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Subconscious Problem Solving Using Hazy Heuristics

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Abstract

While learning a structured problem solving methodology one typically rues the tedium interfering with inventive thinking. Later, as the methodology inures in one's subconscious, shortcuts take form. This paper focuses on the shortcuts of the structured problem solving.

We have ample evidence that our conscious does not solve problems – our subconscious does. That realization raises the issue of how to communicate problem-solving cues from our conscious to our subconscious and accept any ideas that are returned. Presented here are arguments for the elimination of constraining logic in major parts of current structured, problem-solving methodologies. Unified structured inventive thinking (USIT) is used as an example.

This should not be a bitter pill for logically trained technologists to take. It does not substitute for any of one's early learning of problem-solving methodologies. Instead, once a methodology is mastered, it encourages taking short cuts by eliminating or reducing heuristic constructions that have become second nature in one's logical thinking. Logic is subdued in favor of evocative vague cues – sometimes thought of as the poetic license of the intuition.

Two examples are presented of rapid problem solving using USIT in an abbreviated form. One solution concept resulted in a USA patent, "Pedestrian Impact Energy Management Device With Seesaw Elements".

A problem and its solution concepts refer to the pre-engineering phase of problem solving. In this phase all concepts are accepted without filtering. Proof of concept and model calculations come later. Unfiltered concepts are a potential source of surprising ideas.

Keywords: hazy heuristics, invention, subconscious problem solving, seeding the subconscious, structured problem solving, subconscious links, USIT, solution concepts

1. Introduction

We, who spend a significant portion of our careers solving problems 'consciously', do so using heuristics (formulated clues) in verbal and graphic structures involving symbols. Ostensibly, they all serve as conscious links (seeds) to our subconscious where ideas are assembled from bits of memory. We have ample evidence that our conscious does not solve problems. It communicates them. We learn, invent, and practice heuristics for communicating problems to our subconscious. Uselessness of the conscious brain is an idea a century and a half old, yet it is still a research subject of neural scientists. Here, logic is relegated to introspective and extroversive communications, while subconscious is used to invent.

The idea that the conscious brain is useless in problem solving is not new. To span its history, I'll quote the opening paragraph of a recent book review by Chris Frith on consciousness and the brain.

> "In 1874, Thomas Henry Huxley gave a prescient lecture on mind and brain. The biologist argued that subjective experience depends on the brain's 'anterior divisions', and that consciousness has as little effect on behavior as a steam whistle has on a locomotive's progress – rendering humans little more than 'conscious automata'. He raised two questions that remain key in contemporary studies of the neural basis of consciousness: what is special about the neural processes that

underlie consciousness, and what, if anything, is consciousness for?" "Frith, C. (2014, January)".

Conscious-automata is a key phrase for this discussion. At times, we may be those conscious automata. It can happen while learning and practicing structured problem solving (SPS). While learning, we spend time constructing logical heuristics in tables, graphs, words, and symbols as cues to spark links to our subconscious. As we experience success with these methods they gradually become reliable crutches. With crutches in hand, we become conscious automata.

This paper argues for weaning ourselves from these crutches and moving toward making more effective subconscious links. They occur when recognizing when SPS has become engrained in our thinking and then allow minimizing the tedium of writing and drawing heuristics. Consequently, specific heuristics need no longer to be consciously named and graphed, they arise automatically as needed. This has an impact on the logical formulation of a problem as organized in our conscious.

2. Conscious-subconscious Links in Thinking

Consider a common example of using heuristics to solve a problem, in this case, the problem of how to recall a person's name.

The alphabet-pneumonic is popular for this job. It is used to step through the alphabet one letter at a time. It may happen automatically. Within moments a first letter, and maybe even its syllable, come vaguely into view (a subconscious token of information), but often not quite what is recognizable. Mental focus on this first foggy clue may narrow the alphabet search or even evoke a vague characteristic of the person. Then quickly arise in the conscious another syllable, and eventually the name being sought. As the name is recovered, further concentration can evoke more definitive information, such as, the last dinner shared with the person or a challenging game of chess. This is a path of mental stepping-stones, which recover from the subconscious bits of personal history related to each clue (or sometimes not related). Such links may or may not have been intentionally stored for future use. Chains of links are thought paths to conscious understanding. Considerable introspection is required to become aware, or even suspicious, of the switching back and forth between unconscious and conscious states in this exercise.

It seems evident in the above example that the conscious was involved in deciding to start the solution process using the alphabet heuristic. Or was that tossed up from the subconscious as the thought, 'I can't remember his name', was being formulated in the conscious? I suspect the latter. And it arose quicker than its awareness became conscious focus.

It is also evident that each idea returned from the subconscious was vetted by comparing the latest idea with the previous one being attentively held in the conscious. Then it was accepted or rejected. Who did the vetting? At first, I suspect the conscious, but perhaps with subconscious help.

Furthermore, the speed of forming these conscious-subconscious-links is remarkable. Physicist Hermann von Helmholtz (1821-1894) famously used perception as an example of speed during subconscious inference relative to the more slow conscious awareness.

I also suspect that each word inserted into an oral or written phrase is suggested and vetted by the subconscious.

2.1 The Dynamics of Subconscious and Conscious Thinking

So what is vetting? It can be understood in computer-like terms as follows. A tentative, but dynamic, list of items grows as each new item is compared with each item already in the list. If it is deemed relevant it is added to the list. If not, it is discarded. In this model the dynamics of growth seems to favor the short time constant of subconscious, random selection. Whereas the longer time constant of the conscious would suffice in a holding process for achieving focus by filing information.

How is it possible that the slowly plodding conscious is able to select effective thought provoking seeds? Are only the conscious ordered and the subconscious disordered? Dreaming comes to mind regarding the last question. Dreams occur consisting of unconscious associations that conscious, logical thinking often would not allow. This raises the question of what is consciousness.

Cognitive neuroscientist Dehaene offers a definition: "Consciousness is this: we are conscious of whatever we choose to focus our attention on." (Dehaene, S., 2014) That definition suggests there are all manner of associations going on in our subconscious. Consciousness is made up of those we focus on as a result of their relevance. Perhaps then, slowness of consciousness goes with sustaining in focus continuous associations. This dynamic points to the physics of information transfer between neurons at synapse interfaces.

2.2 A Model of Problem Solving

Sleeping is a relaxed state of the brain. In sleep the brain is still active but is not able to maintain focus on relevant associations that constitute cognition. This is causal of the need to awaken and write down ideas caught in dreams before they are lost from our semi-consciousness.

These observations fit the model of signals from the five senses being dealt with subconsciously. Their relevant associations, still around when the brain is resting, are moved into long-term memory. Then making associations for cognition with, for example, an object, attribute, or function now recorded in memory – the keys of USIT analyses.

When we are awake our subconscious is constantly trying to solve problems, whether consciously prodded or not. Our senses feed signals, of their five transduced kinds of electrical information, into our brain where they sail through the neural network. At relevant synapses they are compared with long-term and short-term memory. Successful comparisons support instantaneous vetting regarding any necessary aversive action or a benign incident to be ignored. I use the metaphor that all unanswered questions, failed immediate vettings, are problems. Problems are defined as unanswered questions. When successful subconscious associations are accessed by the conscious and resolve an issue a problem disappears.

A useful model unfolds here that helps to understand how all of problem solving is done by the subconscious. When the initial surge of neural current finds a relevant synapse, momentary focus marks that connection while the current passes on through the network. When and if a second relevant synapse is encountered the two now bring prolonged focus. As other relevant synaptic responses occur they prolong the focus further forming an instance of developing consciousness (e.g., recall). My mental image of this has one hand holding selected neurons for comparison with one just selected in the other hand.

3. Foggy Thinking

We know words and sentences, and we know how to employ grammar in their use to effect unambiguous written and verbal communication. Typically, however, we are well along in our education and its practice before our communication becomes rigorous and clear to others. Yet, from early beginnings we consciously communicate with our subconscious and we know what we mean in these communications. If that be true, and I believe it is, then grammatical communication has evolved not for internal thinking but for expressing our thoughts to others. It is much too slow for internal communication.

Internal thinking does not require the rigors of grammar. Speaking and writing grammatically require some degree of conscious filtering – think first then speak. Thoughts are too spontaneous to have undergone such filtering. Clear evidence of that lies in the time (and repeated time) it takes to write grammatically. Speech suffers for the same reason. It has, at best, the benefit of practice that enables some automatic pre-correction of speech – the voice of education.

Internalized creative thinking during brainstorming is so spontaneous that often non-grammatical and illogical associations of nouns, adjectives, and verbs are made. Foggy ideas come to mind that require some correction to render them even internally acceptable. The payoff of word-generification in SPS is encouraging thinking to find new viewpoints while maintaining subconscious control on relevance of the thought paths followed. Thought paths are the root causes of inventive thinking. But are they required to be rigorous?

We don't know how effective a specific word clue is as compared with a different word. We do know that the same idea can be expressed in different ways, and that different people can prefer different words in expressing similar thoughts. Hence, it is unlikely that specific word choice is important in communicating to the subconscious. This allows mental room for generification that reduces rigor of logic, thus opening access to a broader solution space. The A used in beginning the name recall example is likely to be far off the target making it a vague clue. Yet it initiates a

working procedure having high probability of success. These realizations beg for diversity in seeding the subconscious.

The forgoing discussion shows that rigor in the solution-concept phase of problem solving is not necessary. This is because the subconscious works in iterative stages of vague thinking. SPS methodologies are heavy in the use of logical heuristics. Let's examine a more intuitive beginning to solution searches where relevant, yet vague, concepts arise. Note the use of introspection in the following.

4. Vague Problem Example – A Fishing-lure Manufacturer's Problem

Here is a quickly formulated and solved problem. Suppose the barb of a fishhook lure gets caught on roots under water, thus defeating the lure's function – an unwanted effect. Here's a scenario of analysis simplification (Table 1.) that came to mind as I wrote this article.

Table 1. A Scenario of analysis simplification

Simple statement development	Vague Solution Concepts
'Barb on hook catches roots.'	**(1)** Protect barb; **(2)** eliminate barb; (**3**) eliminate roots; Barb can be **(4)** protected part of the time by adding a ventral fin to the lure **(5)** keeping the barb on a lure's topside away from roots below.
Three word-clues and no prior sketch	
'Barb catches objects.'	**(6)** Eliminate barb when not in fish's mouth; **(7)** Hide it within the lure and **(8)** release it when fish's mouth encloses it. This solves the problem of non-fish contact snagging the lure. But it raises a new issue. (However, no filtering is allowed here.)
Two word-clues and no prior sketch	

The above eight (and two to follow) numbered items are immediate solution-concept associations with only a few word-clues. Mental images were aware but not put to paper until some minutes later.

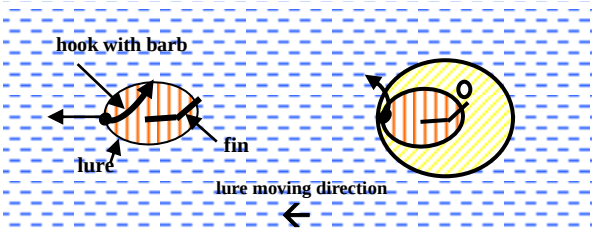

Fig. 1. Post solution sketches: Left, moving lure with retracted hook and bent fin. Right, lure enclosed by a fish's mouth, stopping flow, releasing hook, and snaring fish.

That specific wording, 'fish-mouth closure', sparks a new idea. Mouth closure suggests **(9)** an encircling entrapment. As the lure enters the fish's mouth surrounding water flow slows. **(10)** The reduction of flow could be used to release the hook. Hidden barb is shown on the left side of Figure 1 and released inside of fish's closed mouth on the right side.

Nothing profound stands out in this demonstration, and none were intended. Its purpose is to demonstrate identification of a problem with immediate attempt to find a solution concept and without consciously pausing to recall heuristics or to employ filters. It took a few moments to think of an example problem that most people would understand. Then several popped up from the subconscious. Unintentionally snared fishing lure was selected. Note how quickly minimal information produced multiple ideas.

As I started to draw a sketch it came to mind to look at the contact with two objects, hook and a generic object. Accompanying this idea came another simplification, focus on barb exposed and barb unexposed – the problem and its solution concept. Most time consuming in this exercise was concentrating on what to type, its grammar, paragraph and table layouts, and the mechanics of typing and drawing. Thinking, writing, and drawing were multiplexed processes. Conscious focus switched frequently between these three efforts. I can't do any two of them simultaneously.

As I examine what happened it is evident that several fundamental heuristics came into use subconsciously: Simplify a problem statement to one unwanted effect, two objects, and a point of contact (fish and hook). Then, if possible, simplify it further to one object in two states, hidden barb (a solution) and exposed barb (the problem). Allow no filtering of ideas – a heuristic. Eliminate unnecessary objects, roots, water, and fish – a heuristic. These are four elementary USIT heuristics, which are not unique to any methodology. Elimination of barb evoked to hide it – one solution concept. One object-attribute-function string (OAF) was visualized during the analysis process, a conscious effort.

In this example a solution concept was quickly found using an abbreviated version of USIT. Its

solution is a pre-engineering concept. All of the solution process focused on the problem statement. No formal graphics and procedures of USIT were consciously addressed except for one OAF string. It reminds one to focus on points of contact. Any realistic embodiment of these ideas would follow with a proof-of-concept in the engineering phase of problem solving.

Conclusions of the last paragraph and this section raise the question: if everything is done in the subconscious, how can it be claimed that no other heuristics were used? The answer is: I can't make that claim! My justification is that this example is one of the simplest SPS cases I can recall. It came to mind, was analyzed, and solution concepts found quickly. The table and sketch were made after the fact of solving the problem. Other, heuristics surely were involved subconsciously, which, by now, are well developed in memory.

Note that those immediate, vague solution concepts that came to mind are the goal of STS. You need only hand to a brainstorming team the phrases 'protect barb', 'eliminate barb', and 'eliminate roots' and they will be off and running, expanding them into the next phase of problem solving for engineering.

5. Pre-engineering Structured-problem Solving Concepts

A more complex example of a problem is one that was assigned to a USIT team to find plausible concepts for making an automobile bumper less harmful to pedestrians. Two teams worked on this problem. The first was a USIT team that produced a variety of concepts and an invention disclosure. Later a second team, whose USIT training was not known, improved on the disclosure and obtained a patent. I served on both teams.

Generification of technical names, bumper and pedestrian, led to two objects of different sizes, O_1 and O_2. This broadened the solution space to be searched in several ways. It helped also to begin without using attributes that bring too specific objects to mind, which might reduce solution space. It is assumed that this helps to mitigate some of the logical control of SPS allowing intuition some leeway. The team chose a standard OAF triad as a problem/solution graphic, Figure 2, to start with. Note that the Os in Figure 2 (see References) can represent one, two, or three objects.

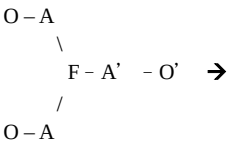

Fig. 2

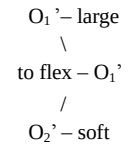

Fig.3

Fig. 2. Generic OAF graphic of problem/solution statement. F is an unwanted effect when representing a problem or a wanted effect when representing a solution. A' and O' are in solution space where O_1' and O_2' are in contact.

Fig. 3. OAF-graphic of solution space with adaptation of Figure 2 with example values of A' and F'.

While constructing Fig. 2 and Fig. 3, ideas came to mind that there are two problems separated in time. Simplify the problem by reducing it to two objects. Eliminate O_2 and make A_1' soft in one situation and hard in the other. Thus, the wanted effect has two conditions to meet, to flex at one time and to stiffen at the other. When flexing, O_1's attribute should be soft, compliant, etc. When stiffening, it should be hard, non-compliant, etc. With these two problems identified the problem/solution heuristic can be inserted into a sentence. Thus, O-A-F-A'-O' (a symbolic sentence) becomes the simplified problem/solution heuristic with O and O' being the same object at different times.

Looking at the word flex suggests that it can be expressed in other attribute words, such as, soft, moveable, elastic, compliant, and plastic, for example. The attributes of O_1' can be functions of space and time, A'(x,t). Note that one's subconscious can handle these conditions without additional sketches.

In the pre-engineering stage of problem solving we don't need (and should avoid) engineering parameters requiring numbers or detailed equations, which can act as premature filters. Those are appropriate to use during mathematical modeling for proof-of-concept.

Then came an ah-ha! Time-dependent elasticity, plasticity and mobility brought to mind viscous fluids. That suggested a generalization to non-Newtonian fluids. Two useful concepts arose from this realization: thixotropy and rheopexy, which are complimentary types of time-dependent viscosity. Thixotropic fluids have viscosity that decreases under time-dependent strain – sometimes referred to as shear thinning (e.g., ketchup and yogurt). Rheopexy, on the other hand, has an increase in viscosity under time-dependent shear (e.g., gypsum paste and printer inks). It is not necessary

to select particular materials at this point. Such details are a bit premature. They can wait for the proof of concept stage. By then other ways of using one or both of these attributes may arise. Flow of particulate solids comes to mind.

Several solution concepts came from these observations.

(1) The large object could be divided into cells containing one or the other or a mixture of these fluids giving the cells time-dependent viscosity.

(2) Cells allow properties to be distributed inhomogeneously in space.

(3) The fluids used could have, within their cell volumes, dispersed spheres or other shaped solids to allow a larger range of stiffness (disperse and mix).

(4) Elastic particles could be dispersed in the fluids to affect conformability to O_2's penetrating shape into O_1'.

(5) Independently suspend individual cells to allow separation when making contact with a small object and prevent separation when contacting a large object.

The last idea, (5), popped up when Nobel's invention came to mind of putting nitroglycerin into isolated cells of dolomite to make dynamite. Ideas spark similar ideas.

Another solution concept that occurred is of a bumper divided into multiple, movable parts. Motion of cells occurs automatically following O-O contact. If the contact area is large, (Figs. 4 & 5), the cells move to more equally spaced regions for non-conformal stiffening. If the contact area is small, as shown in Fig. 6, the segments move around the area of contact for local shape conformance effectively creating a soft region. This work led to a US Patent 6,554,332,B1.

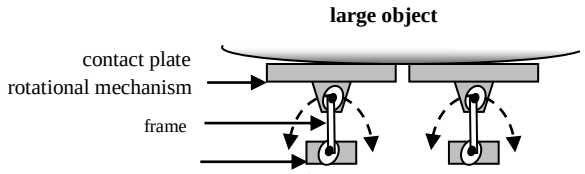

Fig. 4. Illustrating orientation of moveable bumper segments to effectively stiffen contact becoming nearly flat.

Drawings of this concept from the patent application are shown in Figs. 5 and 6. Contact plates have been simplified with fewer parts and a conformal layer added (No. 16 in the Figs. 5 and 6)

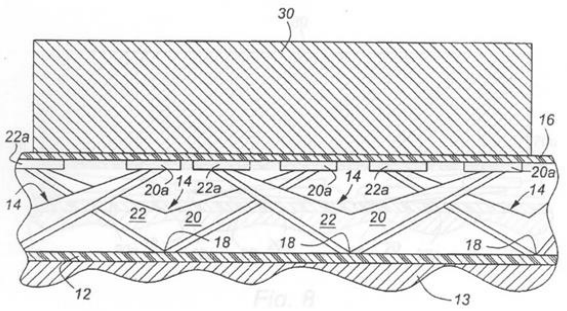

Fig. 5. Large object conformal-shape accommodation design as improved in patent (not to scale).

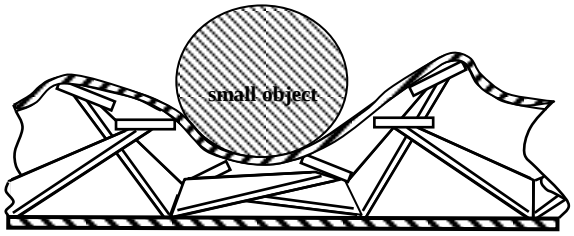

Fig. 6. Small object-conformal-shape design. Contact plates now support the conformal material contacting the small object (not to scale).

Problem solving examples just illustrated are not intended for post-logic analysis by mapping their parts onto heuristic diagrams. Rather, two points were intended: the first to show how little pre-information was used before the first ideas surfaced and second to show how vague the information was compared with final solution ideas.

Mapping solution results back onto a problem-solving methodology, after the fact, in order to give credence to the methodology and to its application can be somewhat questionable. An original problem and the results are understood metaphorically without such mapping. This is especially true when generic words are used to describe a problem. Unfortunately brainstorming teams can waste much time in satisfying all participants' needs for logic not required by the subconscious.

In brainstorming teams, solution results come under instant examination. Each team member quickly tries to improve a solution concept when it arises – perhaps to share in the credit. If they can't improve it they will try to criticize it. This is odd, considering the arguments made earlier, in that no one knows which, if

any, of the components in a problem statement actually sparks creative thinking. This supports generification of word choices to make more concepts discoverable. It is also odd to criticize new ideas that may not be obviously valid. It would make more sense to remember that the idea came from an illogical, subconscious, collection of neural network elements and instead try to find its relevance. In other words, ponder why did the subconscious bring up a particular concept?

6. Perspectives of a Problem

A core of inventive thinking is finding unusual perspectives of a problem situation for inspiration. In the above example, perspective developed from three simple symbolic words, O, A, and F. They have already been registered in the subconscious with various logical links to the subconscious; such as experiences presented from our five senses. They may also be registered by metaphors that we may have imagined. In USIT they are fundamental to problem definition and solution.

Different viewpoints can arise in the same brain. Structured inventive thinking preempts such conflicts by encouraging spontaneous thoughts to be recognized without criticism.

Once experience enables, the symbols O-A-F speaks to our subconscious, stepping-stones through solution-space arise automatically. Then follows the mental visualization of the simple graphic for problem definition shown in Figure 2. However, this graphic heuristic, the triad of links, can be reduced to a more generic symbol, a single O-A-F metaphor, from which more complex unions can be formed. (Sickafus, 1999).

Problem perspectives are a critical part of conscious invention. At least we think so. We don't know what solution perspectives the subconscious has, if it has any. We know that the subconscious is faster than the conscious in finding associations of past and present observations. It probably finds them randomly, proffers them to the conscious, and continues its search. Meanwhile the plodding conscious files them for reference. It is this relatively slower speed of our conscious that exacerbates the tedium of writing and drawing heuristics as well as our eagerness to get on with invention.

Our best effort in structured problem solving is to take a real-world situation into a hazy world of problem space using hazy metaphors. Then enjoy the wealth of metaphoric solution concepts that are served to the conscious.

A confession is appropriate here. The first idea to come to mind in the bumper problem was not a non-Newtonian fluid, but that of a physical impulse, probably associated with an initial image of bumper collision. Then followed recollection of seeing a Jesus Christ lizard dash up a stream in Panama – foot impulse on water. That led to thixotropy and it led to non-Newtonian fluids. "Thank you subconscious!" Retelling a problem's solution experience has its privileges.

7. Summary

Hazy heuristics are proposed as a problem-solving strategy to subdue spontaneous criticism and thereby benefit from the intuitive power of metaphorical thinking. Thus, they broaden the problem solver's search of solution space.

If the process of problem solving is divided into sections like, information gathering, brainstorming, structured problem solving, pre-engineering filtering, modeling, proof-of-concept, etc. Application of hazy heuristics, a la USIT and all of its structure, is the post brainstorming, pre-engineering filtering section. In this scenario brainstorming gathers the low hanging fruit. USIT sweeps up the vetoed ideas and others not previously noticed.

The way hazy heuristics work is treated in three components in the manuscript:

- Evidence that the brain is intuitive and not logical, which implies that we miscue the subconscious when using logical seeds;
- Speed of intuition trumps that of the conscious and is essential for innovative thinking. Logical thinking threatens to veto intuitive thinking;
- Metaphors (hazy heuristics) are more receptive to the intuitive thinking than to logic.

Once mechanical thinking is mastered we move to strategic thinking. Here we drop our automaton crutches, pick up paper and pencil, and proceed rapidly to generate ideas from our memories which are full of training and experience.

References

Frith, C. (2014, 30 January 2014, 505, 615). Joined-up thinking: Nature.

Dehaene, Stanislas, Consciousness and the Brain: Deciphering How the Brain Codes Our Thoughts, Viking Books, 2014.

Helmholtz, Hermann von, Unconscious Thought Theory, Wikipedia, the free encyclopedia

Sickafus, E. N. (1997). Unified Structured Inventive Thinking – How to Invent.

US Patent 6,554,332,B1, Pedestrian Impact Energy Management Device With Seesaw Elements, Inventors Peter John Schuster, Liz Tait, Bradely Staines, Christopher William Lucas, and Edward Nathan Sickafus.

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