It's time for a complete theory of partial predictability in language

Louise McNally
U. Pompeu Fabra

Olivier Bonami
U. Paris Cité

Denis Paperno
Utrecht U.

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1 Introduction

The meaning of linguistic expressions typically falls somewhere between being fully predictable and fully arbitrary. This is most evident when looking at the lexicon. Consider a word such as *descender*. Knowledge of English morphology allows one to infer easily that this word is likely to name an individual or artefact moving downwards. This will push an interpreter towards the right meaning, but falls short of predicting some of the readings documented in the *Oxford English Dictionary*,[1] such as "a part of a letterform or character that extends below the baseline of the text", or "any of various devices around which the rope is wrapped in abseiling, enabling a controlled descent to be made".

This situation is evidently common, and is the reason why dictionaries document the meanings of thousands of morphologically complex words rather than just roots and affixes, as a Bloomfieldian lexicon would (Bloomfield, 1933). It is also well established that partial predictability does not stop at the word level, but rather extends to larger expressions, including idioms, complex predicates, and constructions (Di Sciullo and Williams, 1987; Fillmore et al., 1988; Jackendoff, 1998).

Given the centrality of partial predictability to linguistic experience, it is striking that it plays such a minor role in theoretical linguistics. For many, partial predictability is a phenomenon to be set aside: the job of linguistic theory is to explain the uniquely infinite generative capacity of language and the semantic compositionality that goes hand in hand with it. For others, partial predictability is shining evidence that theories of language focused on full productivity and compositionality are missing the point (see e.g. Booij and Masini 2015; Goldberg 2019; Langacker 2019; Jackendoff and Audring 2020). But surprisingly little attention has been devoted to understanding how partial predictability of meaning actually works, research being mostly focused on simple binary decisions as to what needs to be listed in the lexicon.

In this piece, we argue that it is time for linguistic theory to recognize partial predictability as a central design feature of human language, and we propose a strategy for

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[1]Consulted online January 31, 2023.

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doing so based on the probabilistic interaction of linguistic knowledge, world knowledge, and context. We focus on partial predictability in derivational morphology, although much of what we say applies beyond, and what we have to say is orthogonal to debates about the autonomy of morphology (see e.g. Anderson 1992; Halle and Marantz 1993; Aronoff 1994; Bruening 2018) or the sustainability of a divide between inflection and derivation (see e.g. Perlmutter 1988; Dressler 1989; Anderson 1992; Booij 1996; Spencer 2013; Bonami and Paperno 2018; Haspelmath 2024).

In section 2 we argue that insights from theoretical morphology largely ignored by semanticists are crucial to progress. In section 3 we point to a path forward that starts by placing new focus on what we call scenario knowledge and linking it in a new way to the lexicon; we then highlight some ways in which recent developments in predictive language modeling can help to address some of the challenges posed by working with scenario knowledge. Finally, in section 4 we briefly highlight some of the new opportunities both within linguistic theory and beyond that could be opened up by moving partial predictability from the periphery to the core of linguistic theory.

2   Missed insights

Most work on meaning in the context of word formation starts implicitly or explicitly from assumed parallels between morphology and syntax. As a result, assumptions about how the predictability of meaning should be approached tend to be inherited from work on compositional semantics in the context of syntactic constructions.

2.1   The paradigmatic lexicon

One such assumption holds that speakers determine the meaning of a complex expression by compositional combination of the meaning of constitutive subexpressions. Strikingly, this assumption is prevalent both in broadly generativist and cognitivist approaches to the problem (see e.g. Goldberg 2019; Langacker 2019). It is ultimately grounded in an Item and Arrangement (Hockett, 1954) view of the organization of both syntax and morphology, and leaves aside decades of research on the paradigmatic organization of morphological systems (see Blevins 2016 for a recent overview).

A view of morphology as a system of relations between fully formed words predates Bloomfield (Kruszewski, 1883; Saussure, 1916), has continued to have supporters (Robins, 1959; Matthews, 1972; Jackendoff, 1975; van Marle, 1984; Bochner, 1993; Bybee, 2001; Hay and Baayen, 2005) and has thrived in recent decades (Booij, 2010; Booij and Masini, 2015; Jackendoff and Audring, 2020). Although paradigms are most readily invoked when reasoning about inflection, recent years have witnessed a surge of interest for the idea that the derived lexicon itself is structured by a rich system of paradigmatic relations (Bauer, 1997, 2019; Pounder, 2000; Blevins, 2001; Štekauer, 2014; Boyé and Schalchli, 2016; Bonami and Strnadová, 2019; Hathout and Namer, 2022). These come in at least three varieties, illustrated graphically in Figure 1. Word families, represented horizontally and highlighted by solid black edges, group words sharing a root and naming related concepts. Word series, represented by gray boxes, group words that share nonroot phonological material and name concepts associated
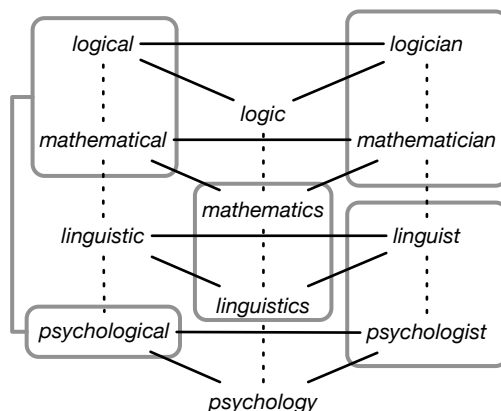
Figure 1: A small portion of the English paradigmatic lexicon, with three kinds of paradigmatic relations highlighted: inclusion in a word family (horizontal planes materialized by solid black edges) or a word series (gray boxes), paradigmatic alignments (dashed vertical edges).

with the same sets of broad ontological types (e.g. nouns in *-ist* name humans). Finally, words are paradigmatically aligned (Bonami and Strnadová, 2019) if they play parallel roles in their respective families; this is materialized by dashed vertical edges. Importantly, paradigmatic alignment is based on content, not form (Štekauer, 2014). Hence different contrasts in form may encode the same semantic relations between words in different families: Semantically, *linguist* is to *linguistics* as *logician* is to *logic*, although neither the affixes nor even the direction of derivation is shared across the two families.

A paradigmatic view of the word formation system leads to different expectations about the predictability of meaning, which may rely on other words that a given word relates to within the paradigmatic lexicon. The literature cited above provides many types of examples where this is relevant. To take one example, although the meaning of the recently coined *cissexist* ("exhibiting prejudice against transgender people") is far from obvious from its component parts, it is easily predicted from knowledge of the meaning of *cissexism* ("prejudice against transgender people"), despite the absence of a direct derivational relationship between the two. See Bonami and Guzmán Naranjo (2023) for quantitative evidence that this high predictability between *-ism* and *-ist* derivatives is systemic.

2.2 Onomasiology constrains semasiology

A side effect of the focus on combinatorics is that it deemphasizes an obvious but profound property of novel word formation. Derivational affixes are heavily polyfunctional (see Salvadori and Huyghe 2022 for a recent appraisal) and have highly underspecified meanings (Lieber, 2004, 2016). On the other hand, derived words tend to have a collection of fairly specific conventionalized meanings, as witnessed e.g. by the

example of *descender* above. Why is that so?

Reasoning about the communicative situation helps make sense of this fact. Coining a novel derived word is one of the means a speaker may deploy to name a novel concept (Štekauer, 2005).[2] In that endeavor they are constrained by the limited resources of the extant lexicon: They will pick a form that is *compatible* with conveying that meaning, rather than a form that must convey that meaning exactly. To make sense of what is said, the listener then can't be content with assigning a highly underspecified meaning to the word: they need to identify the correct specific concept that was intended. One way of conceptualizing this is to see the task of the listener as one of estimating a probability distribution of possible meanings for the word, conditional on assumed shared knowledge of the lexicon and the world, as well as contextual cues. The use of probabilistic approaches to both semantics and pragmatics has increased considerably in the last decade (see Erk 2022 for a recent overview); adapting them to novel word formation is a natural next step. The specific challenges posed by modeling the meaning of complex words are likely to bring to the fore the interest of probabilistic approaches, as well to suggest new directions in which to develop and integrate them.

3   A way forward

A fuller understanding of partial predictability in language requires looking beyond morpheme combinatorics to other areas where patterns are evident. The obvious place to look is word families: Words sharing a root tend to convey related meanings, so that knowledge of the meaning of one word helps make sense of the meaning of a related word. This kind of partial predictability drives a considerable amount of neology, and is also the basis for many examples of polysemy and idiom formation that lie beyond the boundaries of current theories of sense extension, which have focused mainly on specific, highly conventionalized types of metaphor (Lakoff and Johnson 1980, Bowdle and Gentner 2005), metonymy (Lapata and Lascarides 2003), or, to a lesser extent, autohyponymy (Horn 1984). Hearers can clearly predict a lot of meaning with a combination of enough signal related to the root together with morphological and contextual clues, and speakers exploit this in developing new forms for new concepts they want to express.

In this section we suggest that the way to gain greater insight into this kind of partial predictability requires a renewed focus on what we will refer to as *scenario knowledge*, embracing its complexity and detail, as well as a new means of connecting this knowledge to the linguistic signal. We then suggest how recent advances in predictive language modeling can help address some of the challenges involved.

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[2]Using morphology is not the only possibility of course: using an existing word in a novel sense, or creating a radically new word unrelated to the existing lexicon, e.g. via borrowing, are clear alternatives. Arguably the use of morphology strikes a balance between ease of memorization by reuse of preestablished conventions and minimization of ambiguity. Note that we also leave aside for present purposes situations where lexical innovation is not motivated by a lexical gap but by sociolinguistic and other factors.

3.1 Lean in to scenario knowledge

Sanford and Garrod (1998) define scenarios as "representations of specific situations, available in long-term memory" (p. 162). They contemplate two types of scenarios: those for "stereotypic and well-established large-scale activities, such as a courtroom trial", which include roles for various sorts of participants (lawyer, judge, defendant, etc.); and those for "more restricted events, such as driving or digging", (p. 164; the latter are similar to McRae and Matsuki's 2009 generalized event knowledge).

Drawing on this definition, we view scenarios as partial models of knowledge of varying granularity that group related entities and concepts. In addition to describing relatively stereotypical (if culturally variable) experience, such as the courtroom trial or driving, we posit that scenario knowledge can also involve very specific information about society or culture, such as that related to the COVID-19 pandemic, or even about individuals, such as Plato. Scenarios as we understand them are obviously related to some ways of concretizing Fillmore's (1982) notion of frame; however, frames are put to such broad and diverse uses as to make a proper comparison of the two notions impossible in a work of this length. For now, we limit ourselves to highlighting the potentially very fine granularity of scenarios, which has not to our knowledge been a feature of interest in research using frames, as well as the novelty of the way we propose to relate scenario knowledge to the lexicon.

Our use of scenarios takes direct inspiration from Erk and Herbelot (2024). Erk and Herbelot crucially distinguish scenario knowledge from word meaning and propose that scenarios, though not connected to word meaning directly, probabilistically influence the concepts that words convey in sentential contexts. Note that if we follow e.g. Yeh and Barsalou (2006) in taking concepts to correspond to information that determines a category or classifier of entities, scenarios will differ sharply from concepts in the sort of groupings of entities that they facilitate. Specifically, the entities grouped together in scenarios are *heterogeneous* insofar as we would not generally describe them all using the same word (modulo polysemy or metonymy). For example, a baked goods making-and-selling scenario will group the production activity (*baking*), what is made (*baked goods*, the recent *plurale tantum* form *bakes*, *bread*), who does it (*baker*), where it happens (*bakery*, *oven*), etc. In contrast to scenarios, concepts serve to cluster *homogeneous* sets of entities—at least homogeneous enough that we are willing to give them the same name. For example, the word *bakery* can be associated with a concept that will serve to classify the places that have a particular role in a scenario involving baking.

We propose a new way to relate scenarios to language, by linking them not to individual words but rather to (partial) *word families*. A word family will typically be associated with more than one scenario: For example, the family containing *bake* and *outbake* is linked both to the baked goods-making-and-selling scenario (*Nobody could outbake her Strudel*) and to a scenario involving industrial heating processes (*The crucibles were outbaked to remove oxygen from the graphite*; note the different sense of the verb). However, not all members of a family are necessarily relevant for all scenarios: *bakery* is linked only to the baked goods-making-and-selling scenario. We also see nothing in principle to prevent a given scenario from being associated with more than one word family, particularly if the scenario in question is relatively coarse-grained. For example, a generic scenario involving politicians and typical followers, policies,

or actions might be associated with distinct (and, again, partial) word families related to the names of specific political leaders (e.g., *Bonapartist*, *Bonapartism*; *Thatcherist*, *Thatcherism*; *Trumpist*, *Trumpism*; etc.). This generic scenario would presumably share features with the much more detailed scenarios each respective family will be linked to.

The word family-scenario link captures the fact that members of the same word family tend to express concepts that participate in the same scenarios, and that, conversely, entities that are strongly associated with a specific scenario tend to be named by words that form a family associated with that scenario (although this does not mean that entities associated with a scenario *must* be named by words belonging to a family linked to that scenario – consider *oven* or *bread*, mentioned above). Thus, the part of the linguistic form that overlaps across family members serves as an important cue to the scenario in question; and the more detailed the information associated with a specific scenario is, the more it will be able to inform the meaning of any word within the same word family, including new words that are coined.

Which entity ends up providing the core form that identifies a family is subject to variation. For example, while in English, the core of the baked goods-making-and-selling scenario is the name of the activity, in Spanish the core is the name of the most prominent type of baked good, *pan* 'bread' (*panadero* 'baker', *panadería* 'bakery', *panificar* 'prepare baked goods'); in Catalan, it is the instrument, *forn* 'oven' (*forn* 'bakery', *forner* 'baker', *fornejar* 'to bake', *enfornar* 'put in the oven (in order to bake)'). There might even be no such core, as in French, where *boulanger* 'baker' and *boulangerie* 'bakery' are related but based on a bound root, unrelated to words naming participants such a type of baked good (*pain* 'pain') or baking instrument (*four* 'oven').[3]

Our proposal extends Erk & Herbelot's by making explicit how scenarios are linked to the linguistic signal: they are not merely an "extralinguistic" resource used to flesh out an underspecified word meaning; rather, they are specifically what word families signal. Positing a direct word family-scenario link immediately illuminates various aspects of the partial predictability of the lexicon.

First, this link, together with morphological knowledge, supports predictions about new word forms and meanings. For example, knowing who Jair Bolsonaro is and that he is a political leader supports a number of very specific inferences about the meaning of the recently coined words *Bolsonarist* and *Bolsonarism*, which build on knowledge both of him and of similar word families involving politicians (see above). These inferences are quite different from the inferences we would draw for these words if Bolsonaro were known to be e.g. a literary figure, in which case *Bosolonarist* would more likely describe an expert on his work (cp. *Danteist*) rather than a supporter of his politics, and (*a*) *Bolsonarism* would more likely describe a characteristic literary style (cp. *Danteism*) or turn of phrase (cp. *Chaucerism*) rather than an ideology. We envision such inferences deriving from the fact that a coarse-grained scenario involving a political leader is likely to consist of different participants than one for a literary figure; language users will take

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[3]The history of this morphological family is intricate, see e.g. the entry for *boulanger* in the *Trésor de la langue française*, accessible here: `https://www.cnrtl.fr/definition/boulanger`. Note that there is an etymological connection to *boule* 'ball, round bread' through Dutch and Picard, but no perceptible synchronic relatedness. Note also that *boulange* is attested as a rare informal term for the trade of baking, but it is clearly a backformation from *boulanger*, and unknown to most French speakers.

this knowledge into account together with information provided by morphology when considering specific word form-meaning pairings.

Second, it becomes immediately clear why the productivity of this sort of family-inspired word formation is *partial*: The simple fact that scenarios are both limited in size (even if the bounds are fuzzy), as well as often very specific, limits productivity. Continuing with the example of words formed from proper names of politicians, the fact that Trump has a particular style of speaking has facilitated an additional sense for *Trumpism* as a turn of phrase that is not attested for *Bolsonarism*; conversely, the fact that Joe Biden is not associated with a unique ideology but is known for how he speaks is reflected in the lack of an ideology sense for *Bidenism* alongside its attested turn-of-phrase sense.[4] Relatedly, nobody should be surprised that many proper names fail to yield forms in *-ism* at all.

Third, we gain insight into the variable nature of what and how much can be predicted for any new word when it is encountered for the first time. The specificity and variability of scenarios may make the details of the meaning of a new word only very partially predictable to a hearer unfamiliar with the relevant scenario. In contrast, for the hearer who *is* familiar with a given scenario, hearing a new form related to it can be extraordinarily informative and impactful.[5] While nothing in the abstract would prevent *Bolsonarism* or *Bidenism* from taking on the senses they do not currently share with *Trumpism*, positing an intimate scenario-word family link clearly predicts that the likelihood that language users will contemplate such possibilities is heavily conditioned on scenario knowledge. This is a prediction that could be fruitfully tested through experiments involving language processing.

Finally, if word families are simply groups of words that share a sufficient amount of overlapping form to identify the scenarios associated with the family, and if the lexicon is supported by the other sorts of paradigmatic relations illustrated in Figure 1, there is no reason to assume that all family members need to be derived in a specific order or from a specific source morpheme; effectively, we open the door to freeing the semantics of word formation from the problematic predictions of the Item and Arrangement model mentioned in section 2.1.

Developing a testable model of how scenario knowledge is exploited in language use faces obvious, significant challenges. How can this knowledge be represented in a scalable fashion? How does one decide where the boundaries of scenarios lie? How detailed must scenarios be? How is information from multiple scenarios integrated when we interpret complex expressions? How does scenario knowledge interact with morphological knowledge and knowledge of the rest of the lexicon more generally? How, ultimately, must the foundations for a theory of meaning be rethought? Fortunately, these challenges are not intractable; on the contrary, recent advances in predictive language modeling offer promising methods and ideas that linguists can draw on.

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[4]See the respective Wiktionary entries for these terms, consulted online March 2, 2024.

[5]A reviewer points out that a related example of this phenomenon is manifest in compounding, where the basic compositional interpretation a formal semantic analysis would give to the compounding process often significantly underdetermines the specificity of the actual compound word meaning.

3.2 Take inspiration from predictive language modeling

Additional sources of inspiration and insight that motivate our proposal come from recent developments in modern natural language processing (NLP). The last decade in particular has been marked by successes of neural network models that aim to predict linguistic contexts or continuations, from the simplistic order-insensitive approaches of Mikolov et al. (2013) to token-in-bidirectional-context prediction in Devlin et al. (2019) and to ever larger modern predictive models such as PaLM (Chowdhery et al., 2022) and GPT4 (OpenAI et al., 2024).

First, modern NLP models show that semantically relevant aspects of complex words can be extracted without explicit morphological information. Although novel and rare words still present challenges, approaches based on subword information, e.g. character n-grams (Bojanowski et al., 2017) or byte pair encoding (Sennrich et al., 2015) are surprisingly effective. None of the widely used subword methods rely on morphemes. Bojanowski et al.'s fastText, for example, relies on all character sequences within a word (e.g. *#so*, *son*, *ong*, *ng#*) as cues contributing to the representation of the word (*song*). Despite its simplicity and morphology-agnostic nature, fastText remains a robust model for producing vector representations of rare words, to the extent that its predictions are used as a reference for evaluating newer contextualized models (Soler et al., 2024) or to improve the representations derived from contextualized methods (Liu et al., 2020); cf. Apidianaki (2023) for a recent survey.

Second, modern NLP models suggest different ways of addressing long-standing problems in lexical semantics which are usually set aside in linguistic theory as intractable or irrelevant. This includes moving beyond the limitations of categorical predictions (e.g. on productivity or well-formedness) towards explicitly graded or probabilistic predictions. So vector representations of words are usually evaluated on continuous measures of word similarity or relatedness judgments that they predict, and language models assign probabilities to the appearance of different tokens in context, rather than simply categorizing them as fitting the context or not.

Another interesting prospect offered by recent NLP is an operationalization of the role of context. Neural network-based language models produce contextualized word representations, whereby words obtain different vector representations in different contexts. It has been shown that uses of words corresponding to the same meaning are assigned similar contextualized vectors (cf. the overview in Loureiro et al., 2020).

Last but not least, modern NLP models build a vast associative memory that to some extent incorporates the kinds of knowledge that we propose here to characterize using the notion of scenarios. For example, the vector of the word *baker* is close in the vector space to vectors of related words such as *bakery*. In large language models scenario information can be even more elaborate and go beyond simple association to include factual knowledge (for example, ChatGPT reproduces the fact that Christopher Columbus died in 1506[6]).

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[6]See `https://openai.com/blog/chatgpt/`, consulted on February 5, 2023.

4   New opportunities

Our interest in a new theory of partial predictability of both forms and meanings has been motivated not only by the missed insights mentioned in section 2, but also by the conviction that it can lead to important new opportunities both for research in theoretical linguistics and for research involving human language in other fields. In this section we briefly point to some areas we find promising.

First, a concerted focus on partial predictability can vastly expand the set of problems and data on the agenda for linguistic theory. The potential for gains are most obvious in the area of morphology and semantics for word formation processes, but would clearly extend to many of the known complexities of the lexicon/syntax and lexicon/compositional semantics interface. A fuller understanding of partial predictability of both form and meaning would surely offer new perspectives from which to address long-standing debates about whether there is a boundary between morphology and syntax, and if so, what it consists in. It would also offer prospects for new insights into well-known form-meaning pairings that are poorly handled in classical approaches where the morpheme is the foundation of meaning, such as the emergence of pseudoaffixes (e.g. -*gate* in *Panamagate*), blends, or phonaesthemes. In addition, it could also provide a fruitful basis for the study of morphology expressed by nonconcatenative means.

Second, and perhaps more importantly for linguistic theory, focused attention on partial predictability would also have tremendous bridge-building potential in a field which has been characterized for decades by a rift – sometimes acrimonious – between subcommunities focused on the fully productive and subcommunities mainly concerned with arguing that it is wrong to focus on the fully productive without going far enough in developing a convincing alternative. We do not doubt that many linguists likely share our view that both subcommunities have identified essential features of human language; our interest is in pushing both sides forward by identifying a neglected area of study and a strategy for approaching it.

Third, embracing partial predictability would bring words and word meaning back into the center of attention of theoretical linguists, and encourage examination of the role partial regularities can play, which we think can be particularly powerful if properly connected to a well-developed model of scenario knowledge. Here the potential for theoretical linguistics to increase its impact in other fields could grow significantly. A well-developed theory of the word family-scenario link and its role in the larger linguistic system, particularly under the assumption that scenarios can be of many different levels of granularity, would establish immediate connections to a host of areas in which that link is arguably central. We see potential for new insights in any domain where metaphor or allusions matter, ranging from literary studies to contemporary critical discourse analysis, and more generally, in any area where language is studied in relation to a specific social or historical context. We also see opportunities for new bridges between linguistic theory and work in lexicography, terminology, as well as philological studies.

Fourth, words have long been a major focus of interest in research on language and cognition. Our proposal to connect scenario knowledge to word families opens the door to new studies of the way detailed world knowledge is accessed and exploited in language production and processing, and how lexical organization interacts with memory.

It also has implications for research into efficient communication, where the possible information-theoretic impact of word family-based paradigmatic lexical organization has, to our knowledge, rarely been taken into account.

Finally, at a time when language technologies are evolving at an astonishing pace, linguistic theory should have a role to play in furthering progress in artificial intelligence by offering tools for overcoming problems associated with rare and novel word forms.

5   Outlook

Partial predictability phenomena cannot be divorced from grammar and therefore should not be relegated to the periphery of linguistic theory. In fact, predictable, semantically transparent relations between linguistic signs must be seen as a special case of more general mechanisms of creativity in linguistic production and interpretation. Semantic inference with reference to scenario knowledge is a general pattern, producing predictable results when scenarios themselves are aligned; thus, *Trumpists* and *Bolsonarists* are more likely to be interpreted as political partisans, and *Platonists*, as philosophical believers.

Partially predictable phenomena are essential to word formation, and word formation is essential to the creativity of language. Indeed, linguistic creativity is unthinkable without the coining of new words. Coining, as a creative act, cannot by definition be fully predictable, but we can and should characterize the coining process with more precision even for only partially predictable outcomes. As we have argued here, when a need arises to name a novel concept or type of entity, scenario knowledge around that concept provides the scaffolding for the coining process.

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