On the Nature of Presence

Kristinn R. Thórisson
Reykjavík University
Ofanleiti 2, 103 Reykjavík, Iceland
thorisson@ru.is

Abstract

In this paper I present an analysis of presence and explore the concept from a cognitive standpoint. I propose that a natural system's ability to produce cues evoking a sense of *cognitive presence* in an observer, is related to how closely the production of those cues stems from the system's cognitive architecture. More specifically, the ability to express presence is related to emergent properties of interactions between hierarchically organized processes operating at *several levels of detail*. The closer an artificial system copies these emergent properties, the stronger the perception of a mind-like presence. Using thought experiments and implemented A.I. systems as a vehicle for exploration, I describe four categories of presence cues and discuss how they relate to co-present co-temporal natural communication. I hypothesize that expression of cognitive presence is more strongly related to low-level, animal-like cognition than to high-level human-like cognition, but that in general, presence may only be loosely connected to the actual cognitive validity of the underlying architecture.

1 Introduction

The field of telerobotics (cf. Goldberg 2000, Sheridan 1992) revolves around using technology to change the ability of people to act and perceive in the world such that their perception and action happens in a different place than their body and brain are located. In the case of vision, a camera is placed at one location, and its signal fed to a display located arbitrarily far away, where the camera images are shown to a user. The role of the equipment is to fool the user's eyes and brain into believing that they are actually located where the camera has been placed, not where their body – and thus sensory organs – are actually located.[1] The idea is not to fool the user completely, but to make them feel as close as possible to actually being at the remote location. Just like the suspension of disbelief in a movie theater, it is therefore quite possible to *know* of the illusion of telepresence and yet *believe in it* at the same time. The goal of this exercise is to elicit natural responses and reflexes from the perceiver, as he operates remotely-controlled robots or other equipment, who otherwise might respond more slowly or unnaturally to circumstances during his teleoperation tasks.

To produce a sense of telepresence, one can use goggles with built-in displays that track the user's head movements and transfer them to the movement of the remote cameras. Close temporal proximity of camera and head movements produces a stronger illusion of telepresence (Sheridan 1992). Stereoscopic projection, using one camera and display per eye, also helps make the illusion stronger. In the field of robotics the concept of *telepresence* is thus typically defined as the sense of being present in a different place (than one's body) and it is generally considered to have a quality of *strength* associated with it representing how strong that feeling is (Riley et al. 2001, Sas & O'Hare 2003). Viewed this way, this perceived strength would be at a maximum in the case where the observer is sensing an actually present environment, directly through her unfettered biological sensory organs.[2] It is important to note that when evaluating the strength of perceived presence during teleoperation people fall back on prior experience: The closer the experience is to their experience in natural circumstances, the stronger the feeling of telepresence.

In this paper I wish to discuss a concept directly related to telepresence, the concept of *cognitive presence*. First we will look at the definition of the concept and why it may be worthwhile to study it in the context of cognitive science and A.I. Then we

[1] Note that the concept is transient: It is equally adequate to view telepresence as the *feeling of one's body being in a different place* and as the feeling of a remote environment replacing the body's *immediate surroundings*.

[2] All other things being equal, such as the perceiver being fully awake.

will use thought experiments to explore the concept more thoroughly and try to understand its causes and manifestations. The last two sections present a discussion of the relationship between cognitive presence and cognitive model validity.

observed is chosen as a reference point. We even tend to go a step further: Humans tend to use introspection as a way to understand other intelligent systems. In fact, we also ascribe human-like mental capabilities to animals; we even do so with inanimate objects such as computers and toasters (Reeves & Nass 1996). Human factors engineers often refer to such anthropomorphization as a fallacy.

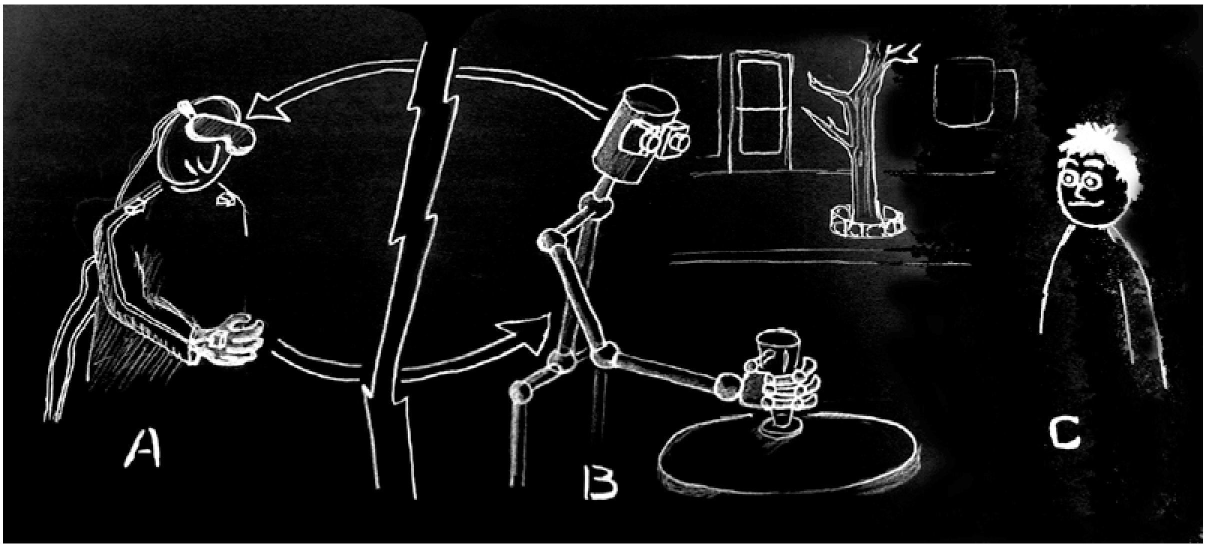

Figure 1. Teleoperated humanoid robot with onlooker. Control signals (lower arrow) are carried from the head and arm movements of the operator (A) to the robot (B); sensory signals (upper arrow) are carried back from the robot to the operator's sensory apparatus (vision, hearing, touch). The tightness of this loop determines the experience of presence: The more direct the coupling and the less of a transmission delay, the stronger the sense of telepresence experienced by the operator. An onlooker (C) may experience the telerobot as having cognitive presence if the robot's actions contain features which the onlooker sees as being caused by cognition.

2 Cognitive Presence

A telepresence setup can be seen in Figure 1: An operator (A) is remote-controlling a robot (B); the robot's vision and hearing is transported back to the operator. An observer (C) is looking at the robot. The observer may sense that the robot has human-like thought processes behind its actions, that its behavior is a manifestation of actual thought. The observer is experiencing what I call *cognitive presence.* I define cognitive presence as an observer's sense of thought being present in another entity, the feeling that "somebody is home". This gives an *observer-centric definition* of a system's quality, in other words, presence is defined by an observer looking at a system from the outside. Provided a system's ability to (a) sense its environment and (b) express the results of its thought processes to a perceiver familiar with it, or familiar with intelligent systems like it, cognitive presence is practically inevitable. Just like the teleoperator falling back on comparisons to the familiar responses of his unencumbered sensory-motor system, judging the presence of cognitive abilities requires the observant falling back on prior experience of cognitive systems. As default, the most similar system to the one

When observing unknown natural biological systems, cognitive presence is evoked by how closely a subset of the observed dynamic features, or behaviors, resemble those observed in other systems known to possess cognition. The strength of the presence experienced is thus a function of the underlying thought processes of the system, but are also limited by the ability of the underlying processes to express their existence via some recognizable medium such as a familiar body shape. Another way to define cognitive presence is to say that it is the *sensed evidence for mental processes causing the observed behaviors*. As shorthand we will say that an entity "has presence", and "is capable of expressing presence", if it has the ability to evoke a sense of cognitive presence in an onlooker.

One problem with this definition is that many things can evoke a sense of cognitive presence, even a letter: A letter with random sequences of words does not evoke a sense of cognitive presence (displaced in time) while a thoughtfully written one does. To distinguish this form of cognitive presence from others we need to add two dimensions to the equation: Embodiment and interaction. *Embodied cognitive presence* is a sense of cognitive presence evoked by directly observing the behavior of the physical embodiment of a behaving thing. *Interactive cognitive presence* is a sense of cognitive presence evoked through interaction with the physical embodiment of a dynamic thing. Interactive cognitive presence does not have to imply embodied cognitive presence: As in the case of a letter, the interaction can be displaced in time and happen via various media. Another example is the Turing Test (Turing 1950), which presents a way to measure interactive but non-embodied cognitive presence.[3]

A much stronger sense cognitive presence can be achieved in an interactive system than in a video or audio recording of a behaving system. Conversely, interactive cognitive presence is a lot harder to achieve because interaction requires the system to have an active perception-action loop. Humans use prior experience to judge the strength of the presence; for a simulated human we will get embodied cognitive presence only if the behavior of the virtual human resembles that of a real human in some critical ways – ways which are the topic of the rest of this paper. For a given period of behavior, the strength of the perceived embodied cognitive presence will thus be, roughly speaking, a function of (a) the amount of opportunity for the simulated human to express the results of its thoughts through its behavior, and (b) the similarity of its behavior to the perceiver's experience of real humans. As such, it is (typically) easy to recognize and classify in embodied intelligent systems like those we human observers are familiar with, like animals and fellow humans. Yet it is, make no mistake, a phenomenon that is hard to quantify.

3 Motivations

The concept of presence can serve several purposes in artificial intelligence and cognitive research. First, it can serve as a guide for classifying computational artifacts that produce human- and animal-like behavior. Second, it can be studied in and of itself by trying to answer the question: Can we create artificial systems that give human perceivers a strong sense of presence? The latter seems to have been the approach in several conferences on simulated characters emphasizing "believable" agents. One could ask what the difference is between believability and presence. Unfortunately we do not have space for this topic here. Suffice it to say that the main difference between the concept "believability" and the concept of cognitive presence is that the former leaves out the very thing to which it refers (believable as what?), preventing it from being taken seriously as a scientific concept.[4]

A related term often used in agent research is "lifelike". This term clearly refers to a goal, that of making someone believe something. It shares with presence a sense of "surface validity": Like the watchmaker building automatons, the modern author of lifelike humanoids seems content with the "illusion" of life that stops at the surface. As long as they move in a lifelike manner it doesn't matter what's inside their heads. Just as it's possible to build lifelike systems without modeling a single living cell, it might thus be possible to build systems that express cognitive presence without modeling a single human-like thought.

However, we do not understand the relationship between presence and cognitive architecture, and until we do it seems a rather tentative goal to pursue presence as a research topic in and of itself. There may be no more than a loose connection between the two and, because presence is an as-of-yet unquantified perceptuo-emotional quality of perceiving systems, there may be vastly more ways of creating presence than there are ways of generating presence in a system from first principles, that is, from accurate models of cognition. In Section 6 we will come back to this issue, which I call *cognitive validity*.

Further, while it might be argued that cognitive presence, being an emergent property of known living, thinking systems, is bound to emerge from artificially intelligent systems at some point in our development of them, it is not clear how, what kind, or whether, presence will emerge from half-finished or partially-accurate cognitive models. Using presence as a guiding light in building cognitive models may therefore lead down more than one blind alley.

Another reason for wanting to capture presence in an artificially intelligent system comes from the human factors perspective: Someone interacting with a system that doesn't *seem* to be present may become impatient, even mystified; at worst, the interaction may break down. This is the strongest argument for studying presence, in my opinion, but it applies only to systems that are intended to interact with humans. Other systems, those that automatically refuse or accept insurance applications, for example, do not need to show any presence, as the concept is used here. We will look at these issues further in Section 6.

[3] It has been argued that the Turing Test does not measure intelligence (Hayes & Ford 1995). If it actually measures *something* it could be argued that this is likely to be cognitive presence.

[4] We could take "believability" here to simply mean "believable in its mimicry of the natural phenomenon of which the system is a model", e.g. a simulated humanoid is believable if it's precisely like a human (in all, or some selected, aspects) and less believable if it's not. Viewed this way the term "believability" is broader than cognitive presence – the latter is only one of many prerequisites for achieving the former.

4 Dissecting Presence

Provided, then, that presence is a desired emergent property of embodied dynamic systems with a perception-action loop that interact with humans, we will now attempt to dissect the concept into smaller constituents.

We will assume, among other things on the grounds of prior research (Thórisson 1999, Bryson & Thórisson 2000, Thórisson et al. 2004), that presence is a secondary, emergent property of behaving systems, and that embodied cognitive presence is made up of a number of *presence cues*. These cues combine to form the impression – strong or weak – of cognitive presence in someone observing the system.

What many animals have in common – for example cats, dogs and cockroaches – is a keen sense of their surroundings and context, especially that which is relevant to their own survival. They all avoid objects falling on them, but while the cockroach runs away from just about anything that is the size of humans, cats and dogs have a better object-recognition system and can easily identify whether animals approaching them are friendly humans or fearsome predators. (They also have less to fear from humans than cockroaches do, but that's beside the point.)

A simple thought experiment can help us start to isolate the cues that contribute to a sense of presence in these behaving systems. Imagine a small rectangular block sitting on the floor. The square is an abstracted roach – it has the brain, sensory apparatus and mobile abilities of a roach precisely copied, but it looks like a tiny block. As it's immobile you don't see any signs of mental activity – there is no cognitive presence. As you move closer to it, however, the block starts scurrying around. At this point in time, if the movements are very much like those of a real cockroach, you may be fooled into thinking it's an actual cockroach. The block is “fleeing”. It has suddenly achieved cognitive presence because certain features in its behavior, namely the pattern of movement it follows, evokes the concept of a fleeing cockroach in your mind. The main difference between the behavior of an actual cockroach and the block: When it's not moving we seen no tentacles waving about, sniffing the surroundings. In this example we see that the roach's moving tentacles are a presence cue that is separate from its scurrying behavior. In fact, scurrying is a very different activity in its nature than sniffing for danger by moving the tentacles around. The latter is a prerequisite for scurrying and has therefore the highest level of priority in the animal's perceptual apparatus – if it didn't the animal would soon be killed while doing something else.

This movement of the perceptual apparatus to detect danger and observe their environment applies to all animal species, courtesy of natural selection. If we see a tree falling on us we will stop anything else we may be doing to avoid getting hurt. In a behaving system this constant sampling of the world represents processes in the *Reactive* category of presence cues: We humans move our eyes to detect objects and our head to localize sound, the roach moves its tentacles to look for food. One of the main distinguishing features of presence cues in the Reactive category is that all processes and resulting behaviors in it happen on very short timescales, up to perhaps half a second, or two seconds at most. That is, their perception-action loop is very tight. These presence cues reflect something about the "sampling rate" of the system's cognitive circuits. The cognitive processes producing such cues are also very context-driven.

If the Reactive category were all that there is to the story there would be no difference between presence expressed by humans and that expressed by roaches. But there is. Let's compare different species again to make this clearer. When it's not fleeing, a cockroach scurries around seemingly without much sense of planning. What distinguishes a dog's presence from e.g. that of a roach, and even a hamster, is a much stronger expression of human-like qualities such as more obviously recognizable planning (e.g. when searching for objects), more obvious display of focus of attention and higher-level object recognition. A dog displays clearly certain cues that we can relate to human intelligence, and as a result we humans have an easy time recognizing them. With their object recognition and relatively powerful memory they can identify the closet where their food is stored, when hungry, even without the sense of smell. Their *intention* (and inherent prediction) is a cognitive presence cue: They are aware of the environment. Someone is certainly “home" in an agent that can predict its surroundings in this way. We have an agent that can plan. The second category of presence cues relates to the execution of such tasks and plans, I call it the *Planning category* of presence cues. It includes behaviors related to task knowledge and planning of behaviors, from several seconds to minutes to hours. And because observers always judge by comparing to that with which they are familiar, the more a system's planning capabilities replicate human planning, the more such behaviors will act as a presence cue.

As seen with the animal examples, human thought is not required to produce cues for cognitive presence. Looking at dogs and cats we immediately see that there is no need for systems to talk or possess (human-like) logical thought either: Most would agree that there is clear evidence of thought in their behavior. Both cats and dogs understand spoken words and one might ask whether language understanding is perhaps necessary for a system to produce presence cues in the Planning category. Looking at the roach again, we see that this is not the case: Fleeing is clearly a form of planning, albeit a fairly primitive one.

Household pets are not able to accomplish much with language; they treat speech as a particular category of environmental sound. With this in mind it is not a leap to propose that yet another category of presence cues relates to the use of symbolic actions and semantic context, in the form of language and embodied communication. We will call it the *Symbolic* category of presence cues. Our animal examples can help clarify what kind of cues are exclusive to language-capable minds. Both cats and dogs understand the meaning of single words, but can hardly be said to understand the syntax of sentences. And they are not capable of much symbolic expression, except perhaps in a very small way which relates to their bodily function and the immediate here-and-now. Their use of communicative behaviors is therefore more accurately classified as belonging to the Planning category. The actions that characterize the Symbolic category – speech, written language, (symbolic) drawings and situated body language – are all indications of human-level intelligence. Actions in the Symbolic and Planning categories typically involve processes which take longer than two seconds to execute, never less than half a second, and typically minutes, hours, days or even years. This sets them very clearly apart from Reactive cues. What separates the Planning and Symbolic categories from each other is the fact that the former primarily involves direct operations on real-world things while the latter primarily an exchange of symbols.

A synthetic agent or robot moving about, being observed by human onlookers, may express cognitive presence cues in all of the above identified categories. Whether teleoperated or controlled exclusively by software, its ability to express Reactive presence cues will be determined by the similarity of its use of sensory mechanisms (cameras, microphones) to the way humans and animals use their sensory apparatus, and indirectly by the similarity of the underlying processes controlling the behavior of these sensory systems. Existence of Planning cues is determined by the similarity of its "long-term" behavior (over several seconds or more) and the ability of the observer to recognize some kind of purposeful goals in their behavior over time. The ability to express Symbolic cues is determined by its ability to produce recognizable communicative actions.

We have used thought experiments as the main method of exploring presence. However, there are experiments that back up the hypotheses presented. In tests done with virtual humanoids capable of real-time turn-taking with people (Thórisson 1999) I found that turning off computational processes (and thus resulting behaviors) in the Reactive category strongly affect the way people experience the agent. Among the reactive behaviors tested were behaviors complex gaze patterns related to turn-taking, facing the speaker when listening, gazing at the things talked about, gesturing in the direction of objects, etc. People would rate a talking humanoid with reactive behaviors as having more language skills than one without them, even though their language skills were identical (Cassell & Thórisson 1999). Users also rated a character with reactive behaviors as more life-like than characters without such behaviors, and they rated agents capable of emotional facial expressions as less life-like when they had no reactive behaviors. Humanoid agents with behavioral cues from all categories of cognitive presence cues were rated as being less like fish and more like dogs and humans. While these experiments were not done to specifically analyze presence – and one could argue that there is a difference between expressing features of lifelikeness and expressing a sense of presence – they point in the direction that behaviors in the Reactive category may present stronger cues for cognitive presence than processes in the Planning and Symbolic categories.

The experiments presented here only hint in a certain direction; clearly these hypotheses need to be further tested.

5 Interaction Between Processes

We have described three categories of presence cues. Processes in the three categories do not operate in isolation; they interact. For example, people will look in the direction they are listening (Riesberg et al. 1981) and they have a strong tendency to look at objects under discussion (Cooper 1974), both examples of interaction between presence cues in the Planning and Reactive categories. And such actions may in turn be related to a plan for interrupting, understanding or replying (Goodwin 1981), thus interacting with cues from the Symbolic category. This highlights a major difference between the cockroach and us is that in human social interaction the same mechanisms responsible for Reactive category presence cues, for example fixations, serve a secondary purpose, namely, that of directing attention towards subtle and not-so-subtle communicative signals embedded in facial expressions, hand movements and the body language of our interlocutors, to take some examples. Were humans to evolve eyes that could shift attention completely without mechanical movement (for instance a large retina where attention would invisibly select portions to process) our expressed level of presence would most likely be significantly diminished. Contrary to intuition, the Reactive category is therefore alive and well in social interaction, in spite of being something we have in common with much simpler animals.

Over any sampled period of conversation and social interaction a mixture of all three categories can typically be found. In many cases the actions that contribute to a sense of presence cannot be teased apart: Is a glance into the air a sign that the person is thinking, is looking at the airplane flying overhead, or is getting distracted for a moment admiring the trees? It is no coincidence that these are the same kinds of questions that dialogue participants need to ask of their immediate surroundings during the course of a face-to-face interaction; presence in dialogue emerges from interactions between the planning, perception and motor control processes that are responsible for a participant's behavior in real-time dialogue (Thórisson 2002).

The interaction between the categories of processes controlling the person's movements are clearly coordinated – if they were random there would be no way for the person to operate in the real world, because to support plans processes in the reactive category need to support the numerous tiny actions – perceptual and motor – that are needed to execute each step of the plan. For someone to interrupt a speaker, without being impolite, they need to perceive features of the speaker's behaviors, hesitations, pauses, etc. and choose the right point in time to start speaking. To do something as complex as this, cognitive processes supporting behaviors in each of the three categories in the interrupter's mind need to be closely coordinated. The coordination of cues from these areas present patterns to a perceiver that also can be compared to prior experience and weighted for evidence of cognitive presence. This is the fourth category of cognitive presence. We will call it the *Holistic* category of presence cues. It concerns the coordination of behaviors in the three other categories.

6 Cognitive Validity

We take the concept of *cognitive validity* of a system to mean the system's potential to do things, i.e. perceive, think and act, in the same way that natural cognitive systems do them.

If we define "faking it" as the method of producing presence in a system without a valid underlying cognitive architecture, it can be reasonably deduced from the discussion so far that presence cues in the Planning and Symbolic categories will be more difficult to produce in an artificial system because (a) they require significant processing power and knowledge represented to work correctly, and (b) they are probably harder to "fake" than Reactive category processes (see e.g. the Loebner Prize[5]). While it is difficult to say whether Planning or Symbolic category processes are harder to implement, it may be argued that Planning-type processes have come further in A.I. research than systems producing language – that is, robots are navigating better than they are speaking. This, however, says nothing of whether one is easier to fake than the other. Holistic presence cues will most likely be the most difficult to implement, because by definition they rely on the correct operation of behaviors in the other categories.

The cognitive validity (Vc) of a system and the strength of the presence (Ps) it expresses could have several kinds of relationships. If there is a direct linear relationship between Vc and Ps there is very strong reason to look closely at presence when constructing a cognitive system. We might also see a low-threshold effect: Beyond certain low levels of Vc, Ps would automatically be very high. In this case presence is hardly relevant to the progress of A.I., and cognitive science except possibly in the early days. Observed results with simulated humanoids (Thórisson 1999) indicate that if cognitive skills and behaviors from the Reactive category are included in an otherwise fairly simple agent, presence is almost certain to emerge. Further, it seems that its strength may be in some ways correlated with the validity of the agent's cognitive architecture. However, these preliminary results need to be replicated and the relationship between cognitive architecture and perception of presence needs to be studied in much greater detail.

7 Discussion

As a result of these ruminations we can conclude that most natural systems expressing presence do so via behaviors that are the result of a combination of cognitive processes at various levels of detail, time scales and of various types. If presence is an emergent phenomenon, as argued here, it seems likely that artificial systems capable of expressing presence will only need to duplicate a small part of the cognitive processes which produce the behaviors observed, at least in the Reactive category. Gandalf, an early virtual humanoid capable of real-time multimodal dialogue, already expressed significant presence in the Reactive category, and some presence in the others (Thórisson 1999). Many (but not all) of the perceptual and decision processes needed to support Reactive presence cues are relatively simple and require not too much computing power. Given the right architecture, they can be imple-

[5] Loebner Prize http://www.loebner.net/Prizef/loebner-prize.html

mented on a single desktop computer today (even counting the perceptual processes needed to support them). Moreover, it seems as though these behaviors are easier to produce than those in the other categories *without* a functionally valid cognitive architecture driving it.

It is clear that many higher-level living organisms express a sort of presence that is different from that of lower animals, because they have increasing amounts of processes that belong to the Planning, Symbolic and Holistic categories. The perceived difference between the behavior of low and high-level animals, arachnids and monkeys for example, exemplifies the difference in presence produced by processes in the Reactive category versus the Symbolic and Planning category, respectively. Differences found between the presence cues of an ape and a human are mainly due to differences in processes belonging to the Symbolic and Planning categories, mainly the former.

Of the four categories of presence cues identified here, the Holistic category is probably the least studied. Because it concerns the integration and interaction of cues from the other categories, it may well be that a closer scrutiny of this category presents the biggest benefits of studying presence. Nevertheless, it remains to be shown that presence cues are anything more than epiphenomena of natural cognitive processes, and until there is clear evidence of anything more, presence should probably rise no higher in priority on the research lists of A.I. and cognitive scientists than telepresence has risen on the lists of virtual reality and telerobotics researchers.

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