the ability to learn a language) interact with cultural inputs to produce specific behaviors (e.g., the specific language learned). Basic gender differences, such as greater eagerness for sex among men and greater coyness among women,[35] are explained as sexually dimorphic psychological adaptations that reflect the different reproductive strategies of males and females.[26][36] Evolutionary psychologists contrast their approach to what they term the "standard social science model," according to which the mind is a general-purpose cognition device shaped almost entirely by culture.[37][38]

7.1.6.1 List of cultural universals

Among the cultural universals listed by Brown (1991) are:

7.1.6.1.1 Language and cognition

Main article: Linguistic universal

- Language employed to manipulate others
- Language employed to misinform or mislead
- Language is translatable
- Abstraction in speech and thought
- Antonyms, synonyms
- Logical notions of "and", "not", "opposite", "equivalent", "part/whole", "general/particular"
- Binary cognitive distinctions
- Color terms: black, white
- Classification of: age, behavioral propensities, body parts, colors, fauna, flora, inner states, kin, sex, space, tools, weather conditions
- Continua (ordering as cognitive pattern)
- Discrepancies between speech, thought, and action
- Figurative speech, metaphors

- Symbolism, symbolic speech
- Synesthetic metaphors
- Tabooed utterances
- Special speech for special occasions
- Prestige from proficient use of language (e.g. poetry)
- Planning
- Units of time

7.1.6.1.2 Society

- Personal names
- Family or household
- Kin groups
- Peer groups not based on family
- Actions under self-control distinguished from those not under control
- Affection expressed and felt
- Age grades
- Age statuses
- Age terms
- Law: rights and obligations, rules of membership
- Moral sentiments
- Distinguishing right and wrong, good and bad
- Promise/oath
- Prestige inequalities
- Statuses and roles
- Leaders
- De facto oligarchy
- Property
- Coalitions
- Collective identities
- Conflict
- Cooperative labor
- Gender roles
- Males on average travel greater distances over lifetime
- Marriage, though this is disputed [2]
- Husband older than wife on average
- Copulation normally conducted in privacy
- Incest prevention or avoidance, incest between mother and son unthinkable or tabooed
- Collective decision making
- Etiquette
- Inheritance rules
- Generosity admired, gift giving
- Redress of wrongs, sanctions
- Sexual jealousy
- Sexual violence
- Shame
- Territoriality
- Triangular awareness (assessing relationships among the self and two other people)

- Some forms of proscribed violence
- Visiting
- Trade

7.1.6.1.3 Myth, ritual and aesthetics

Further information: Myth and ritual

- Magical thinking
- Use of magic to increase life and win love
- Beliefs about death
- Beliefs about disease
- Beliefs about fortune and misfortune
- Divination
- Attempts to control weather
- Dream interpretation
- Beliefs and narratives
- Proverbs, sayings
- Poetry/rhetorics
- Healing practices, medicine
- Childbirth customs
- Rites of passage
- Music, rhythm, dance
- Play
- Toys, playthings
- Death rituals, mourning
- Feasting
- Body adornment
- Hairstyles
- Art

7.1.6.1.4 Technology

- Shelter
- Control of fire
- Tools, tool making
- Weapons, spear
- Containers
- Cooking
- Lever
- Cordage

7.1.7 Instinct

Instinct or **innate behavior** is the inherent inclination of a living organism towards a particular complex behavior. The simplest example of an instinctive behavior is a fixed action pattern (FAP), in which a very short to medium length sequence of actions, without variation, are carried out in response to a clearly defined stimulus.

An instinctive behavior of shaking water from wet fur.

A baby leatherback turtle makes its way to the open ocean

Any behavior is instinctive if it is performed without being based upon prior experience (that is, in the absence of learning), and is therefore an expression of innate biological factors. Sea turtles, newly hatched on a beach, will automatically move toward the ocean. A marsupial climbs into its mother's pouch upon being born. Honeybees communicate by dancing in the direction of a food source without formal instruction. Other examples include animal fighting, animal courtship behavior, internal escape functions, and the building of nests.

Instincts are inborn complex patterns of behavior that exist in most members of the species, and should be distinguished from reflexes, which are simple responses of an organism to a specific stimulus, such as the contraction of the pupil in response to bright light or the spasmodic movement of the lower leg when the knee is tapped. The absence of volitional capacity must not be confused with an inability to modify fixed action patterns. For example, people may be able to modify a stimulated fixed action pattern by consciously recognizing the point of its activation and simply stop doing it, whereas animals without a sufficiently strong volitional capacity may not be able to disengage from their fixed action patterns, once activated.[1]

The role of instincts in determining the behavior of animals varies from species to species. The more complex the neural system of an animal, the greater is the role of the cerebral cortex and social learning, and instincts play a lesser role. A comparison between a crocodile and an elephant illustrates how mammals for example are heavily dependent on social learning. Lionesses and chimpanzees raised in zoos away from their birth mothers most often reject their own offspring because they have not been taught the skills of mothering.[citation needed] Such is not the case with simpler species such as reptiles.

In everyday speech, the word instinct is often used to refer to intuition or even clairvoyance.

7.1.7.1 Reflexes

Main article: Reflex

Examples of behaviors that do not require conscious will include many reflexes. The stimulus in a reflex may not require brain activity but instead may travel to the spinal cord as a message that is then transmitted back through the body, tracing a path called the reflex arc. Reflexes are similar to fixed action patterns in that most reflexes meet the criteria of a FAP. However, a fixed action pattern can be processed in the brain as well; a male stickleback's instinctive aggression towards anything red during his mating season is such an example. Examples of instinctive behaviors in humans include many of the primitive reflexes, such as rooting and suckling, behaviors which are present in mammals. In rats, it has been observed that innate responses are related to specific chemicals, and these chemicals are detected by two organs located in the nose: the vomeronasal organ (VNO) and the main olfactory epithelium (MOE).[9]