Theory of Language as of Reflection of World Modeling by Human Intelligence

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Abstract

Language mechanisms are not understood in part because many linguistic phenomena are studied in isolation, and in part because the relationship between language and intelligence is not taken into account. This article calls to shift focus from "solving tasks" to "differentiation", which we believe is the fundamental ability behind intelligence. Comparable properties facilitate differentiation. We introduce a multi-dimensional search as a computational paradigm of cognition. It enables a new view on specialization and generalization. We propose to view language as a reflection of how intelligence models the world. It makes differentiation a fundamental approach in our theory of language. We depart from traditional views on reference and meaning and propose to view them with differentiation in mind. We introduce referential flexibility of symbols and coherence constraints, which help us to explain how polysemy and context work in tandem for resolving meaning. These contributions will stimulate research in computational linguistics.

Keywords:
theory of reference, theory of meaning, generalization, compositionality

Ну що б, здавалося, слова...
Слова та голос — більш нічого.
А серце б'ється — ожива,
Як їх почує!.. Знать, од Бога
І голос той, і ті слова
Ідуть меж люди! . . .
Т. Г. Шевченко, 1848

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1. Introduction

Language serves multiple roles important to society and even though we understand others' language we may say that we do not understand language. We understand what others say but we do not know the mechanisms for both "saying" and "understanding". According to Fabbro et al. (2022), "language still remains rather enigmatic".

The above problem was approached using the "divide-and-conquer" technique, which led to the separation of various phenomena under the language umbrella, which were studied in isolation. Some of those areas are mentioned in Mitkov (2022). This, in turn, created problems, as theories developed for those phenomena did not account for the "big picture" as a whole and other phenomena in particular. For example, theories of reference often neglect the polysemy of words, and syntax is studied separately from pragmatics. This creates opportunities for persisting in theories based on misconceptions. In this paper, we propose an approach that considers various phenomena and relationships among them.

One more relationship, the neglection of which negatively affects the study of language, is that of language with intelligence, another under-understood phenomenon. Best theories of intelligence so far, such as the Cattell–Horn–Carroll theory analyzed in McGrew (2009), serve only to develop metrics of intelligence not trying to explain how it operates. Those metrics heavily rely on linguistic skills, which suggests that there is some relationship between language and intelligence. The same is implied by the Turing test from Turing (1950).

In this paper, we propose a theory of language that unifies previously isolated areas using a uniform set of tools and approaches. To develop such a theory, we first introduce a basic theory of intelligence. This theory is based on the assumption that intelligence depends on differentiation. From that assumption, we propose basic components and a core algorithm behind intelligence.

We then postulate that language reflects the way intelligence models the world and propose three functions of language. We then proceed with the introduction of referential flexibility and coherence constraints, which along with the core components of intelligence allow for new approaches to the analysis of references, meaning, and language universals.

2. Context for a Theory of Language

The world around us is engaged in the eternal interaction of static and dynamic phenomena, objects and actions. Among objects, the animate ones are of particular interest to us. Even the life-friendly environment on Earth provides a lot of dangers and challenges for living creatures. To deal with them and ensure their survival, all the species develop certain competencies. Witkowski et al. (2023) define "observer-relative competencies to solve problems in some specified space" as intelligence and later refine this definition with "different spaces and with different competencies" and apply it to all biological beings. The authors, however, do not define the mechanism of intelligence. Existing theories of intelligence describe its manifestations but not the principles of its work.

The Cattell–Horn–Carroll theory, which according to McGrew (2009) is "the most widely recognized psychometric taxonomy of cognitive abilities", heavily relies on language skills in its assessment of intelligence.

Dennett (1997) questions how language contributes to intelligence and undermines the role of language in communication, which is a cooperative process, on the basis of his claim that humans are competitive. We suggest a moderate approach - if not taken to extremes, both cooperation and competition bring benefits, so there must be a balance. We also believe that it is more appropriate to ask how intelligence contributes to language.

Turing (1950), acknowledging that the laws of intelligence had not been discovered, proposed to use language to test a hidden interlocutor's intelligence. We support the Turing test and believe that the insight behind it was correct.

According to Chomsky (2006), "Only the most preliminary and tentative hypotheses can be offered concerning the nature of language, its use, and its acquisition." We extend this suggestion to intelligence and consider several hypotheses about its nature and relationship with language.

According to Fabbro et al. (2022), the main function of language is communicative. Chomsky (2006) advocates the role of language in facilitating thinking. Both of those roles imply the third one, namely the role in knowledge representation. We claim that this function is fundamental. Let us summarize the following three functions of language:

- representation of knowledge;
- processing of knowledge;
- transfer of knowledge.

The mechanisms used in language to perform those functions are not clear. In this paper, we propose several hypotheses explaining those mechanisms.

The first function is tightly related to the concept of context. A good review of existing definitions of context is provided in Illes (2001). We find the following one the most fitting, "A context is a psychological construct, a subset of the hearer's assumptions of the world. It is these assumptions, of course, rather than the actual state of the world, that affect the interpretation of an utterance. A context in this sense is not limited to information about the immediately physical environment or the immediately preceding utterances: expectations about the future, scientific hypotheses or religious beliefs, anecdotal memories, general cultural assumptions, beliefs about the mental state of the speaker, may all play a role in interpretation." from Sperber and Wilson (1986). We will add that imaginary worlds should also be included. We claim that another important aspect of context is that each speaker shares some part of it with listeners, and some part of the context is private only to the speaker.

Many definitions of context include only elements of the world relevant to the speaker, as in Widdowson (1996), "Those aspects of the circumstances of actual language use which are taken as relevant to meaning.". We believe that this approach is wrong for a very simple reason. Consider the following command from a coach to a player, "Take the ball." Obviously, only one ball is relevant to the coach. But that command will be viewed differently if there are several balls or just one nearby. We claim that all the objects should be taken into consideration when talking about context. In this paper, we will not analyze the concept of relevance for the sake of brevity. Also, it is not relevant to the main topic of this paper. Readers interested in the subject are advised to read Sperber and Wilson (1986).

There is one more aspect related to the private part of the speaker's context and relevance. Suppose, the private context contains actions from the past the speaker is not proud of. The speaker may decide to "rewrite history" and create a "good image" of himself/herself in the eyes of listeners. The new history then will be a part of the context. This is related to Grice's principle of cooperation, Grice (1989). But we argue that not all speakers are cooperative. Consider a detective interrogating a criminal. We can hardly expect cooperation from both parties. The Grice's maxims of communication should be considered as points in a multi-dimensional space of communication but we should consider all the points from the cooperation-competition spectrum. This also takes into account the views of Dennett (1997).

Context-dependency is considered an issue in the analysis of natural languages. We believe that context helps to resolve ambiguity. One of the forms of ambiguity is polysemy, which we will address next. According to Rodd et al. (2002), 80% of common English words have more than one meaning. This creates a problem for theories of reference that consider the principle of compositionality, see Szabó (2022), as their fundamental component. It says that the meaning of a complex phrase is composed of the meanings of its pieces. This principle is controversial. On the one hand, the meaning of a phrase creates a context to choose the meanings of words in the phrase, on the other hand, the meaning of the phrase depends on the meanings of its words. In our theory, context is tightly related to coherence constraints which are used to handle ambiguity and resolve meanings of words and complex phrases.

The topic of reference is discussed by many authors. Some of them are mentioned in Michaelson and Reimer (2022), "we have introduced four distinct models for the metasemantics of referential terms:

1. On the descriptivist model, words refer in virtue of being associated with a specific descriptive content that serves to identify a particular object or individual as the referent.

2. On the causal model, words refer in virtue of being associated with chains of use leading back to an initiating use or 'baptism' of the referent.

3. On the character model, words refer in virtue of being associated with regular rules of reference. Paradigm rules of this sort will themselves allude to repeatable elements of the context, identifying which of these elements is the referent for which sort of term.

4. On the intentionalist model, words refer in virtue of being used, intentionally, to refer to particular objects. In other words, words refer in virtue of their being uttered as part of complex intentional acts which somehow target particular objects or individuals."

We claim that these and other theories are correct in some of their claims but fail in describing the complete mechanism behind references.

Some authors of theories of reference intuitively recognized the difference between ordinary descriptors and proper names, see Kripke (1972), but in our opinion, they failed to explain the difference explicitly. The difference implies that there are different mechanisms for referring to objects. There are other issues with references. On the one hand, references in natural languages may refer to real objects, on the other hand, the same reference in a different context may refer to a different object. The mechanisms behind that observation have not been explained. We will propose hypotheses about those mechanisms.

Theories of reference claim that words either refer to objects directly, as names in Kaplan (1990), or to concepts from our mental representations Fodor and Pylyshyn (2015). But in the latter case, it is unclear how we resolve references to real objects, besides, the structure of mental representations has never been explained. Direct references are also unacceptable due to the obvious context-dependency of references. We show in our theory how to use context to treat ambiguity and references.

Concepts are involved in the discussions about generalization as in Bekaert et al. (2002). We know that natural languages demonstrate generalization but traditional theories cannot explain how they achieve that. Our theory provides a hypothesis about that. This will also clarify how concepts are generated. About that, we disagree with Fodor (1998).

Fodor and Pylyshyn (1988) and other authors add another flavor to generalization when discussing a compositional generalization, which stands for the human ability to utter and understand an infinite number of phrases using a finite number of words, or as Chomsky (1965) puts it, "infinite use of finite means".

Objects and concepts are related to symbols or signs. They are studied by semiotics, see Sebeok (1994), which is interested in the nature of meaning. The same is studied by semantics and pragmatics. One of the issues with symbols is the grounding problem, introduced in Harnad (1990), or how they get their meaning. On the one hand, symbols are meaningless, on the other hand, they may have multiple meanings. Natural language speakers have no problems encoding and decoding specific meanings using such vague tools. The question of how they achieve that remains open. We introduce the referential flexibility of symbols and explain different ways in which symbols may be used in language.

One of the approaches to meaning is through the truth conditions, Frege (1892), for expressions and propositions. There are multiple issues with that approach. One of them is related to the treatment of interrogative and imperative sentences. The concept of truth conditions cannot be applied to them. We claim that sentences of those types also have meaning and it is decoded by natural language speakers without any usage of truth conditions or the first-order predicate logic. We provide equal treatment for all types of sentences in our theory.

Another problem with truth conditions is related to the vagueness of natural languages discussed in Sorensen (2022). In its presence and taking into account the inevitable measurement and precision errors, it is hard to expect any sentence to be true. The best available option is for them to be "good enough", which is far from the truth respected by logicians. In our theory, we propose to prioritize vagueness over truth.

There are also unresolved issues related to the referring versus descriptive nature of expressions. The main principle used in their analysis is the principle of compositionality mentioned above. We refute that principle and propose an alternative approach and its implementation. We then continue with this topic in the discussion of multiple messages delivered in a single sentence, as discussed in pragmatics Potts (2022).

Currently researched large language models, see Tamkin et al. (2021), require big amounts of data and compute resources for training. Despite good results in some areas they are still limited and make mistakes. Many of their errors may be attributed to the so-called long-tail problem, Anderson (2008). The proposed approach handles that problem by considering properties in isolation, which enables transfer learning, Zhuang et al. (2019).

We believe that all those issues are handled with a limited toolbox, which we describe in this paper. The application of this toolbox is directed at taming ambiguity by respecting context through all the stages of analysis - syntactic, semantic, and pragmatic. In the process of describing the toolbox, we cover what we believe may constitute the universals of language. The mentioned toolbox requires more research and deserves to be added to the computational linguistics agenda.

3. Theory of Intelligence

Witkowski et al. (2023) use the phrase "different spaces and with different competencies" in their definition of intelligence. We claim that this and many other definitions of intelligence are wrong placing emphasis on "spaces, competencies, and tasks". We believe that the research focus should be shifted to "different and differences".

We are not alone in our focus on differentiation. Bateson (1972) is almost poetic about difference starting with, "But what is a difference? A difference is a very peculiar and obscure concept. It is certainly not a thing or an event."

If we think about how we differentiate objects, we do it using static values of properties. When we compare actions, we compare dynamic changes in properties. Note that words like "tall", "average", and "short", used to evaluate height, refer not to points but rather to ranges.

We will reflect the above observations in the following assumptions:

1. Intelligence is based on differentiation.

2. Differentiation is based on comparable properties.

3. Properties have ranges.

4. Everything can be viewed as an object.

Examples (the list is not exhaustive):

- physical objects (animate, inanimate; already non-existing, existing, not yet existing; real, hypothetical, imaginary; individual, sets);
- abstract objects (idea, love, square root, etc.);
- scenes;
- states;
- events, actions;
- properties.

5. Objects have multiple properties.

6. Objects are compared by one property at a time.

7. Actions may change multiple properties.

8. Actions are compared by how they change one property.

Also, we consider the following concepts and constructs:

1. Available candidates - all the objects currently within reach.

2. Context - set of available objects.

3. Comparable properties - any comparable attribute of any object. We will treat object categories as multi-dimensional properties.

Also, we state the following propositions:

1. All manifestations of intelligence can be represented with the help of differentiation. Consider differences between states expressed in terms of properties and consider what actions may cause such changes.

2. Intelligence operates only with available candidates.

3. Knowledge is represented in the form of sentences with constituents resolved to objects from the context. This will be explained later.

4. The single algorithm of intelligence is based on a multi-dimensional search, where comparable properties are viewed as dimensions.

5. Search is guided by a question, which defines the category of the object fitting for the answer and imposes restrictions (this is similar to coherence constraints, which will be discussed later) that must be respected.

6. Search is performed among knowledge representations stored in memory.

Thus, our theory proposes a multi-dimensional search based on comparisons and differentiation as a computational paradigm of cognition.

This is only a basic theory to support our further discussion about the theory of language. For a solid theory of intelligence, further research is required.

3.1. Vagueness

Discussion of differentiation and comparisons should also address the issue of vagueness, analyzed in depth in Sorensen (2022). The author pays a lot of attention to borderline cases. We want to attract attention to the following quote, "Where there is no perceived need for a decision, criteria are left undeveloped." Language has a rich toolbox of modifiers and easily comes up with new terms if needed. We claim that unclarity caused by borderline cases is tolerable and does not justify the effort of introducing and tracking additional differentiation factors. Consider a reference to a "borderline color" between green and blue. Whatever label a speaker chooses, green or blue, it will be close to the actual color and definitely different from, say, red. The speaker's choice will reflect the peculiarities of his/her perception. We will return to this observation later.

3.2. What is generalization?

It may seem that generalization is based on similarities. We claim that generalization happens after specialization in the reverse direction. First, objects of the same class are differentiated into subclasses, afterwards, those subclasses can generalize to the parent class. Specialization introduces differentiating factors that split the parent class into subclasses. When we ignore those differentiating factors we generalize back to the parent class. Considering generalization through the prism of differentiation is more efficient computationally than using similarities as discussed in Bekaert et al. (2002).

Specialization may proceed along various properties of the parent class. That creates possibilities for different kinds of generalization. It amplifies the role of comparable properties.

We have mentioned that objects have multiple dimensions. Usually, textual reports mention only some properties affected by the reported events. Knowing the objects involved and their other properties, we may use our common-world knowledge to reconstruct how other properties could be affected. It may be a useful instrument to consider objects as multi-dimensional cubes. We may view objects as junctions of multiple dimensions, from which associations may arise. However useful are multi-dimensional cubes they will not work with the effects of actions on multiple properties of different objects (one illustrative example of such effects may be an explosion). But the allegory of junctions may still be useful in producing associations based on actions.

Another topic is compositional generalization, which stands behind the ability of language to form infinitely many phrases using a limited number of words. We explain this by the need to address the infinitely wide variety of objects in a wide variety of contexts with understandably limited resources of memory and computing of our brain given real-time constraints. We apply a limited number of properties as filters and because of their logarithmic complexity, they are efficient in "referring" to objects.

We will complete this discussion with the "out-of-distribution generalization". Note that we process properties separately from objects having them. Therefore, each property accumulates historical data of reactions to different actions. When we encounter a new object having some known property, we may apply the existing knowledge. If differences are observed compared to the expected reactions we will update our knowledge.

4. Theory of Language

Sebeok (1994) contemplates, "Language as a Primary Modelling System?" We claim that language is a tool created and used by intelligence. Language reflects how intelligence operates and models the world.

Another tool created to facilitate language is symbols. Cappelen and Dever (2021) state, "The sock is not about anything. ... The sentence 'The Eiffel Tower is in Paris', on the other hand, is about something — it exhibits what philosophers imaginatively call 'aboutness'." This quote, in our opinion, is good for two reasons - it introduces important topics and illustrates some misconceptions. The first sentence in that quote deserves special attention. We disagree and claim that anything can serve as a symbol, which initially has no meaning but can be assigned a meaning.

We may illustrate these claims with several examples. Who played chess with a set with missing pieces knows how easy it is to substitute missing pieces with any other objects - usually, compact and easy to handle. In the Ukrainian proposal ritual, a girl presents a boy with a pumpkin symbolizing "no" or an embroidered towel symbolizing "yes". A folded sock may be used as a ball. A sock on a door handle in a student dormitory may mean

"Do not disturb. Studying." Even quotation marks may carry additional meaning. Symbols do not have to be compact and easy to handle. Think about additional meanings of the Berlin Wall, Statue of Liberty, or White House.

Symbols do not carry meaning unless assigned one (or many). Usually, a group of people has to agree that a certain item carries a certain meaning. But some items may be assigned meaning by a single person and that meaning will remain private to that person. One example of such private symbols is represented by amulets. For example, one may have a lucky sock. Note that the same item may be reassigned with different meanings multiple times. Each assignment requires the convention to be shared by the people involved. Such conventions are not free of charge, they involve costs. The bigger the group the bigger the costs. The smaller the group the easier it is to assign new meanings to existing words and introduce new words. These views may be found in De Saussure (1966).

Words are special symbols in language. But meaning can be communicated using different kinds of symbols and codes, for example, nods or flowers. Language may be considered one example of a meaning-encoding system.

The following assumptions reflect what we discussed above:

1. Any objects can serve as symbols.
2. Symbols are meaningless but can be assigned meaning.
3. Meaning assignments can be private or public.
4. Speakers can be anywhere in the cooperation/competition spectrum.
5. All the context is taken into account but only relevant objects are reported.

Consider also the following constructs:

1. Referential flexibility - the ability of symbols to easily acquire meanings.
2. Coherence constraints - constraints imposed on each word or phrase in a sentence by all the other words and phrases in order to make the whole sentence coherent.
3. Filtering operation - operation applied to the context (set of available candidates) taking a range of some property as an argument and leaving only those objects in the set that have that property with a value within that range.

Adjectives and nouns may refer to ranges of multiple properties (one range per property). Verbs may refer to multiple actions, each action may change multiple properties. Actions also have expectations for subject and direct/indirect object roles, which are stated in terms of properties/categories. Modifiers fine-tune the position within a range or the amplitude of a change respectively.

The following list of propositions is not exhaustive:

1. Public convention about meaning comes at a cost and is inertial.
2. Words refer to ranges of properties.
3. Noun phrases differentiate objects from the context as stacked filters or sieves.
4. Ranges of properties refer to concepts (ranges of categories).
5. Names refer to sets of objects.
6. Referential flexibility leads to polysemy.
7. Coherence constraints work on many levels and filter out incoherent interpretations.
8. Context-dependency handles ambiguity.
9. Decoding process involves many levels of analysis with different contexts.

Below we provide several examples of how all of the above may be applied in practice.

4.1. What are synonyms/antonyms?

The system of ranges starts with the following three: "below average", "average", "above average". Note the use of "average" range as a reference point.

The word "high" may refer to the "above average" range of properties "height", "pitch", and "blood sugar level", to name a few. We use the first one when we say "high tree", the second one in "high voice", and the third one in "high sugar".

In the first meaning from the above example, "high" is synonymous with "tall", in the second - with "feminine", and in the third - with "dangerous". Note that the words "feminine" and "dangerous" are not synonyms because they do not refer to the same range of the same property.

Now recall the use of the "average" range as a reference point. Antonyms refer to ranges of the same property symmetric with respect to that reference point. This is especially clear when we consider fine-tuned ranges like "warm" vs "cold", "hot" vs "freezing". Note that the same ideas are easily applied to verbs and modifiers.

Not all properties have the "average" range. For example, the "name" property does not have it. We may have synonym names, but not antonym names unless we use antonym words as names. Referential flexibility allows for that.

4.2. What are references?

The process of referring to an object is always related to the current context. When we refer to an object, we do not compose its description, we do not use some kind of "direct reference". Instead, we provide a sequence of filters to differentiate the object from the context. There can be different filters and we choose from them arbitrarily. If we are cooperative we try to provide the most efficient differentiating factors. When we are uncooperative we may provide inefficient or misleading differentiating factors.

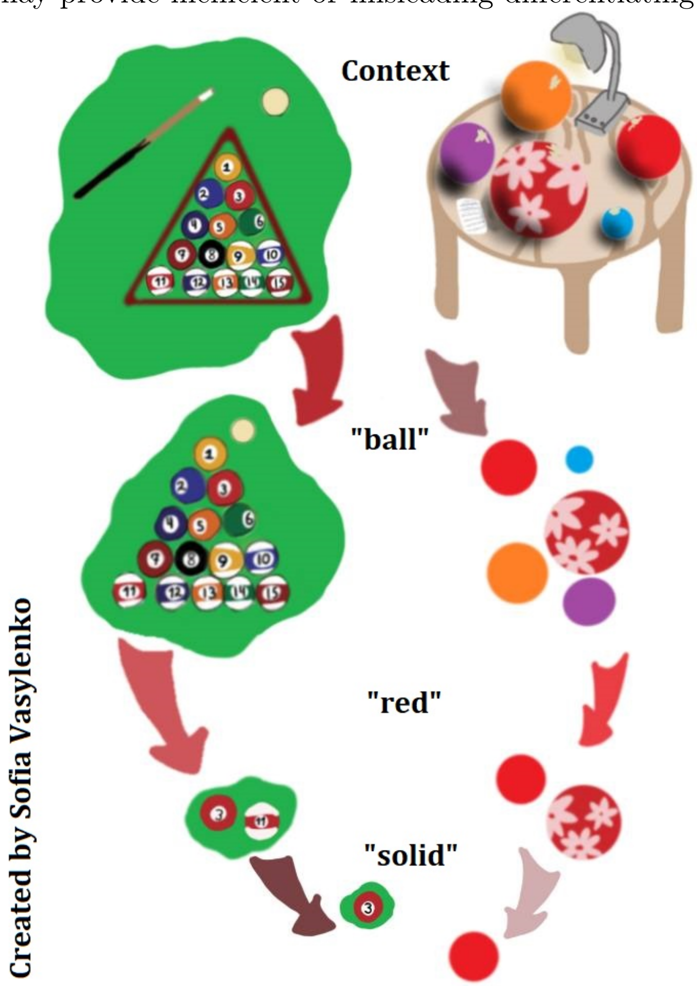

Figure 1. Differentiation of objects from contexts.

For example, consider Figure 1. We have two different contexts. The first filter uses the "category" property and its range "ball" and we consider further only balls. The second filter uses the "color" property and its "red" range and we are left with only red balls. Finally, we use the "ornament" (for lack of a better word) category and its range "solid" and we are down to a single object. If not, we could stack filters as long as needed. Sometimes, accuracy is not required - our interlocutor is intelligent and will engage in the process of trying to figure out what we are referring to. If still ambiguous, the interlocutor may ask clarifying questions or wait for additional clues.

Adjectives and nouns refer to ranges of properties. It is worth mentioning that ranges, in turn, refer to concepts (ranges). Consider size "small" - we know animals of that size, for example. When we apply the "small animal" filter, we consider the whole range of matching categories and respective objects in the context.

It is different with names. Names refer to particular objects. Because of referential flexibility, we may say that names refer to sets of objects. The filtering operation proceeds in essentially the same way. Note that for differentiation purposes, in a big group the first name may not be enough, and in a family the family name is useless.

To differentiate an object from a context, we have two options - to indicate properties the object has or to indicate properties the object does not have. The second option explains the role of negation - it eliminates options. When we consider differentiation as a set operation, the positive descriptor leads to a set intersection, while negation is an intersection with a set complement.

Such a flexible mechanism of differentiation of objects from context should exist in each language. It is another universal. Negation is also universal due to its role in differentiation.

If we recall our discussion of vagueness, when we refer we essentially make estimates of properties. If any vagueness is involved, our "references" will reflect how we approach that vagueness. How we word our references often reflects our internal views, beliefs, attitudes, etc.

4.3. What is meaning?

There are different kinds of meaning. For example, when we return home from an unfamiliar part of town and see a familiar building that building means that "we are home". Linguistics is interested in a different kind of meaning.

Austin (1962) introduced the concept of speech acts. Indeed, with utterances, we request or report information or request actions. We claim that meaning involves more, even if we are talking about literal meaning. We differentiate out of utterances the involved objects, their properties, and changes of those properties. Utterances may trigger inference processes and as a result, we may figure out more information. Utterances may use figurative speech, which may require additional inferences. Yet other differences are involved when we use code words or foreign language insertions in our speech. When non-native speakers make mistakes, their intentions can still be understood. Meaning is so much more than truth conditions.

4.4. Knowledge representation formulas

In terms of syntax, static sentences may be described by the SVC formula. Sentences describing dynamic actions follow the SVO formula. We claim that every language should have structures to encode those formulas. They belong among language universals. In our theory, we claim that these formulas may be differentiated only in the semantic or even pragmatic (discourse-involving) stage of sentence analysis. The reason for this is the need to perform reference resolution, or object differentiation in our theory. The following examples will help to understand why this is so. Consider the following sentences:

1. These days are pure joy.
2. These days will bring new experiences.
3. These days eat apples.

Syntactically, all these sentences follow the form "NP verb NP". But all three have different illocutionary forces. The first one may be resolved to SVC because of the linking verb and coherence of the object "days" and the property "experience" and its range "joy". The second sentence resolves to the SVO formula because of the transitive verb and coherence of the expected subject and object for the action "bring". But the SVO formula will not work in the third sentence because "days" cannot be associated or generalized to "eater". However, syntactically, there is another possibility for that sentence - imperative. In that case, a subject is not required, "these days" may be interpreted as the "adverbial of time" and the sentence looks coherent when resolved as the AVO formula.

Before storing sentences in memory, we need to resolve references to objects in the context. For each object there we record information about their properties and their participation in different sentences in different roles. This may help with anaphora resolution.

4.5. Meta-information

We store sentences in the proposed form to be able later to query them for various kinds of information. In order to be compact, most sentences in a discourse, which we will discuss later, do not repeat indications of where and when the described events occur. We propose to keep track of such information with the help of meta-information tags. Time and place adverbials are only some of the possible tags to keep. Others may include speaker, listener, source, reliability, etc.

One example of where such meta-information may be useful is in the resolution of vocatives. Consider the following sentences:

1. My dear diary John is my love.
2. My dear diary John is my journal.

Both sentences follow the SVC formula, the only problem is to determine which of the first two noun phrases is a vocative and which is a subject. The subject should be coherent with the property described by the complement. Note that we again require taking into account both the syntactic and semantic roles of constituents. The above examples contained all the necessary information to differentiate the vocative from the subject. In the cases when this is impossible, a meta-information tag for a listener would be helpful.

4.6. Anaphora resolution

Consider the following example of anaphora resolution and available candidates: "Stiven saw a car. It was red. It was yesterday. It was raining." We are interested in understanding each "it". All the available candidates are provided in the first sentence, some of them implicitly. Overall, there are four "objects" mentioned - Stiven, car, day (implicitly), the event of seeing (indirectly). The property "color" is only available for "car". The "time" property is only available for "event". The "weather" property is available for "day". This example also demonstrates coherence constraints in action.

Related to anaphora is cataphora. It is when a "relative reference" is used before anything was said about an "object". For example, "Because he was in a hurry, John took a taxi". We claim that "he" provides a lot of information to include an object into our container - "person", "male". Later we add the "name" property to the entry. But the use of coherence constraints remains - "being in a hurry" is coherent with "taking a taxi".

Levesque (2012) proposed to prepare pairs of sentences with small differences that affect the resolution of an ambiguity contained in them. Consider the following two sentences from that dataset:

Joan made sure to thank Susan for all the help she received.

Joan made sure to thank Susan for all the help she had given.

How should "she" be resolved in each case? Is it Joan or Susan? In our theory, we propose to keep track of expected direct/indirect objects for each action. In this case, "thank smb for smth" expects something good, to which "help" generalizes well. If she received help, she should be the subject of "thank", otherwise, she should be the direct object. Such "rules" will be stored in a system in the form of resolved sentences.

4.7. Ambiguity resolution

Sometimes, information from the sentence is not sufficient for disambiguation of grammatical structures and therefore constituents. Consider the example "Visiting relatives can be annoying". Is it "visiting whom" or "visiting who"? Imagine now that the following sentence is mentioned in the context, "I don't like the climate there." The "visit" action may change, among others, the property "exposure to climate". Note the use of anaphoric "there" and that "don't like" resolves to the same range of the "attitude" property as "annoying". All these considerations support the version that I visited my relatives.

As an alternative, consider the following hint instead, "I don't like when my house gets crowded." In this case, we consider "visit" as changing the property "number of people in my house". "gets crowded" means the increase in that number. Therefore, this hint supports the version that relatives visited me.

4.8. Secondary meaning

Potts (2022) mentions the following, "We often 'mean more than we say'. What principles guide this pragmatic enrichment, and how do semantic values (conventional aspects of meaning) enable and constrain such enrichment?" In its simplest form, this can be achieved with references.

Consider the primary message we want to deliver, "Peter passed the procedure." If we want to additionally deliver "That procedure was difficult." we may say "Peter passed that difficult procedure." If the additional message is "He barely succeeded." we may say "Peter barely passed the procedure." Note that language has a flexible system of modifiers for noun and verb phrases. Modifiers have to be present in all languages because they make language efficient.

4.9. Code words

Consider the following situation. A mother tells her husband in private "When you are back, mention a butterfly in a positive or negative sentence and I will understand whether you bought a present for our daughter's birthday." The father comes home in the evening and says "I saw a big and beautiful butterfly today." The daughter reacts with "I also saw a butterfly today." How will the mother understand those two almost identical utterances? This example illustrates the power of words' referential flexibility and the importance of meta-information and conventions. This example may illustrate one more opportunity. Consider the father saying "I haven't seen a single butterfly today" and the mother asked him "Have you been in the park?" We claim that the father will correctly understand "park" as a "shop" without additional agreement about "park". The convention about "butterfly" will suffice. The "park" will be resolved using inferences, "What is to present as the park is to butterflies?" Such situations are decoded differently from the general mechanism, which will be discussed shortly. As with any complex activity, it should be governed by stored formulas tied to specific code words. We will not discuss the details in this paper.

4.10. Basic mathematics

We propose to store all objects (available candidates) in a set C (for context). Any filtering operation applied to the set may change its size, which will correspond to the number of objects in the context satisfying the filtering condition.

Objects have multiple properties. All properties are comparable. Some of them may even support a sorting operation. This will ensure some order in the set with indexes of elements being ordinal numbers for respective objects.

We may consider subsets of our context set and operations with them. Note that we should not blindly add sizes of subsets as subsets may overlap. Instead we should apply filtering operations that created each subset to the whole set - this will produce the correct result. Mathematical operations of higher complexity may be expressed in terms of lower-complexity operations. For example, multiplication can be represented using addition. Mathematical rules may be easy to express in the form of resolved sentences as proposed above.

4.11. Formalism

Now we may provide a tentative formal description of the theory. We will avoid strict separation of syntax and semantics because above we have demonstrated that in some cases they are coupled too tightly.

As an input, we consider an utterance U, which describes some elements from a context Cx, the sentence is produced by a narrator N and is addressed to a listener L. The utterance U is composed of words w. For now, we will consider the set W of w to include adjectives, nouns, verbs, and modifiers. The treatment of other parts of speech will be added in future papers. Words w may refer to properties p from the set P. Each property contains ranges r. Also, we should consider objects O from the context Cx, syntactic constituent roles S, V, C, O_d, O_i, A, and semantic roles. As the output, we expect to produce a sentence M with resolved syntactic formula with resolved semantic roles of each constituent and filled meta-information tags.

We need to also introduce a filtering operator F. As arguments, it will accept the context set Cx of objects O (available candidates) and coherence constraints (property/range pairs to be matched). As output, it will produce the set of matched objects (it can contain 0, 1, or many objects). This operator works with all kinds of objects and properties.

For example, consider a football match and its commentator. The commentator utters, "The guest team younger forward kicked the ball". A radio listener needs to decode the meaning of the utterance. With this example, we will demonstrate how the above parameters may help with linguistic analysis.

We will start by defining the stages of the process and the contexts involved:

1. The narrator's view includes the stadium, players, spectators, seats, referees, ball, cameras, ad boards, etc. There are also dynamic actions, both on the field and outside. The narrator picks some elements (static or dynamic) and reports them. The guiding question: "What is of interest at this moment?" In this paper, we do not address how to make decisions or set goals, treat priorities or build plans. We skip the detailed analysis of this stage.

2. To "refer to" the picked objects (to differentiate them out of the context), the narrator evaluates the properties of all the objects and picks those that will differentiate the chosen objects faster. At this stage, differentiation is done among properties. The guiding question: "How to differentiate the selected elements?" The set of objects will include properties from P. The

coherence constraints will include properties of objects O and those of the chosen elements.

3. The narrator stacks "the compositional reference" (the set of differentiating factors) by selecting words that refer to proper ranges of the selected properties. The differentiation occurs among words. The guiding question: "What are the proper words?" The set of objects will include words from W. The coherence constraints will include differentiating properties and ranges.

4. The narrator combines references together to form a sentence. Whether it will be SVC or SVO formula depends on the elements chosen in p.1. The differentiation occurs among sentence forms. The guiding question: "What is the proper grammatical construct?" The set of objects will include grammatical constructs. The coherence constraints will include available information about the chosen elements. (Consider, for example, differentiation between active and passive voice - do we know who performed the action? is the subject or direct object in our focus?)

5. Now, the listener hears words. Each word may represent different parts of speech. The listener has phrase templates expecting various parts of speech at different positions. All possible combinations are matched. In the end, incomplete phrases are discarded, rule violating combinations are discarded. The rule is simple: each word may be used no more and no less than once. If there are several possible interpretations, keep them all - they are available candidates for the next stage. We differentiate among possible valid phrases given the words. The guiding question: "What phrases can be built from those words?" The set of objects will include phrase templates. The coherence constraints will include parts of speech of available words and their order (if a particular language is word-order sensitive). We will provide more details in the syntax section.

6. Each NP is resolved semantically. At this stage, parts of speech for each word are fixed (within each interpretation). Each phrase refers to a single object (groups are also considered objects) having multiple properties. Each word in the phrase may refer to multiple properties from P. Each range in turn refers to several possible properties. Set intersections will help to figure out the coherent set of properties referred to by each word in the phrase. We differentiate the properties referred to by each word. The guiding question: "What does each word mean?" (To which property does it refer?) The set of objects will include properties from P. The coherence constraints will include sets of references to P of each word.

7. The resolved properties are applied to the objects in C from p.1 giving

the listener the semantic roles of differentiated objects. This allows differentiating the action referred to by the verb and the sentence formula and the sentence meaning. The guiding question: "What are the objects differentiated by each phrase?" The set of objects will include objects O. The coherence constraints will include resolved differentiating factors. We will provide more details in the semantics section.

8. We consider the verb phrase and resolve to what action it refers, based on the differentiated objects and their categories. The guiding question: "What action does the verb phrase refer to?" The set of objects will include actions the main verb may refer to. The coherence constraints will include the resolved objects categories.

9. We determine the formula for the sentence. The guiding question: "What is the sentence formula?" The set of objects will include possible formulas of the sentence. It will finalize the constituent roles of each phrase. The coherence constraints will include the verb phrase's syntactic and semantic properties.

10. Now we can answer the question, "What does the sentence mean?" (What static or dynamic aspect of the scene did the narrator describe?"). It is time for pragmatics to kick in with the guiding question, "So what?" We will cover inferences in an upcoming paper. Now, the listener's context is updated and it is time to switch their roles (if it is a dialogue) or process another sentence (if in the listener mode only). Back to stage 1.

Note the guiding role of questions and coherence constraints at each stage. Context and available candidates are also different at each stage.

4.12. Language universals

In our theory, we believe that any grammar should contain the following differentiating instruments:

a) static vs dynamic phenomena descriptions (SVC vs SVO);

b) objects descriptions (noun phrases);

c) negation;

d) modifiers for fine-tuning the above;

e) time periods and durations (verb forms, tenses, aspects);

f) source of action (active vs passive voice)...

This list is not exhaustive. The reasons for including these tools in the language universals follow from the differentiating nature of language and intelligence.

5. Discussion

The proposed theory implies a shift of focus in several areas of research. Namely, we propose focusing more on comparable properties than on objects and actions. Differentiation deserves more attention than similarities. A multi-dimensional search, based on filtering, comparisons, and differentiation, may prove more efficient than statistical methods or logical operations. We call to consider differentiating objects from the context instead of referring to them. We propose to respect the context and polysemy more as aspects making natural languages efficient and interesting.

The support of theory may be found in the following quote from Bateson (1972), "the world of form and communication invokes no things, forces, or impacts but only differences and ideas. (A difference which makes a difference is an idea. It is a "bit," a unit of information.)". The computational paradigm proposed in this paper is different from currently used statistical machine learning approaches. Together with the described mechanism of generalization and associations, it may constitute foundational components of the paradigm shift called for by Zhu et al. (2020).

In order to test the proposed theory, a new kind of dictionary based on properties and ranges has to be developed. We believe that the best test for this theory is to prepare and train a bot on general knowledge and use it to pass the Turing test. The same bot may be used as the core functionality in the text and voice (with a little additional work) chatbots - let the natural language speakers decide how good the proposed theory is.

We do not address extensively the inference mechanisms and the generation of new knowledge. The research in those areas will bring more discoveries.

6. Conclusions

This theory may be of interest to students and professionals in various areas of natural language processing - from semiotics and theory of reference to syntax, semantics, and pragmatics. Researchers in those areas will find new tools for advancing their respective directions of research.

We believe that the large language models based on the transformer architecture may be combined with the software based on this theory because in some areas LLMs will show better performance, namely, the transfer of styles, statistical relationships, etc. Combining the strongest aspects of both approaches will lead to much better performance of language processing software.

On the other hand, LLMs are approaching the limits in terms of value over cost. The software based on this theory may be compact and communicate more naturally.

Overall, the theory provides relatively simple explanations for numerous practices in the usage of natural languages. It adds new tools to the toolboxes of computational linguistics and philosophy of language. The theory proposes new points of view on various linguistic tasks. The explanatory potential of the theory may help to advance the study and understanding of language. The timeliness of this theory may be attributed to the growing concerns about the explainability of AI, which this theory may help to satisfy. It proposes several unique and original ideas that may prove useful for other researchers in their areas. The theory proposes a relatively limited set of new ideas, which makes it easy to apply. The new dictionary has to be prepared once and may be shared among all researchers, the knowledge base prepared in one language may be immediately available to users of other languages as soon as the dictionary and syntactic work will be completed for those languages. The usefulness of the theory may be contemplated in its theoretical novelty, its potential in addressing the standing issues in linguistics, and providing value to end-users of various applications using natural language processing. As soon as the basic preparations are done, the theory will be easy to test in various ways by both linguistic experts and ordinary speakers of the language.

Implications of this theory may include theoretical progress in the study of language and a new approach to the development of text-processing software.

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