



Living language and embodied cognition: Thoughts on the sciences of language inspired by the LLM challenge^{*}

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Huang, Chu-Ren. 2026. Living language and embodied cognition: Thoughts on the sciences of language inspired by the LLM challenge. *Linguistic Research* 43(Special Edition): 281-295. A linguistic act, in its simplest and most essential form, is the exchange of information between two people (i.e., two intelligent agents), with two design characteristics: first, the shared access to the expressed linguistic content and second, the lack of access to each other's internal cognitive processes. I argue that current linguistic theories do not account for these two design characteristics of language. I further demonstrate that language, both as a theoretical entity and in actual language use, is a multiply embedded self-hyponym. The existence of multiple self-hyponyms is compatible with the view of language as a dynamic, self-adaptive complex system, but incompatible with many time-dependent linguistic theories that typically focus on a specific level of the self-hyponym. Drawing on Embodied Cognition and prediction-driven communication, I conclude that shared language data contain rich sensory information that supports brain-to-brain alignment and compatible knowledge within a community. It also helps explain the success of agents lacking direct sensory input, including LLMs and agents with sensory impairments. (The Hong Kong Polytechnic University)

Keywords Language, Large Language Models, embodied cognition, self-adaptive complex system, self-hyponym

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1. Foundation: What is *Language*

Language is the foundational concept for language sciences, including but not limited to linguistics and the emergent Large Language Models (LLM). However, it is typically presupposed without a clear definition or postulation. Knowing what *Language* is should inform us about what LLMs actually model and how linguistic knowledge may contribute to the success of Generative AI (GenAI). Given that language is a common topic of ancient and modern scholarship, there seem to be as many versions of its *definition* as there are theories of *Language*¹. One reassuring fact that mitigates the daunting task of unifying so many definitions of *Language* is that proponents of conflicting theories at least seem to agree they are talking about the same language. This, I would argue, echoes the self-hyponymy of the concept *Language* in human languages. A quick survey of languages in the world shows that: First, most (if not all) languages have a term for the conceptual entity *Language*. Second, most (if not all) languages share a remarkable practice of using the term as a nested self-hyponym, as illustrated in Table 1, using English for convenience. I will refer to it from here on as the Russian Doll Self-hyponymy, as each level of the definition of *Language* can be conceptualized as being contained in the next level up *Language*.

1 Given the multiple meanings of the word language, as well as different versions of theories, I adopt the following convention to differentiate them while retaining using the same word to maintain linguistic felicity: First, indexes are used to indicate any of the self-hyponymic levels of language, as defined in Table 1. Second, in italics with initial capitalization, i.e. *Language*, it refers to specific theoretical definition of language that should be clear in context. Third, with capitalization but without italics, i.e. *Language*, it refers to the overall definition that covers all the self-hyponymic levels. This is the basic concept I aim to capture. And lastly, without any explicit marks, language is understood intuitively as a non-technical term.

Table 1. Language: The nested self-hyponymy

• Language ₁ : the collective sum of all linguistic activities and abilities of all human being in the world from past to future; (i.e., Language)
• Language ₂ : the shared system of linguistic communication by a specific people, throughout the duration of existence of the people and the system; (i.e. Language, such as Chinese, French, and English) or: <i>language₁ as used by a certain people</i>
• Language ₃ : language ₂ as used by a specific people at a specific period of time (i.e. Language, such as Middle English, Archaic Chinese, Middle Chinese, Modern Chinese, etc.)
• Language ₄ : (or dialect) language _{2/3} as used by a specific people in a specific region and developed to an extent that it has a separate cultural identity and may (or may not) be mutually unintelligible with other language ₄ 's
• Language ₅ : language _{2/3} as used by a people in a specific region to the extent that it can be differentiated from others (i.e., American English, Brazilian Portuguese, Taiwan Mandarin, etc.)
• Language ₆ : language ₃ as used by a specific group of people related to their shared special purpose and/or profession (i.e., Academic English, tourist Japanese, business Chinese, etc.)
...
• Language _n : language ₃ as used for a special occasion, often with specific social functions or intention in mind by the user (romantic language, polite language, persuasive language)
• Language _{n+1} : the word choices of a specific speaker (i.e., 'watch your language!')

As we move through the different levels of language's self-hyponyms, it becomes evident that different theories of Language focus on different levels of self-hyponymy. As such, they do not necessarily contradict one another. The Chomskyan tradition of generative grammar focuses on Language₁, or what is called UG (Chomsky 1957). In descriptive and pedagogical studies, as well as in daily conversation, people typically switch effortlessly between Language₃ and Language₂, although perhaps with focus on a more specific aspect of either. De Saussure (1922) proposed to resolve the potential confusion by introducing more precisely defined technical terms: *langage*, *langue*, and *parole*. These terms remain popular and useful among linguists but have not been adopted by all other disciplines or in daily language.

Note that, in English and in Chinese, the term 'a Russian doll' (a matryoshka doll) 俄罗斯娃娃 *e4luo2si1 wa1wa5* refers to a set of self-embedded dolls. Two crucial facts are that: First, a Russian doll consists of a set of dolls, but not a set of Russian

dolls. Second, a set of dolls is not necessarily a Russian doll set, as the concept requires that the dolls look similar and be stackable inside one another in order of size. Thus, “doll” and “Russian doll” are two related but separate concepts. While any specific doll ISA *doll*, the same cannot be said for a matryoshka doll. The concept of “Russian Dolls” does not inherit features directly from “doll” as in an ISA relation. In sum, the concept of Russian dolls is built on a holistic view of the constituent dolls in terms of their similarity and the transitive-containing relationship among them.

The Russian Doll metaphor demonstrates that an explanatory theoretical model of Language cannot be developed based on only one of the hyponymic level of it, contrary to many previous attempts. The fact that all these attempts had to prefix their model account by ‘defining’ which *Language* is being accounted for underlining the dilemma. There are no logical ISA relations between the holistic concept of Language and each *language_i*. IS-A-KIND-OF relation more precisely describe the relationship between each *language_i* and Language. However, the IS-A-KIND-OF relation is not sufficient as it cannot account for the multiple embedded containing relation among the *language_i*’s.

The conceptualization of ‘Russian Doll’ is built upon the self-containing relation of the set of dolls, not on the physical features of a specific doll. Similarly, I posit that the conceptualization of Language must capture the self-hyponymic relation of the various levels of *language_i*’s. It is also observed that this concept is lexicalized in many languages that use ‘language’ as one of the most productive regular polysemy.² Thus, the focus will be on *language_i*’s instead of a particular *language_i*. The key research question is: What is the conceptual foundation, or the minimal ontological commitment, that would describe all *language_i*’s and support the lexicalization of the meaning of Language as this complex Russian Doll Self-hyponymy?

2. The sharable data approach to a complex self-adaptive system

I noted earlier that the lexical concept of ‘language’ refers to a full range of different conceptually related entities, e.g. Chinese as both the modern language we speak and

2 Note that this regular polysemy is very different from the ones addressed by qualia structure in Pustejovsky’s (1991,1995) generative lexicon. That is, it does not involve the highlighting of certain aspects of a complex meaning, such as the telicity versus the composition of a fruit or an artifact.

the inherited language that defines our culture, and language as the universal ability to acquire the system (the capitalized *Language*) to the choices of specific words (e.g., ‘watch your language’). To disentangle this highly intertwined set of self-hyponyms, I start by focusing on two of the most used levels, which I refer to as the ‘modern language’ and the ‘cultural language’.

We often use the term language to refer to the language we speak today, i.e., our mother tongue or that of others in our contemporary time. Let’s refer to this as the ‘modern language’ for lack of better terms. This use seems to be simple and intuitive, but it turns out to be more complicated in the real world. For instance, we assume we speak the same ‘modern language’ with our grandparents and our grandchildren, since both groups are our contemporaries for some period in our own lifespans. Similarly, we can say that our grandparents speak the same language as their grandparents, and our grandchildren speak the same language as their grandchildren. It is also assumed *a priori* that a speaker speaks the same (modern) language throughout their lifespan once it is acquired or learned. Given the transitivity of the sameness relation, does this mean that our great-great-grandparents speak the same language as our great-great-grandchildren, even though they are not contemporaries, and so on and so forth? The answer is yes and no: Yes, they speak the same language in the sense of the ‘cultural language,’ the language shared by the self-identified people throughout their history. The answer is no by the mutual intelligibility condition of speaking the same ‘modern language’ held in linguistics. An illustrative scenario, often introduced in linguistic lectures on language change, is that we would not be able to understand each other if we could time-travel and talk to Confucius or Shakespeare. In addition, if we agree that our great-grandparents and our great-grandchildren, who do not live in the same period of time and never talked to each other, speak different ‘modern languages,’ does this mean that we speak (at least two) different ‘modern languages’ in our own lifetime, since we speak those two different languages with them respectively?

This dilemma arose from the confounding of the endurant/perdurant dichotomy in ontological perspectives (Bittner et al. 2004; Huang 2015, 2016). Language is a continuant through time, with changes. The concept of Language is endurant; that is, it must ‘persist’ regardless of the changes of time. However, being mutually intelligible is an occurrent that changes through time, since it is an eventive occurrence that can only be evaluated at a specific time. Mutual intelligibility, being anchored

at a specific time, is not an ontologically suitable way to identify a language as continuant through time. This is demonstrated by the fact that English is the language shared by us and by Shakespeare, and Chinese is the language shared by all Chinese speakers and Confucius. These facts are true both for the self-hyponym *language*₂ and the self-hypernym Language. This long-standing linguistic dilemma arose from confusing a heuristic function of language (i.e., the concurrent events of understanding each other mediated by language) with a defining attribute of the endurant/continuant concept.

This dilemma can be resolved by asking a simple question: Which aspect of language do our grandparents share with us, and our grandchildren with us, but not by our grandparents and grandchildren? The answer is the shared data of language use. It is well established that the actual use of language is unique to each time and to each sub-community of speakers (Weinreich et al. 1968). And this has been the foundation for data-driven approaches to historical and social linguistics, as well as a wide range of data-driven studies in computational linguistics, corpus linguistics, and digital humanities. Each of the *language*_{*i*}'s in Table 1 can be described by the same formula:

- (1) *Language*_{*i*} is The sum of language uses, given a time span *T*_{*i*}, by and within the speaking community *SC*_{*i*}.

To effectively model these multiple *language*_{*i*} and account for how they dynamically interact and change, we could take the theoretical view of language as a self-adaptive complex system (e.g. Beckner et al. 2009). Since the system is dynamically adapting to language use data, to capture a stage of the system or to compare different stages of the system, a model of the system of each stage could be derived from the sum of use data from that stage.

Note that this view also addresses the dilemma of whether the younger and older me speak the same language. If we take the whole lifespan, which is the natural temporal demarcation of any person, of course they speak the same language throughout that lifespan according to (1). However, if we take different snapshots of different stages of the lifespan for comparison, such as the snapshot with our grandparents and the snapshots with our grandchildren, the languages would be different. These are still consistent with (1), since each is anchored by a different

time span T_i .

Crucially, these differences reflect the change of ontological perspectives described in Grenon and Smith (2004). They argued, following the endurant/perdurant dichotomy established by Aristotle, that ontologies are depicted from two different perspectives: the SNAP (snapshot) perspective captures the time-independent nature of an endurant/continuant; and the SPAN (spatiotemporal) ontology captures the time-dependent changes of a perdurant/occurrent. Note that, in accounting for space and time, Grenon and Smith (2004) proposed applying SNAP/SPAN ontological perspectives to account for two fundamentally different types of entities. For language, both perspectives are required. Inspired by Aristotle's *On Interpretation*³, I argue that linguistic conceptualization relies on the ability to manipulate time-dependency (Huang 2016; Zhong et al. 2023). Within language, we manipulate time-dependency through the Noun/Verb dichotomy, following Aristotle. Within the complex self-hyponym systems of language conceptualization, this manipulation occurs through demarcating different time spans and alternating SNAP/SPAN perspectives.

3. From dynamicity of accessible data to large language models

I demonstrated above that access to the collection of dynamic language data is a constant in human cognition, anchoring the diversity of individual experiences by supporting the distillation of the shared complex self-adaptive system of language for any specific span of time. This shared-data-driven account offers a new perspective that supports the emergent multi-brain model of language and cognition (e.g., Di Paolo and De Jaegher 2012; Hari et al. 2015; Schoot et al. 2016). Language and social interaction require the participation of multiple agents. More specifically, Language is a multi-agent system in which each agent does not have direct access to the inner workings of other agents (i.e. the Blackbox), and there is no 'master program' controlling or synchronizing the brain activities of all agents. To understand the system, multi-brain or brain-to-brain approaches have focused on alignment and interaction, especially during conversation (e.g. Garrod and Pickering 2004; Menenti et al. 2012). Note, however, that just as an identical design of the brain itself cannot

3 Accessed through: McLaughlin, J. (2017). *The Originals: Classic Readings in Western Philosophy*. Thompson Rivers University/BCCampus. <https://pressbooks.bccampus.ca/classicreadings/>

guarantee identical action, having the same alignment or interaction strategies itself also cannot guarantee identical cognitive states and knowledge, given the idiosyncrasy of each agent and the selective nature of perception and reaction to stimuli. I argue that access to the same shared dynamic language data is the necessary third leg of the tripod to ensure that the multi-agent system dynamically adapts to and maintains the same language system. Salicchi et al. (2026) offer a good example of how the shared dataset maintains and predicts effective communication and emotion alignment, even though each agent's alignment action varies across contexts (e.g., the best alignment strategy when Anger is detected is not Anger).

In this multi-agent, complex, dynamic, self-adaptive system, and given the self-embedded hyponymic conceptualization, three seemingly competing, if not contradictory, ontological commitments are required. Synchronically, it requires all speakers at any specific time span to commit to the same language₃. Diachronically, it first requires that each specific speaker commits to speaking the same language₃ through his/her lifespan. Secondly, it requires that a significant majority (if not all) speakers throughout history commit to the fact that the language₃ that they speak is an instantiation of the same Language₂. Based on the formulation of (1), we posit that these competing ontological commitments are each supported by the shared data as modulated by SPAN variations. In other words, without specifying how the conceptualization and identical ontological commitment is achieved, we posit that the shared data is the verifiable empirical foundation.

Given this perspective on the foundational features of Language as a complex, dynamic, self-adaptive system consisting of multiple agents with shared access to language data, we can take a more synergistic view of the recent success of the emergent Large Language Model (LLM). The LLM-based Generative AI approaches achieve remarkable results in mimicking human cognitive behaviors, especially language (e.g. Abbasiantaeb et al. 2024; Chen et al. 2026; Guo et al. 2026; Yang et al. 2026). I would argue that their success is expected given the accessible shared-data model we proposed. Recall the position above that the shared brain, the shared alignment strategy, and the shared accessibility are the tripartite foundation to build a shared language. For this position to be verified, it is necessary to demonstrate that different agents are able to distill the same level of knowledge. In other words, the growing literature and record of success of LLMs provide empirical support that, given a sufficient set of shared language data, different agents with similar designs

could distill compatible high-quality information on par with the shared human knowledge. The success of the various LLMs provides the supporting evidence for how accessibility to shared dynamic data can lead to the same knowledge, even though the selected portions of the dataset may vary. On the other hand, from this perspective, the success of the LLMs simply mimics the success of multiple human brains accessing the same dataset. Globally, the AI systems are still mimicking the collective human behaviors.

In particular, the manipulation of time-dependency through the SPAN/SNAP ontological perspective maintains the robustness of the conceptualization of Language despite the dynamism of multiply embedded self-hyponymy and the variations of human brains. The power of language lies in how it enables the effective learning of knowledge grounded on shared language data. LLMs function by applying massive computing power to an unprecedented collection of language big data. Humans thrive by leveraging our embodied experiences, and the embodied architecture of our cognition to learn from a smaller set of shared data. This data-centered view provides a straightforward account of language as a self-adaptive complex system, resulting from the dynamic growth of shared data/experience. In addition, the nested self-hyponyms conceptualization of 'language' captures the essence of language as a complex system while foregrounding different levels of its subsystems in daily human life.

4. Challenges: Bridging language and embodied cognition

I noted earlier that the shared cognitive mechanism (the brain), the shared alignment strategy, and the access to the same language data are the three pillars of a dynamic, self-adaptive system of Language. However, having these three pillars does not guarantee that each brain would distill the same linguistic system. It would be a fallacy to make such a deduction, not unlike the fallacy of deducing that the shared neuro-cognitive design would lead to universal grammar.

The theory of embodied cognition also poses another condition: the shared embodied experience as the foundation of conceptualization. The theory of embodied cognition started with Gibson's (1966) original position that sensory input underlies the perceptual system and thus provides the foundation of conceptualization. It has

since developed into later, more nuanced positions (Wilson 2002; Shapiro 2012; Wilson and Golonka 2013) that, beyond the necessary involvement of embodied sensory input, argue that embodied experience informs the architecture of cognitive structure. Embodied cognition provides a necessary condition for the Russian-doll hyponymy of language conceptualization, reinforcing shared language data with shared embodied experience. It has also been a focal point of intensive LLM-related research recently, as it is unclear whether LLM-based AI approaches have embodied design and/or access to sensory experience.

One crucial challenge to the embodied cognition account is the observation that sensory impairments do not preclude full development of linguistic and cognitive competence. That is, people with specific sensory impairments, such as blindness or deafness, still develop full cognitive and linguistic ability and can describe the perceptual properties of all sensory domains. Helen Keller's writing and Beethoven's ability to keep composing after going deaf are two well-known, widely discussed cases. These facts underline the need to shift focus from sensory input to cognitive architecture as the cornerstone of embodied cognition, but they still leave the why and how questions open.

The 'cultural language' language₂ is another context where direct sensory input is not accessible, and its inaccessibility does not preclude cognition. Language₂ is also the context where the *a priori* premise of current linguistic theory that spoken language is primary would be challenged. Note that even in languages without writing systems, the shared memory is preserved not by the inheritance of spoken forms, but by the inheritance of the text and the structured knowledge represented by the text. That is, after several hundred years, cultural memories will be passed on orally in the same story, but not necessarily in the same spoken forms or grammar.

More specifically, sound and sound systems can change, and they invariably do over long enough time spans. We compare two classics from two languages to illustrate this point: *The Classic of Poetry* (**Shijing** 詩經, aka the Book of Odes) and *Beowulf*. *The Classic of Poetry* was written roughly 3,000 years ago and is still being read and is legible today. *Beowulf* was written a little more than 1,000 years ago but is only legible to experts today. The main difference is that the English writing system uses phonology as its orthographically relevant level (ORL; Sproat 2000). *Beowulf* was written down and preserved to represent its spoken form 1,000 years ago. The Chinese writing system, by contrast, has semantics as its orthographically relevant level (Sproat

2000; Huang and Hsieh 2015); hence, the text directly preserves structured meaning. When modern people, or any literate Chinese people over the past three thousand years, read *The Classic of Poetry*, they read it aloud in different (and likely mutually unintelligible) spoken forms, but still read and comprehend the preserved information. This does not mean that a ‘cultural language’ Language₂ would be less effective in sharing cultural knowledge because of its writing system. The text, as a carrier of information, can be updated to reflect language changes while remaining the same text. Various contemporary English editions of the Bible are a good example. The key is that language₂ is established through sharing texts and inheriting the structured knowledge recorded in them. The stipulation that spoken language is primary is another instance of taking the wrong SNAP ontological perspective while dealing with an enduring entity that occupies a SPAN of time.

But why can we distill sensory information from ancient texts, writing about a time and place we do not have direct embodied experience of? And why do people with sensory impairment develop sensory knowledge in a modality that they are incapable of perceiving? The simple answer is that this is the norm, not the exception. We observe, as Friston and Frith (2015a) set as their premise, “that our sensations are largely generated by **other agents** like ourselves.” That is, in the vast repertoire of information about sensory inputs of each person, the portion that any specific person has experienced first-hand is minuscule. Hence, we can deduce that learning sensory information from others is a cornerstone of cognition.

In Friston and Frith’s (2015a, b) theory, communication, for all sentient agents, is the inference of the behaviors of others through the sharing of sensory signals. They also argue that, with attenuated attention to sensory signals (Friston and Frith 2015a) and active inference (Friston and Frith 2015b), the two agents can reliably arrive at the same, or at least compatible, predictions and mental states. While their theory and study focus on two communicating agents, our concern is a society of many agents and the shared collected data of their communication (i.e., shared language data). For each human agent, the contemporary language data they experience is the collection of interactions with multiple other agents. For communication to succeed, an agent must reach agreement (make predictions and learn the same objects) with each interlocutor. And this condition applies to all other agents too. This is exactly what we posited earlier: that language_i is defined by the shared language data of that particular span of time and defined by the shared ‘predictions’ of the agents

involved. Also note that language as a medium of communication has few spatiotemporal constraints, through both the advancement of print and digital technology and the long temporal span of cultural languages.

Bringing these points together, the argument comes down to this: Language's Russian Doll self-hyponymy is not a terminological nuisance; it is the direct consequence of building every level of Language, from one speaker's word choice to the sum of all human linguistic activity, out of the same material: the shared data of language use, bounded by a time span and a speaking community. That shared-data foundation is what lets an enduring concept like Language survive the perdurant, moment-bound fact of mutual intelligibility. It is also what makes language's two design characteristics work: because speakers share access to linguistic content but never gain access to each other's minds, agents can still converge on compatible knowledge simply by drawing on the same language data. LLM success is best read as an existence proof of this mechanism, not as evidence that data access is all there is to language. Embodied cognition supplies the missing ingredient: not raw sensory input, since blind, deaf, and text-only readers of long-dead languages all develop full linguistic competence, but the cognitive architecture that processes and organizes information into knowledge, regardless of whether that information arrives as sound, sight, touch, or written text. Current LLMs already have data in abundance; what they still lack is this architecture, and that is where the sciences of language still have the most to teach the sciences of AI.

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