Systematicity in the semantics of noun compounds: The role of artifacts vs. natural kinds

Abstract: The nature of the relationship between the head and modifier in English noun compounds has long posed a challenge to semantic theories. We argue that the type of head-modifier relation in an English endocentric noun-headed compound depends on how its referent is categorized: specifically, on whether the referent is conceptualized as an artifact, made by humans for a purpose; or as a natural kind, existing independently of humans. We propose the Events vs. Essences Hypothesis: the modifier in an artifact-headed compound typically refers to an event of use or creation associated with that artifact, while the modifier in a natural kind-headed compound typically makes reference to inherent properties reflective of an abstract essence associated with the kind, such as its perceptual properties or native habitat. We present three studies substantiating this hypothesis. First, in a corpus of almost 1,700 attested compounds in two conceptual domains (food/cooking and precious minerals/jewelry), we find that as predicted, compound names referring to artifacts tend to evoke events, whereas compound names referring to natural kinds tend to evoke essential properties. Next, in a production experiment involving compound creation and a comprehension experiment involving compound interpretation, we find that the same tendencies also extend to novel compounds.

Keywords: noun-headed compounds, artifacts, natural kinds, nominal semantics

1 Introduction

English noun-headed compounds are infamous for the diverse and often apparently idiosyncratic relationships that may hold between the compound’s head noun and its modifier. To take a few examples, the modifier chocolate in the
compound *chocolate cake* refers to a key ingredient in the cake; the modifier *foam* in *foam cake* alludes to the cake’s texture; the modifier *wedding* in *wedding cake* refers to the occasion on which the cake is served, while the modifier *skillet* in *skillet cake* refers to the container in which the cake is made. Linguists have long debated whether and how the set of head-modifier relations might be constrained, and relatedly, how the correct relation is identified in context. For a given type of cake, are there any compound names that we don’t expect to find? And how do we know whether *bunny cake* refers to a cake for bunnies to eat, one made of bunnies, or one made to resemble a bunny?

With meanings that depend enormously on context, compounds convey more than the sum of their parts. Compounding is thus taken to present a challenge to semantic compositionality. Observing the highly idiosyncratic head-modifier relations used in compounds, Partee (1995: 341) concludes that “semanticists in general do not expect a semantic theory to provide a compositional semantics for compounds”; rather, she suggests that compounding requires language users to draw on their general cognitive capabilities in some way. Dowty (1979: 314–319) proposes that the head and the modifier in a compound must be linked by some context-dependent, “appropriately classificatory” relation (Zimmer 1971), but does not specify what counts as an appropriately classificatory relation or how such a relation is identified in context.

In order to confront this challenge, our study builds on an insight from functionally oriented research on compounding: compounding is a way of *naming* objects, which is in turn related to the psychological act of *categorizing* them (Bücking 2009; Downing 1977; Kay and Zimmer 1990; Murphy 1988; Olsen 2012: 2125; Zimmer 1971, Zimmer 1972). Humans categorize entities according to cognitively salient attributes – attributes like affordances (Gibson 1977) that matter to how they interact with these entities. Compounds such as *chocolate cake* or *fish spatula* are well-suited to identifying subtypes of the kind named by their head because their modifier can make reference to a unique, identifying property of the subkind. In particular, a compound’s head-modifier relation can be used to reflect a property of its referent that matters for interacting with it, and thus for categorizing it.

In this paper, we propose that the head-modifier relation found in a given compound is strongly influenced by the nature of its referent: in particular, whether the referent is construed as an *artifact*, an entity made by humans for a purpose, or as a *natural kind*, an entity that exists independently of humans. We use the word “construe” because we take an entity’s classification to be socially and culturally constructed, reflecting a naive folk biology.¹ Drawing on the

1 Nevertheless, for succinctness we generally write that a compound names an artifact (or a natural kind) to indicate that the compound names an entity that is construed as an artifact (or a natural kind).
literature, we propose that artifacts are conceptualized – and thus categorized – in terms of the purpose for which they are made. Given that compound names are used to categorize, we then predict that a compound name for an artifact will tend to refer to an associated event: either the event the artifact is intended to be used in (Nichols 2008) or the event of its creation, as these events influence the artifact’s ability to fulfill its purpose. In contrast, philosophers of language and psychologists have suggested that natural kinds are conceptualized in terms of an abstract essence, a folk model integrating a collection of distinctive inherent properties (Bird and Tobin 2017; Keil 1989; Kripke 1972). Therefore, we predict that a compound name for a natural kind will tend to refer to inherent properties reflective of its essence, particularly its physical properties or native habitat. That is, humans interact with artifacts and natural kinds in fundamentally different ways, affecting how these entities of these two types are conceptualized and, in turn, how they are categorized and named: artifacts in terms of events and natural kinds in terms of essences. We support and refine these claims using corpus and experimental studies of compounds.

These claims expand on suggestions drawn from various corners of the literature. In a paper most often cited for showing that the grammar imposes no restrictions on the relations that can hold between a compound’s head and its modifier, Downing (1977) nevertheless points out that there is actually a great deal of systematicity in the head-modifier relations displayed in compounds, arising from functional pressures to highlight salient, contextually identifiable relationships. She further proposes that the nature of the head noun influences the most likely relationships. In a small corpus study, she finds that compound names for animals and plants tend to make reference to their appearance or habitat (Texas roadside flowers, giraffe bird), while compound names for synthetic objects (i.e. artifacts) tend to make reference to their purpose (banana fork). “This would seem to correlate with the fact that synthetic objects are typically created with some goal in mind,” she writes, “while natural entities generally are not.” This suggestion is echoed in Wisniewski and Love (1998), who find that compound names for office supplies (artifacts) display systematically different head-modifier relations than those for wildlife (natural kinds). More generally, the artifact–natural kind distinction has been shown to be critical to naming strategies crosslinguistically (Brown 1995, Brown 1999; Nichols 2008).

This paper confirms and refines the proposal that when a compound names an entity, the nature of that entity strongly influences the head-modifier relation in the compound. We motivate this proposal by taking compounding to be a strategy for naming entities, and we show how such a naming strategy would be expected to give rise to significant differences in artifact and natural kind names. We offer hypotheses laying out how the compound names for the two types of entities are expected to differ. Most generally, we propose the Events vs. Essences
Hypothesis (Section 3): the modifiers in artifact-headed compounds will tend to refer to events associated with their head, while those in natural kind-headed compounds will tend to make reference to salient properties of their head that reflect its essence, such as perceptual properties and habitat. That is, attested modifiers should be those that best convey the types of properties characteristic of each type of entity.

To corroborate our hypotheses, we first present a corpus study which examines close to 1,700 naturally occurring English noun-headed compounds drawn from two large conceptual domains, which each include both artifacts and natural kinds: (i) cooking and food and (ii) jewelry and precious minerals. This study shows that the tendencies we hypothesize are indeed attested in the compounds found in each of these domains.

We then confirm that our hypotheses are borne out in novel compounds, both in production and comprehension. We conduct a production experiment in which participants are asked to give a compound name to a novel physical object drawn from the conceptual domains used in the corpus study. The experiment is designed to test whether the tendencies embodied in our hypotheses are reflected in the productive strategies speakers employ in positing compound names for unfamiliar objects. We follow it with a comprehension experiment in which participants are asked to describe the referent of a novel compound. This experiment is intended to test whether the same tendencies play a role in the interpretation of new compounds. Both of these experiments support our hypotheses.

Our goal in this paper is to show that the choice of head-modifier relation in a given compound depends to a large extent on the nature of its head; however, we acknowledge that our findings cannot tell the whole story. As previous studies have shown, a range of factors come into play in the creation and interpretation of compounds. Processing considerations can affect the head-modifier relation chosen in production or inferred in comprehension; see Gagné (2009) for a review of factors, which include the overall morphological complexity of the compound, its semantic transparency, the distributional semantics of both the head and the modifier, and the informativeness and plausibility of the head-modifier relation (Costello and Keane 1997, Costello and Keane 2000; Gagné and Shoben 1997; Körtvélyessy et al. 2015; Libben 2010; Spalding and Gagné 2007; Wisniewski and Love 1998, among many others). Further, contextual pressures might differentially affect the salience of certain properties of an entity, in turn affecting compound interpretation (Gagné et al. 2005); such pressures may override the preferences we identify. Finally, other factors that enter into giving names to entities might come into play, such as those extensively discussed by Malt and her colleagues (Malt et al. 2003; Malt and Sloman 2004; Sloman et al. 2001: 82–84).
cannot examine all these factors here, but we believe that they could interact in interesting ways with our hypotheses, a topic we leave for future work.

Before continuing, we clarify the domain of investigation. Since we are interested in the choice of head-modifier relations, we focus on endocentric compounds: compounds that refer to a subtype of the type referred to by their head. That is, we consider compounds such as chocolate cake, which denotes a type of cake, or diamond necklace, which denotes a type of necklace, but not exocentric compounds like ladyfinger, which refer not to a type of finger, but rather to a type of cookie with a distinctive shape. Further, we do not distinguish among compounds according to degree of conventionalization, as we find that our hypotheses apply equally well to highly conventional, well attested compounds such as green bean and novel or rarely attested compounds such as stream vegetable.

In the next section, we present the conceptual foundations for our studies through an examination of the artifact–natural kind distinction and its implications for naming entities. This discussion provides the motivation for our hypotheses, introduced in Section 3. We corroborate these hypotheses with our corpus study, presented in Section 4, and our two experimental studies, presented in Section 5. Section 6 concludes.

2 Conceptual foundations: Artifacts, natural kinds, and their names

The distinction between artifacts and natural kinds has been recognized since at least Aristotle. Keil proposes that the notion of natural kind provides “a way of understanding why we have the beliefs we do about the categories of things there are in the world” (1989: 54), and we believe the same holds of the related notion of artifact.

Natural kinds are argued to have “essences” which reflect their biological nature and, thus, are the source of their unique properties (Bird and Tobin 2017; Keil 1989; Kripke 1972; Putnam 1975). Whether the notion “natural kind” is taken to reflect reality or a folk theory of categories, a natural kind’s essence is often said to be manifested in its distinctive physical properties, most often color, size, shape, and texture. Although there is debate about the exact definition and ontological status of natural kinds, we follow common practice in treating biological species (plants and animals) and naturally occurring minerals as natural kinds.

It is often difficult to articulate the features distinctive of a particular natural kind. As Dowty observes, “we know a few characteristics by which examples of a [natural] kind can be more or less reliably recognized but expect there to be other more precise criteria which may not yet be known” (1979: 386) or known only
to experts (Putnam 1975). For example, bears can vary considerably in appearance and behavior, ranging from cute pandas to ferocious grizzlies. However, the properties that distinguish bears from other mammals are quite obscure: according to Wikipedia, bears are distinguished by the “presence of an alisphenoid canal,” their “bunodont” cheek teeth, “vestigial lacrimal bone,” and flattened “carnassials.” Most people who use the word bear cannot identify these traits. Instead, they conceptualize a bear in terms of an elusive set of properties relating to appearance, behavior, and habitat which sum up to bear-ness: that is, an abstract essence.

In contrast, artifacts are usually characterized as entities created for a specific purpose (Hilpinen 2011; see also Keil 1989; Margolis and Laurence 2007; but see Bloom 1996 and Chaigneau et al. 2009 for some complications), and it is this property which sets them apart from natural kinds. Drawing on this idea, Nichols (2008) proposes that an artifact is understood in terms of an “associated event” in which the artifact fulfills its canonical purpose (e.g., cutting for a knife, writing for a pen). Nichols’ characterization of artifacts is reminiscent of the telic role that Pustejovsky (1991, 1995) posits in a noun’s qualia structure, which specifies the intended function of the entity denoted by the noun. Most studies of artifacts privilege tools of various types, which are clearly differentiated by function. However, for other types of artifacts, including objects that people create for pleasure, such as works of art and baked goods, the event of creation or manufacture (e.g., carving for a statue, baking for a cake) may be as important in human interaction with a particular artifact as the event of use. Such events also have a place in Pustejovsky’s qualia structures: his agentive role specifies how an entity comes into being. Thus, we take a broad understanding of the notion of associated event to be relevant to artifacts.

The importance of the associated event to the conceptualization of an artifact can be demonstrated by considering a can opener. Can openers – like many artifacts – may vary considerably in appearance and even material: they can range from small handheld cranks to stand-alone machines. In contrast to bears, however, it is easy to articulate what can openers have in common: they are unified – and distinguished from other tools – in being designed and able to open cans. The shared associated event, however, can be accomplished using various mechanical structures, which is why can openers may vary in their form. Dowty also argues that instances of an artifact are unified by their function while possibly differing in their form, using chairs as his example: If “ordinary chairs are replaced by local anti-gravity devices which suspend a person in mid-air in a sitting position, I believe these devices will deserve and receive the designation

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2 en.wikipedia.org/wiki/Bear
chair, despite the fact that they share no physical properties with present-day chairs” (1979: 386).

There is mounting evidence that the artifact–natural kind distinction influences the ways in which entities are named across languages (Brown 1999; Downing 1977; Nichols 2008; Wisniewski and Love 1998). Although many factors influence naming, we might expect names that show at least some semantic transparency to pick up on the properties of entities that matter to how we categorize them. In particular, we might expect that names for artifacts would make reference to an associated event and those for natural kinds would make reference to properties evocative of their essence. Further, the naming strategies used for each should be those that make such reference possible. We now review some studies that suggest that these expectations are met: languages show differences in their naming strategies for artifacts and natural kinds, and the attested strategies, including the choice of head-modifier relations in compound names, are those that allow reference to the properties characteristic of the type of entity being named.

These points emerge most clearly in an investigation by Brown (1995, 1999) of how entities are named when they are imported from one culture to another. Brown analyzes 292 Native American languages, examining the names for 77 “acculturated items” that were introduced to the Americas by Europeans. These include artifacts such as windows, clocks, and scissors, as well as natural kinds such as horses, cows, peas, and apricots.

Brown finds that an acculturated artifact is considerably more likely than a natural kind to have a “utilitarian” name: a name which explicitly references its purpose; that is, the event it is designed to be used in. Some acculturated artifacts are named by native deverbal nouns that could be considered analogous to English blender or opener; such names explicitly mention the artifact’s associated event of use. Zuni is a language that exploits this strategy: Nichols (2008) finds that all artifact names are built from verbs that reference the artifact’s associated event. Such deverbal names wear the associated event on their “sleeve,” highlighting the deep link between artifacts and events. Another naming strategy for acculturated artifacts noted by Brown invokes the associated event indirectly: in some languages a native word for an entity with the same function as the acculturated item is extended to refer to the imported item, as when a native word meaning ‘sinew’ is used to refer to thread or one meaning ‘shell’ is used to

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3 Keane and Costello (1996) and Costello and Keane (1997) also note that the artifact–natural kind distinction is relevant to compounding, but their studies are concerned with the effects of this distinction on the potential polysemy of a compound rather than on the head-modifier relations involved. For this reason, we do not consider their work further.
refer to a spoon (1999: 32). This strategy is not so often used for acculturated natural kinds, presumably because function does not usually matter to their intrinsic characterization.

Natural kinds, in contrast to artifacts, are characterized by an essence, and Brown’s study suggests that the naming strategies for acculturated natural kinds allow reference to their essence. In Native American languages, natural kinds are significantly more likely than artifacts to be given a name borrowed from the European contact language. For example, the Spanish word for ‘horse’, caballo, was extensively borrowed (with phonological modifications) into indigenous languages (Kiddle 1978): kavá in Southern Ute, ca’ in Tzotzil, and calu in Colorado. Zuni again supports Brown’s observation: Nichols finds that borrowed names for natural kinds are common in Zuni, while, such names are “conspicuously missing” (2008: 686) for artifacts. We suggest that a borrowed name may be used to “capture” the ineffable essence of a natural kind. It provides a unique identifier for the natural kind, allowing speakers to avoid having to articulate its distinctive properties in specific terms.

Other naming strategies evoke the essence of a natural kind more directly. A species’ unique appearance may serve as a proxy for its characteristic behaviors, ecological niche, and genetic makeup. In fact, Brown finds that acculturated natural kinds are often given compound names in which the head identifies an appropriate taxonomic category, and the modifier refers to a perceptual property, such as the item’s size, shape, color, texture, smell, or distinctive part. For instance, a lemon may be named by a compound whose head is the word for ‘orange’ plus the modifier meaning ‘sour’, ‘bitter’, or ‘acidic’, while peas and peaches may be given names corresponding to the English ‘round beans’ and ‘fuzzy plum’, respectively (Brown 1999: 31, 33–34).

The compound strategy for naming natural kinds extends to English. In a small corpus study, Downing (1977) finds that many English compound names for natural kinds reference appearance. She further observes that many compound names for natural kinds have modifiers that reference their typical habitat, as in desert lily. We suggest such modifiers instantiate yet another way to allude to a kind’s essence. Not all living things can live anywhere; rather, they evolve traits that allow them to thrive in their native habitat. A desert lily, unlike other lilies, is able to survive in a low-water environment; the modifier desert evokes this key property. Through a more extensive corpus study of compounds drawn from office supply catalogues and wildlife guides, Wisniewski and Love (1998) corroborate Downing’s observations. They find that compound names for natural kinds

4 The primary goal of Wisniewski and Love (1998) is to evaluate the hypothesis that people will first try to posit a “relation” between a compound’s head and modifier, and only when that fails
typically have modifiers that specify the natural kind’s habitat or perceptual properties: *mountain sheep* evokes the typical habitat of one type of sheep, *leopard lizard* evokes the leopard-like skin pattern characteristic of a particular lizard, and *candy barrel cactus* evokes the unique shape of one type of cactus.

Compounding is a naming strategy that in English is used for artifacts as well as natural kinds, presumably because of the wide range of relations available between the head and modifier. Corroborating Brown’s and Nichols’ studies, Wisniewski and Love (1998: 195) find that compound names for artifacts often involve nouns derived from verbs.\(^5\) Compounds with deverbal heads such as *pencil holder* explicitly reference the event that the artifact is designed for. In many such compounds, the modifier is a noun understood to be the object of the base verb (*hold* *pencils*).\(^6\) In other instances, especially when their head is monomorphemic, compounds naming artifacts only indirectly make reference to an associated event. Consider an example from Downing (1977): a *banana fork*, a piece of cutlery designed for eating a banana; however, the event which relates the fork to the banana – that is, eating – is not explicitly mentioned.

Unlike natural kinds, artifact compounds tend to have head-modifier relations that allow reference to an associated event, as Downing and Wisniewski and Love show. As in the *banana fork* example, Downing (1977) finds that artifacts (what she calls “synthetic objects”) are often given compound names which reference their purpose. Wisniewski and Love (1998: 200) also find that compound names for artifacts may have modifiers which specify a salient material that the head noun is made of (*quartz clock, latex glove*). Such modifiers reference the event in which the artifact is created. Furthermore, since an artifact’s material may affect its ability to fulfill its function, such modifiers may also provide insight into how well the artifact will perform its intended purpose. A silicon spoon, for instance, will not scrape a pan. Whether referencing creation or use, such material modifiers evoke an event associated with the artifact.

In conclusion, studies that come at naming from several perspectives show that names for artifacts evoke events, while names for natural kinds evoke

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\(^5\) Wisniewski and Love (1998: 195) note that 30% of the office supply compounds involve a deverbal element, but they do not distinguish compounds where this element is the head (*glass cleaner*) from those where it is the modifier (*diving suit*).

\(^6\) We leave aside the contentious issue of the appropriate internal structure for these compounds, focusing simply on the head-modifier relation. See Lieber (2004: 47–48) for discussion.
essences. This observation extends to the choice of head-modifier relations in English compounds.

In order to make predictions about the naming strategies applicable to a given entity, we need first to know whether it is an artifact or a natural kind. Here we reiterate a point from Section 1: we take an entity’s classification to reflect a naive folk biology. That is, its classification is socially and culturally mediated according to how humans interact with that entity. (See Grimm 2012 for a discussion of this issue in relation to number marking systems.) In many instances, our conceptual classification will accord with the biological fact of the matter, but there may be deviations. Thus, Sperber (2007) calls attention to “biological artifacts”, such as seedless grapes: natural kinds which have been engineered, bred, trained, or otherwise recruited by humans for a particular purpose. Although such entities are usually nevertheless conceptualized as natural kinds (Keil 2007: 243–244), some do show signs of being conceptualized as artifacts, as attested in their naming patterns. Consider milk cow a cow that produces milk (compare Jersey cow), cart horse a horse that pulls a cart (compare Arabian horse), and pie pumpkin a pumpkin appropriate for making pie (compare sugar pumpkin). In these instances, the entity is given a compound name which makes reference to the event in which the entity fulfills its purpose.

3 Hypotheses

Synthesizing the discussion in Section 2, we propose several hypotheses about the nature of compounds naming artifacts and natural kinds which we show are borne out in the studies that comprise this paper. Our overarching hypothesis follows:

(1) **EVENTS VS. ESSENCES HYPOTHESIS**

Compound names for artifacts will tend to differ from compound names for natural kinds. In compound names for artifacts, the modifier will tend to make reference to an event associated with the artifact, whereas in compound names for natural kinds, the modifier will tend to make reference to properties reflective of the essence of the natural kind.

We state this hypothesis and its corrolaries as tendencies or preferences because we recognize that not all compound names for artifacts and natural kinds conform to them. In fact, we explicitly predict (in the Domain-Dependent Naming Pattern Hypothesis introduced below) some principled deviations from our main hypothesis, the Events vs. Essences Hypothesis. Other deviations may be
attributed to the many interacting factors that affect the compound name an entity is given; see Section 1.

We now set out four corollaries that elaborate on our main hypothesis. We hypothesize that compound names for artifacts will evoke the artifact’s associated event using several strategies suggested by the discussion in Section 2:

(2) **Deverbal Head Hypothesis**

Compound names for artifacts may have a deverbal noun as head.

(3) **Event-Related Modifier Hypothesis**

A compound name for an artifact will tend to have one of two types of modifiers:

a. a modifier that denotes a participant in an associated event, whether of creation or use;

b. a modifier that otherwise makes reference to an associated event, e.g., specifies its time or occasion of use or its mode of creation.

We observed in Section 2 that deverbal artifact names, in which the base verb describes the event in which the artifact is to be used, wear their associated event on their “sleeve”, so it would not be unexpected to find such items as the heads of compounds. In compounds with such heads, the modifier often refers to a participant in the event, most often the object of the base verb (can opener; cf. open a can). The identity of this participant is often critical to the design of the relevant artifact. Even though a can opener and a bottle opener have the same general purpose of opening a container, their designs are different because of the distinctive properties of cans and bottles. Even when the compound’s head is not deverbal, the modifier may indirectly further specify the associated event by making reference to the event participant it is designed to be used on (fish knife). Although the focus of prior work has been on the event the artifact is designed to be used in, we hypothesize that other salient events, such as the event of creation, may be referenced in a compound name. In an event of creation, an ingredient or raw material may be salient (fish soup, quartz clock). Alternatively, other facets of this event may be evoked as in skillet cake, which references the mode of creation.

Next, we elaborate on what the Events vs. Essences Hypothesis means for compounds naming natural kinds. Again we draw on the discussion of naming

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7 Although we hypothesize that compound names for artifacts may have deverbal heads, we do not claim that deverbal nouns must name artifacts. In English, for example, –er nominals can name both instruments and agents (Bauer et al. 2013: 232; Dressler 1986; Levin and Rappaport 1988). Their “agent” uses refer to humans engaged in the activity named by the verb (eater, sender); in fact, these nominals sometimes become names of professions, referring to someone who habitually engages in the activity (baker, teacher, trader).
strategies in Section 2 to suggest specific ways in which the modifier can be used to evoke a kind’s essence. Specifically, we propose:

(4) **ESSENCE-RELATED MODIFIER HYPOTHESIS**
A compound name for a natural kind will tend to use one of three types of modifiers:

a. **PERCEPTUAL**: a modifier that refers to the kind’s perceptual properties, especially appearance;

b. **ENVIRONMENTAL**: a modifier that refers to the kind’s habitat, including geographic location of origin;

c. **BORROWED**: a modifier that is a word borrowed from another language.

As discussed in Section 2, a natural kind’s perceptual properties and habitat can serve as proxies for its distinctive behavior, ecological niche, and evolved traits. Another way to make reference to habitat is via the name of the place where the natural kind originates or thrives (*Belgian endive*, *Chinese broccoli*). Geographic location is often expressed by adjectives describing nationalities or ethnic groups, which is a major reason we include noun-headed compounds with both adjective and noun modifiers in our corpus study.8

Building on the observation that natural kinds may be given borrowed names, we hypothesize that compounds naming natural kinds may involve a borrowed modifier and an English head (*garbanzo bean*), in what Brown (1999: 23) calls a “loan blend”. In such compounds, the head places the compound’s referent into the appropriate taxonomic category, while the borrowed modifier distinguishes the relevant subkind of the kind named by the head.9 The borrowed relation is qualitatively different from the other head-modifier relations because there is no true semantic relation between the head and modifier: the modifier does not name a property of the head or another participant in an event involving the head. Nevertheless, we include this relation in our study because it is well-attested in compounds, presumably for the reasons discussed in Section 2.

We have hypothesized that there will tend to be differences in compound names for artifacts and natural kinds because humans interact with and conceptualize these two types of entities in distinct ways. Similarly, we might predict preferences for distinct head-modifier relations within each of these categories. For example, our corpus study considers kitchen utensils, cakes and

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8 We predict that nationality modifiers should mainly be found in natural kind compounds, but they might also occur occasionally in a compound naming an artifact if its particular method of manufacture or use is associated with a particular culture or ethnic group, as in *Belgian waffle*.

9 Borrowing is known to be sensitive to cultural, social, and attitudinal factors (Hägglund 2009; Sakel 2007), and, undoubtedly, some of these come into play in determining whether a compound should have a borrowed modifier.
cookies, and jewelry because we interact with these three types of artifacts in very
different ways (we use utensils to cook, we bake and eat cakes and cookies, and
we purchase and wear jewelry). These distinct modes of interaction might lead
to differences in what are perceived to be the salient attributes of each type of
artifact; these differences, in turn, might be manifested in distinct preferences for
certain head-modifier relations in their compound names.

(5) DOMAIN-DEPENDENT NAMING PATTERN HYPOTHESIS

Within the set of artifacts as well as within the set of natural kinds, dif-
ferent subtypes may show different preferences for head-modifier relations
based on the interactions distinctive to the members of a subtype and the
attributes made salient by those interactions.

In closing this section, we emphasize yet again that our hypotheses do not
identify the precise name an entity will be given, but rather set out preferences
concerning the possible types of head-modifier relations that will be found if that
entity is given a compound name. Even when these preferences are respected,
there can be some leeway in the compound name given to an entity. For example,
what is called a drawing pin in British English is called a thumb tack in American
English. Here the British name makes reference to the artifact’s purpose (securing
a drawing or similar item to a flat surface), while the American name makes refer-
ence to its mode of use (being pushed into a surface with a thumb and not, say, a
hammer). Both names are consistent with our hypothesis, but in different ways.

4 A corpus investigation of compounds

In order to test the hypotheses laid out in Section 3, we conducted a corpus study
of naturally occurring English compounds. The compounds, culled from online
databases and retailer inventories, are drawn from two conceptual domains:
(i) food and cooking; and (ii) jewelry and precious minerals. Both are large
domains, comprising several types of artifacts and natural kinds. Within the
domain of food and cooking, we collected compounds naming kitchen utensils,
cakes and cookies, and greens and legumes. Within the domain of jewelry and
precious minerals, we collected compounds naming bracelets, necklaces, rings,
and earrings, as well as those naming gemstones, pearls, corals, and ebonies.10

We chose very different domains in order to create a strong testbed for assess-
ing the Events vs. Essences Hypothesis and its corollaries. Further, the presence of
well-defined subdomains within each of these domains allows us to explore the

10 See Keil (1989: 54) on pearls and corals as natural kinds.
existence of subtler effects on naming within subdomains posited in the Domain-Dependent Naming Pattern Hypothesis. Kitchen utensils, which are designed as tools, would generally be considered prototypical artifacts, while the other types of artifacts in our dataset are perhaps less so. Cakes and cookies are created by recipes to be eaten, and jewelry is created to be worn for adornment. Among our natural kinds, greens and legumes are living things, while precious minerals are not.

Even though the artifacts and natural kinds in our corpus are quite heterogeneous, we expect that compound names for artifacts and natural kinds will differ from each other in specific ways. Based on the Events vs. Essences Hypothesis, we predict that the compound names for artifacts in our corpus (kitchen utensils, cakes and cookies, and jewelry) will differ systematically from the compound names for natural kinds (greens, legumes, and precious minerals). In particular, we predict that compound names for artifacts will more often make reference to events, including via the use of deverbal heads (the Event-Related Modifier Hypothesis and the Deverbal Head Hypothesis), while compound names for natural kinds will evoke their essence (the Essence-Related Modifier Hypothesis). According to the Domain-Dependent Naming Pattern Hypothesis, we also predict differences within the various types of artifacts (kitchen utensils, cakes and cookies, and jewelry) and within the various types of natural kinds (greens, legumes, and precious minerals), based on the distinct ways we engage with these different types of entities.

4.1 Methodology

We created a corpus of naturally occurring artifact and natural kind compounds from the two conceptual domains under consideration. The head-modifier relation in each compound was then coded according to a set of head-modifier relation types that we developed. Finally, we assessed the distribution of the diverse head-modifier relations across the conceptual domains and subdomains of the compounds to determine whether our hypotheses are substantiated.

4.1.1 The data set

Compound names for greens and legumes were drawn from various online wholesale food inventories. Compound names for kitchen utensils came from

catalogs available on the Crate and Barrel and Williams-Sonoma websites; we also contributed a small number of additional compounds naming common kitchen utensils that were omitted from the catalogs. Compound names for cakes and cookies were drawn from an online recipe database, Flora’s Recipe Hideout.\(^{12}\) Because this list contained over 5,000 recipes, and names were very long (often including the name of the cook, the type of frosting, and evaluative adjectives like *yummy*), we first removed all postmodifiers, cook names, and evaluative adjectives, extracting only names that occurred at least twice. We added a small number of popular cake and cookie names that were missing from this data. Compound names for gemstones came from GemSelect, a wholesale gem retailer.\(^{13}\) We supplemented this list by searching for “types of emeralds,” “types of rubies,” and so on; these searches took us to web pages dedicated to a particular gem and its subtypes.\(^{14}\) We also gathered compound names of pearls from the print catalogue for Stachura Wholesale, a pearl retailer. Compound names for jewelry were primarily drawn from Kay’s online inventory, but we supplemented this list with the names of some common items that we were familiar with (*opera necklace*).

From these initial lists, we retained only two- and three-word noun-headed compounds. We only kept those compounds whose modifiers were clearly nouns or adjectives, excluding, for instance, *upside-down cake* and *mange-tout pea*.\(^{15}\) We considered only endocentric compounds, that is, those where the entity named is a subtype of the type of entity named by the head noun.

If a three-word compound had the form *[X \([X_2 \text{N}]\)] ([flourless [chocolate cake]], [ankh [toe ring]]), then we also added the compound *[X_2 \text{N}] to our list, if it was not already there (chocolate cake, toe ring); this allowed us to code both the relation of \(X_1\) to \([X_2 \text{N}]\) and the relation of \(X_2\) to \(\text{N}\). Three-word compounds of the form *[\([X_1 \text{X}_2] \text{N}\)] ([chocolate chip cookie], [pie crust cutter]) were simply listed once and coded for the relation of \([X_1 \text{X}_2]\) to \(\text{N}\).

In rare instances, a compound had more than one prominent interpretation. For example, according to Wikipedia, *coffee cake* commonly refers either to a cake

\(^{13}\) www.gemselect.com/
\(^{14}\) typesofdiamonds.net/different-types-of-diamonds/, www.ehow.com/facts_5479044_types-emeralds.html
\(^{15}\) For modifiers that occur in English as either a verb or a noun (*snap in snap pea*), we checked the *Oxford English Dictionary* to see whether the word appeared as a noun or a verb first. We kept only those compounds where the earliest attribution of the modifier was as a noun. We also excluded possessive compounds such as *Jew’s mallow* (a plant), except if the possessive related two parts of a modifier ([devil’s food] cake), rather than relating the modifier to the head.
eaten with coffee, or to a cake that is flavored with coffee.\textsuperscript{16} Coffee cake therefore is listed twice in our corpus, so that it could be coded once for each of the relevant head-modifier relations. We allowed our coders to determine, based on web research, when a compound should be listed multiple times in this way; see Section 4.1.3.

The resulting corpus comprises 1637 unique compounds. Once multiple interpretations of compounds like coffee cake are taken into account, the final list includes 1651 compounds: 327 compound names for kitchen utensils, 295 for cakes and cookies (baked goods), 286 for greens and legumes, 378 for pieces of jewelry, and 365 for gemstones, pearls, corals, and ebonies (precious minerals). Some examples are given in Table 1.

\textbf{Table 1:} Examples of compounds from both conceptual domains.

<table>
<thead>
<tr>
<th>Kitchen utensils</th>
<th>Baked goods</th>
<th>Greens and legumes</th>
<th>Jewelry</th>
<th>Precious minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>avocado tool</td>
<td>wedding cake</td>
<td>Belgium chicory</td>
<td>charm bracelet</td>
<td>coin pearl</td>
</tr>
<tr>
<td>baking scale</td>
<td>yellow cake</td>
<td>Dutch chicory</td>
<td>feather earrings</td>
<td>Ajax turquoise</td>
</tr>
<tr>
<td>cheese mill</td>
<td>spice cookies</td>
<td>grey pea</td>
<td>love knot earrings</td>
<td>conch pearl</td>
</tr>
<tr>
<td>oil thermometer</td>
<td>loaf cake</td>
<td>sugar pea</td>
<td>cowboy boot necklace</td>
<td>lemon citrine</td>
</tr>
<tr>
<td>oil mister</td>
<td>mocha cake</td>
<td>Swiss chard</td>
<td>diamond cross necklace</td>
<td>zebra jasper</td>
</tr>
<tr>
<td>lime juicer</td>
<td>party cake</td>
<td>pigeon pea</td>
<td>praying hands necklace</td>
<td>imperial jasper</td>
</tr>
<tr>
<td>icing spatula</td>
<td>hot water cake</td>
<td>collard greens</td>
<td>citrine necklace</td>
<td>star garnet</td>
</tr>
<tr>
<td>honey dipper</td>
<td>butterfly cake</td>
<td>string bean</td>
<td>ankh toe ring</td>
<td>mint garnet</td>
</tr>
<tr>
<td>toast tongs</td>
<td>coconut cake</td>
<td>borlotti bean</td>
<td>layering necklace</td>
<td>Hawaiian gold coral</td>
</tr>
<tr>
<td>tomato corer</td>
<td>waffle cookies</td>
<td>pinto bean</td>
<td>bubble necklace</td>
<td>Cambodian blue zircon</td>
</tr>
</tbody>
</table>

\textbf{4.1.2 The head-modifier relations}

We developed a set of types of head-modifier relations that could be used to code the relation between the head and modifier in each compound in our corpus. These relations were intended to allow us to analyze the corpus data in the context of our hypotheses. The set of relations was initially developed for

\textsuperscript{16} https://en.wikipedia.org/wiki/Coffee_cake
the food and cooking domain, but the same set was also able to cover the jewelry and precious mineral domain. Our starting point was the set of relations proposed by Wisniewski and Love (1998: 200–201) for their corpus study of noun-noun compounds; however, we refined and extended this set because we were examining a wider set of conceptual domains, as well as adjective-noun compounds. For instance, we added the relations “borrowed” (garbanzo bean) and “method” of creation (skillet cake, made in a skillet). To ensure coverage of the attested adjective-noun compounds, we also added some relations inspired by the semantic classes of adjectives identified in Dixon (1977) and Dixon (2004: 4–5), such as “dimension” and “value”.

Our final list of head-modifier relations is shown in Table 2 together with illustrative examples; a fuller list with detailed descriptions is found in Appendix A. These head-modifier relations were used to code all the compounds in our corpus.¹⁷

Table 2: A list of the head-modifier relations used with examples.

<table>
<thead>
<tr>
<th>Head-modifier relation</th>
<th>Illustrative compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borrowed</td>
<td>fava bean, keshi pearl</td>
</tr>
<tr>
<td>Color</td>
<td>green bean, yellow cake</td>
</tr>
<tr>
<td>Dimension</td>
<td>broad bean, deep spoon</td>
</tr>
<tr>
<td>Distinctive part</td>
<td>red-leaf lettuce, toggle bracelet</td>
</tr>
<tr>
<td>Location</td>
<td>freshwater pearl, garden pea, kitchen scissors</td>
</tr>
<tr>
<td>Made of</td>
<td>honey cake, opal bracelet</td>
</tr>
<tr>
<td>Method</td>
<td>cultured pearl, refrigerator cookies, skillet cake</td>
</tr>
<tr>
<td>Named after</td>
<td>monaliza onyx, [Queen Elizabeth] cake</td>
</tr>
<tr>
<td>Object-nom(inalization)</td>
<td>banana slicer, burger press</td>
</tr>
<tr>
<td>Purpose</td>
<td>chili bean, fish spatula</td>
</tr>
<tr>
<td>Social/political</td>
<td>Boston lettuce, Spanish topaz</td>
</tr>
<tr>
<td>Taste/smell</td>
<td>marrow bean, sugar pea</td>
</tr>
<tr>
<td>Time</td>
<td>birthday cake, wedding band, winter pea</td>
</tr>
<tr>
<td>Used by</td>
<td>cowboy cookies, navy bean</td>
</tr>
<tr>
<td>Value</td>
<td>dream bar, wacky cake</td>
</tr>
<tr>
<td>Visual</td>
<td>kidney bean, lace cookies</td>
</tr>
<tr>
<td>Whole–part</td>
<td>beet greens, turnip top</td>
</tr>
<tr>
<td>Other property</td>
<td>collapsible funnel, itchy bean</td>
</tr>
</tbody>
</table>

When considered in the context of the corollaries of the Events vs. Essences Hypothesis, these head-modifier relations naturally fall into groups according to

¹⁷ This list of head-modifier relations worked for our purposes, but additional relations might be necessary to code a broader set of compounds.
whether they are relevant to events or essences. We therefore collapsed the head-modifier relations into five “meta-relations” shown in Table 3, presented more fully in Appendix A. Each meta-relation subsumes those head-modifier relations with a similar function.

Table 3: The five meta-relations used to code attested compounds.

<table>
<thead>
<tr>
<th>Meta-relation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borrowed:</td>
<td>The modifier is a word from another language. Subsumed relation: borrowed</td>
</tr>
<tr>
<td>Perceptual:</td>
<td>The modifier describes the color, shape, smell, taste, texture, or other facet of the appearance of the head or a distinctive part of the head. Subsumed relations: color, dimension, distinctive part, taste/smell, visual</td>
</tr>
<tr>
<td>Environmental:</td>
<td>The modifier characterizes the environmental origin, habitat, or living conditions of the head. Subsumed relations: location, social/political</td>
</tr>
<tr>
<td>Event:</td>
<td>For events of use, the modifier describes a participant or some other facet of the event that the head is used in; for events of creation, it describes a method or material used in the creation of the head. Subsumed relations: made of, method, object-nom, purpose, time, used by</td>
</tr>
<tr>
<td>Other:</td>
<td>The modifier characterizes some other property of the head. Subsumed relations: named after, other property, whole–part, value</td>
</tr>
</tbody>
</table>

These meta-relations allow us to better test our hypotheses. We predict that compounds referring to artifacts should tend to display head-modifier relations falling under the event meta-relation. The perceptual, environmental, and borrowed meta-relations mirror the three ways of characterizing an essence listed in the Essence-Related Modifier Hypothesis (4), so that compounds referring to natural kinds should tend to display head-modifier relations falling under these three meta-relations. Moreover, since some head-modifier relations are rather infrequently attested in our data, grouping head-modifier relations into the larger meta-relations allows us to control for data sparsity, giving our study more power.

In concluding this section, we note that the set of head-modifier relations we posit overlap considerably with sets proposed in previous studies of compounds (e.g., Downing 1977: 838; Jackendoff 2009: 123–124; Wisniewski and Love 1998: 200–201). We build on this work by grouping our head-modifier relations into meta-relations motivated by the nature of artifacts and natural kinds. In so doing, we also provide insight into why multiple studies have converged on comparable sets of head-modifier relations: these relations embody strategies for highlighting the events and essences critical to identifying subkinds of artifacts and natural kinds, respectively. Thus, the artifact–natural kind distinction gives us a way to understand why certain head-modifier relations are identified in earlier studies and recur across them.
4.1.3 Coding the head-modifier relation

The head-modifier relations used in the 1651 compounds were coded by three paid linguistics graduate students, aided by two others, using a detailed coders’ manual. The coders were blind to our hypotheses through the entire coding process. To avoid biasing the coders, the coders’ manual illustrated the head-modifier relations using compound names of dogs, clothing, and items in other conceptual domains that were not represented in our corpus. The coders also were not aware that the head-modifier relations could be grouped into meta-relations.

For each compound, we asked the coders to choose the head-modifier relation from the list in Table 2 that best fit what they took to be its conventional interpretation. In the few instances where the coders believed a compound had more than one prominent interpretation (coffee cake, discussed in Section 4.1), they coded the compound once for each interpretation. The final head-modifier relation for each compound was determined by consensus among the three coders after any initial disagreements were resolved by discussion. The full, coded dataset, along with the coders’ manual, is available via the Open Science Framework at https://osf.io/t43kd/.

4.2 Results of the corpus study

Using this coded dataset, we tallied the head-modifier relations and meta-relations manifested in compounds from each category (kitchen utensils, greens and legumes, baked goods, jewelry, precious minerals). The aggregated statistics for the five meta-relations are given in Table 4.

---

18 When choosing the appropriate head-modifier relation to assign to a given compound, coders were told to take into account the way the modifier was understood in the compound, rather than a fundamental categorization of the modifier itself. Thus, the head-modifier relation may reflect a metonymic understanding of the modifier, as in lemon citrine, where the relation was coded as “color”. Furthermore, the same modifier may be coded for more than one relation. For example, we coded lemon as “color” in lemon citrine and as “made of” in lemon cake.

19 Thus, although some of the literature makes much of the myriad interpretations available in principle to certain noun-noun compounds when cited in isolation (e.g., Costello and Keane 1997; Downing 1977; Kay and Zimmer 1990; Murphy 1988, 1990), we did not ask our coders to exhaustively determine all the possible interpretations of each compound. In fact, Štekauer (2005) observes that even when a compound can receive multiple interpretations, at most one or two of these are dominant. In fact, no compound in our corpus was given more than two interpretations by the coders.

20 Due to rounding, percentages in Table 4 and some other tables may not always add up to precisely 100%.
Table 4: Results of the corpus study, showing the distribution of meta-relations for artifacts and natural kinds. All differences between natural kinds and artifacts are significant ($\chi^2$ test, $p < .001$)

<table>
<thead>
<tr>
<th></th>
<th>Natural Kinds</th>
<th>Artifacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borrowed</td>
<td>49 (8%)</td>
<td>4 (0%)</td>
</tr>
<tr>
<td>Perceptual</td>
<td>325 (50%)</td>
<td>338 (34%)</td>
</tr>
<tr>
<td>Environmental</td>
<td>174 (27%)</td>
<td>27 (3%)</td>
</tr>
<tr>
<td>Event</td>
<td>36 (6%)</td>
<td>574 (57%)</td>
</tr>
<tr>
<td>Other</td>
<td>67 (10%)</td>
<td>57 (6%)</td>
</tr>
<tr>
<td><strong>N = 651</strong></td>
<td></td>
<td><strong>N = 1000</strong></td>
</tr>
</tbody>
</table>

Compound names for artifacts and natural kinds indeed use distinct meta-relations, and the choices line up well with our hypotheses. As hypothesized, compound names for artifacts evoke events far more often than compound names for natural kinds (57% vs. 6%, $\chi^2$, $p < 1.6 \times 10^{-100}$). Compared to artifacts, natural kinds are much more frequently named for environmental properties (27% vs. 3%, $p < 1.3 \times 10^{-48}$) or perceptual properties (50% vs. 34%, $p < 3.1 \times 10^{-10}$), and they are more likely to have borrowed names (8% vs. 0%, $p < 1.6 \times 10^{-15}$).

Table 5 shows the results disaggregated into specific head-modifier relations. This table shows differences within artifacts and natural kinds as well as between them. Kitchen utensils are overwhelmingly named for associated events (80%), most commonly the “object-nom” relation found in many compounds with deverbal heads (38%; banana slicer, burger press), where the modifier is understood as the object of the base verb. Also common is the “purpose” relation (26%; canning funnel, food scale), the analogue of “object-nom” for heads that are not deverbal. Next is the “made of” relation (16%; silicon spoon). Although this relation makes reference to the event of creation as discussed in Section 2, it may also bear on the event of use since a utensil’s material may be important for its function. Kitchen utensils are also occasionally named for perceptual qualities (11%), especially their shape or appearance, which fall under the “visual” relation (7%; slotted spatula). Also featuring in their names is “other property” (7%; locking tongs, adjustable slicer); such compounds have modifiers that describe features that permit the utensil to perform its intended purpose well.

Baked goods also are most often named for an associated event (71%), the most common of which is “made of” (56%; [chocolate chip] cookie), which allows reference to a key ingredient; however, they are also sometimes named for perceptual qualities (16%), most often “visual” (9%; checkerboard cake).

In contrast, greens and legumes are most often named for perceptual properties (40%; mainly “visual” and “color”) or environmental properties (27%). They are also more likely than kitchen utensils (0%) or baked goods (1%) to have
Table 5: Head-modifier relations for compounds, disaggregated by subdomain.

<table>
<thead>
<tr>
<th>Meta-relations</th>
<th>Relation</th>
<th>Natural Kinds</th>
<th>Artifacts</th>
<th>Natural Kinds</th>
<th>Artifacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Greens and legumes</td>
<td>Kitchen utensils</td>
<td>Baked goods</td>
<td>Precious minerals</td>
</tr>
<tr>
<td>Borrowed</td>
<td>Borrowed</td>
<td>36 (13%)</td>
<td>0 (0%)</td>
<td>2 (1%)</td>
<td>13 (4%)</td>
</tr>
<tr>
<td>Total Borrowed</td>
<td></td>
<td>36 (13%)</td>
<td>0 (0%)</td>
<td>2 (1%)</td>
<td>13 (4%)</td>
</tr>
<tr>
<td>Perceptual</td>
<td>Color</td>
<td>49 (17%)</td>
<td>0 (0%)</td>
<td>10 (4%)</td>
<td>137 (38%)</td>
</tr>
<tr>
<td></td>
<td>Dimension</td>
<td>4 (2%)</td>
<td>7 (2%)</td>
<td>1 (1%)</td>
<td>1 (0%)</td>
</tr>
<tr>
<td></td>
<td>Distinctive Part</td>
<td>13 (5%)</td>
<td>5 (2%)</td>
<td>3 (1%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>Taste/Smell</td>
<td>12 (4%)</td>
<td>0 (0%)</td>
<td>8 (3%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>Visual</td>
<td>35 (12%)</td>
<td>22 (7%)</td>
<td>26 (9%)</td>
<td>74 (20%)</td>
</tr>
<tr>
<td>Total Perceptual</td>
<td></td>
<td>113 (40%)</td>
<td>34 (11%)</td>
<td>48 (16%)</td>
<td>212 (58%)</td>
</tr>
<tr>
<td>Environmental</td>
<td>Location</td>
<td>11 (4%)</td>
<td>3 (1%)</td>
<td>0 (0%)</td>
<td>8 (2%)</td>
</tr>
<tr>
<td></td>
<td>Social/Political</td>
<td>67 (24%)</td>
<td>4 (1%)</td>
<td>15 (5%)</td>
<td>88 (26%)</td>
</tr>
<tr>
<td>Total Environmental</td>
<td></td>
<td>78 (27%)</td>
<td>7 (2%)</td>
<td>15 (5%)</td>
<td>96 (26%)</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Meta-relations</th>
<th>Relation</th>
<th>Natural Kinds</th>
<th>Artifacts</th>
<th>Natural Kinds</th>
<th>Artifacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Greens and legumes</td>
<td>Kitchen utensils</td>
<td>Baked goods</td>
<td>Precious minerals</td>
</tr>
<tr>
<td>Event</td>
<td>Made Of</td>
<td>1 (1%)</td>
<td>51 (16%)</td>
<td>166 (56%)</td>
<td>7 (2%)</td>
</tr>
<tr>
<td></td>
<td>Method</td>
<td>6 (2%)</td>
<td>1 (0%)</td>
<td>27 (9%)</td>
<td>8 (2%)</td>
</tr>
<tr>
<td></td>
<td>Used-By</td>
<td>4 (2%)</td>
<td>0 (0%)</td>
<td>1 (1%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>Object-Nom</td>
<td>0 (0%)</td>
<td>124 (38%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td>3 (1%)</td>
<td>1 (0%)</td>
<td>13 (5%)</td>
<td>1 (0%)</td>
</tr>
<tr>
<td></td>
<td>Purpose</td>
<td>6 (2%)</td>
<td>84 (26%)</td>
<td>1 (1%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td></td>
<td>Total Event</td>
<td>20 (7%)</td>
<td>261 (80%)</td>
<td>208 (71%)</td>
<td>16 (5%)</td>
</tr>
<tr>
<td>Other</td>
<td>Named After</td>
<td>2 (1%)</td>
<td>0 (0%)</td>
<td>11 (4%)</td>
<td>6 (2%)</td>
</tr>
<tr>
<td></td>
<td>Other Property</td>
<td>15 (5%)</td>
<td>24 (7%)</td>
<td>5 (2%)</td>
<td>1 (0%)</td>
</tr>
<tr>
<td></td>
<td>Whole–Part</td>
<td>20 (7%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>7 (2%)</td>
</tr>
<tr>
<td></td>
<td>Value</td>
<td>2 (1%)</td>
<td>1 (0%)</td>
<td>6 (2%)</td>
<td>14 (4%)</td>
</tr>
<tr>
<td></td>
<td>Total Other</td>
<td>39 (14%)</td>
<td>25 (8%)</td>
<td>22 (8%)</td>
<td>28 (8%)</td>
</tr>
</tbody>
</table>

| N = 286 | N = 327 | N = 295 | N = 365 | N = 378 |
borrowed names (13%; adzuki bean). Compared to kitchen utensils (80%) and baked goods (71%), greens and legumes (7%) are far less likely to be named for an associated event. Those that are named for an associated event are most often named for “purpose” (chili bean) or “method” of preparation (dry pea, split pea).

Turning to the conceptual domain of jewelry and precious minerals, pieces of jewelry are usually named for perceptual qualities (68%). This finding may initially seem surprising because we predicted perceptual features to be associated with essences and, therefore, natural kinds, rather than artifacts such as jewelry. However, we suggest that this finding can be attributed to the decorative function of jewelry, which makes its appearance salient. Within the perceptual meta-relation, jewelry is most often named for “distinctive part” (61%; cross ring, heart bangle). Less commonly, jewelry is named for “visual” features (7%; choker necklace, lariat necklace). Although jewelry differs from other artifacts in being often named for perceptual features, it patterns like other artifacts in often being named for an associated event (28%). Within the event meta-relation, the most common relation is “made of” (19%; [sterling silver] bracelet). The material makes reference to the event of the jewelry’s creation, but may also characterize its utility, in that the material of a [sterling silver] bracelet makes it durable as well as imparting a shiny look.

Like jewelry, precious minerals are usually named for perceptual qualities (58%, compared to 68% for jewelry), as predicted for natural kinds. Although the most common relation within the perceptual meta-relation for jewelry is “distinctive part” (heart necklace), the most common perceptual relation for precious minerals is “color” (38%; blue diamond), followed by “visual” (20%; snakeskin agate, star topaz). The names of precious minerals also frequently involve the environmental meta-relation (26%), usually as “social/political” (24%; Australian opal, Chinese pearl) and sometimes as “location” (2%; freshwater pearl). A few precious minerals are named for events (5%), usually “made of” (2%; quartz crystal). Although jewelry and precious minerals are named for perceptual qualities in equal proportions, the second most common meta-relation for precious minerals is environmental (26%, as compared to 1% for jewelry), while the second most common meta-relation for jewelry is event (28%, as compared to 5% for precious minerals).

Finally, we turn to the Deverbal Head Hypothesis, the hypothesis that deverbal heads will be more prevalent among compound names for artifacts than for natural kinds. We focus on the distribution of heads formed from verbs with the affix –er (cherry pitter, paddle grater) in order to avoid potential controversy about whether a head is truly deverbal when the noun and verb have the same form (press). Among compound names for kitchen utensils, 153 of 327 (47%) have –er heads. One baked good has such a head, but it may not be synchronically
recognized as such (graham cracker). Across all other subdomains, there are no such heads. In the aggregate, therefore, 15% (153 of 1000) of the artifact compounds and 0% (0 of 651) of the natural kind compounds had such a head; that is, there is a clear difference between artifacts and natural kinds. We also observe nuance within the category of artifacts: deverbal heads are significantly more frequent among kitchen utensil compounds than among baked good and jewelry compounds. This distribution is not surprising (see Note 7): –er nominals that do not refer to humans tend to refer to instruments, the most canonical of artifacts. Since kitchen utensils are the most prototypical artifacts in our corpus, it is not surprising that they are given the most prototypically instrument-like names.

4.3 Discussion

In both the aggregated and disaggregated results, we find that the head-modifier relations used in compounds depend on whether the compound names an artifact or a natural kind, supporting the Events vs. Essences Hypothesis. Consistent with the Event-Related Modifier Hypothesis, artifacts tend to be named for an associated event. For example, cheese slicer is associated with the event of slicing cheese and refrigerator cookie is associated with the event of refrigerating the dough as a step in the creation of a certain type of cookie. In contrast, natural kinds tend to be named for their essential properties – appearance (kidney bean), location (field greens), or place of origin (Madagascar opal), consistent with parts (a) and (b) of the Essence-Related Modifier Hypothesis. Natural kinds are also overall more likely to have borrowed names, consistent with part (c) of the Essence-Related Modifier Hypothesis, although this effect is driven mainly by the greens and legumes rather than the precious minerals.

Consistent with the Domain-Dependent Naming Pattern Hypothesis, we also find that compounds naming different artifact types (kitchen utensils, baked goods, jewelry) and different natural kind types (greens and legumes, precious minerals) display different preferences for head-modifier relations. Within the category of artifacts, kitchen utensils are often named for an event of use (banana slicer, fish scaler), while baked goods tend to be named for an event of creation (chocolate cake, refrigerator cookie). We suggest that since kitchen utensils are designed for many purposes, the event of use is key to characterizing a particular utensil. In contrast, since all baked goods are intended to be eaten, their event of use does not distinguish among them; instead, they tend to be identified by their key ingredients, evoking the event of their creation. We also find that jewelry is unique among artifacts in often being named for perceptual features, echoing the observation from Wisniewski and Love (1998: 195) that compound names
for items of clothing often pattern with those of natural kinds. This finding fits with the Domain-Dependent Naming Pattern Hypothesis because the perceptual features of jewelry are highly salient to its function as adornment. Moreover, a clear cue that jewelry is an artifact still shines through: jewelry is quite likely to be named for an associated event (28%), as in leather bracelet, which references the material used in the event of creation, or wedding band, which references the time of use.

Within the category of natural kinds, we also find evidence consistent with the Domain-Dependent Naming Pattern Hypothesis. Precious minerals are more often named for their perceptual features than greens and legumes (58% vs. 40%), perhaps because precious minerals are primarily recruited for visual purposes while greens and legumes are recruited for eating. Even within the perceptual meta-relation, precious minerals differ from greens and legumes. Precious minerals are overwhelmingly named for their color (blue diamond, lemon citrine), while greens and legumes are named for a range of perceptual properties, including taste (pepper cress) and shape (kidney bean). We suggest that these distributional differences arise because precious minerals are often recruited for adornment, a purpose for which color is especially relevant.

Our findings could be interpreted as evidence for a continuum between artifacts and natural kinds (see also Keil 1989: 55–56), with kitchen utensils as the most artifact-like artifacts, and pieces of jewelry as artifacts that share with natural kinds a tendency to be named for perceptual features. At the natural kind end of the continuum, precious minerals might be seen as natural-kind-like natural kinds, whereas greens and legumes could be seen as natural kinds that show a slight tendency to be named for associated events related to their use as food, an artifact-like property. Such a cline between artifacts and natural kinds would show, as suggested in earlier sections, that naming depends on how humans construe entities, not just on the biological fact of the matter.

On the whole, the corpus results are consistent with our hypotheses. The compound name given to an entity depends on whether it is conceptualized as an artifact or a natural kind. Within these broad categories, more specific preferences for compound names depends on the way that humans interact with the named entity.

5 Experimental studies

To replicate and generalize the findings from our corpus study, we also tested whether the distinction between artifacts and natural kinds is manifested when people create or interpret novel compounds. We conducted a production
experiment in which participants were asked to give a compound name to a novel physical object, and a comprehension experiment in which participants were asked to describe the referent of a novel compound.21

There is a considerable, ever-growing psycholinguistic literature on compounds, primarily noun-noun compounds. These studies almost exclusively investigate the comprehension of compounds, and the major questions for investigation have been quite different from ours (e.g., determining whether both the whole and the parts are listed in the mental lexicon, identifying the respective role of the head and the modifier in facilitating comprehension; see Gagné 2009 for a review). Instead, we are interested in using comprehension and production studies to evaluate our hypotheses that the head-modifier relation in a compound depends on the nature of its head. We believe there are interesting points of contact between this other work and ours, which could be probed in future studies for further insight into the nature of compounding.

5.1 Experiment 1: A production study

5.1.1 Methods

In our first experiment, participants read a description of a novel artifact or natural kind, as in (6) and (7). Each description mentioned the object’s place of origin, appearance, and use, in a randomized order. Participants were then asked to provide a two-word (compound) name for the object.

(6) You subscribe to a service that sends you new food items every month. This month, you receive a new type of chickpea.
   a. It comes from Istanbul.
   b. It is green in color.
   c. You use it to make hummus.
   What two-word name would you give to this new food?

(7) You subscribe to a service that sends you new household tools every month. This month, you receive a new type of spoon.
   a. It comes from Berlin.
   b. It is blue in color.
   c. You use it to mold cookies.
   What two-word name would you give to this new tool?

21 The data from these experiments are available via the Open Science Framework at https://osf.io/t43kd/.
To distract subjects from the purpose of the study, subjects were also asked how much they thought the object costs and where they would store it in their homes.

Eight items were constructed using the template illustrated in (6) and (7); four described novel artifacts and four described novel natural kinds. The items were presented in a random order. Fifty self-identified native speakers of English participated for pay on Amazon’s Mechanical Turk, all using US IP addresses. Five subjects were later excluded for not following instructions: for giving names that were not compounds (*quiche*) or that were not clearly related to the descriptions given (*big dipper*). A question asking about each subject’s native language came at the end of the experiment, and subjects were paid regardless of their answer to encourage honesty.

### 5.1.2 Results

We coded each compound for whether the modifier referred to place, appearance, or use – the three pieces of information provided about the novel object. We excluded 72 out of a total of 400 responses because they were not exactly two words; they were exocentric compounds (*Zurich’s triangles* to describe a triangular-leafed chard from Zurich); or the compound mistakenly named a food made from the ingredient or tool rather than the ingredient or tool itself (*homemade hummus*). The excluded answers included those from the five subjects mentioned above. We were left with 328 compounds to analyze. Sample compounds provided for the items in (6) and (7) follow:

(8) *Istanbul pea, green chickpea, Turkish chickpea*
(9) *cookie molder, Berlin spoon, blue spoon, cookie spoon*

Table 6 reports count and percent data for the modifiers chosen depending on whether the compound’s referent is an artifact or a natural kind. When the referent is an artifact, the compound’s modifier relates to its use approximately 51.2%
of the time, whereas when the referent is a natural kind, the compound’s modifier relates to its use approximately 4.4% of the time. More than 90% of the modifiers of compounds whose referent is a natural kind refer to place or appearance; however, fewer than 50% of the artifact compounds show such modifiers. Further, among the artifact compounds, there was a strong preference for appearance over place modifiers, in contrast with natural kind compounds which showed these two types of modifiers almost equally. This distribution may reflect the strong correlation between a natural kind’s place of origin and its essential properties, a correlation that does not apply to artifacts.

For the analysis, we collapsed the three types of names (names making reference to place, appearance or use) into two types: names that we predicted to be associated with artifacts (names referencing use) and names that we predicted to be associated with natural kinds (names referencing appearance or place of origin). We used R (R Development Core Team 2012) to conduct a series of logistic regression models (using the glmer() function in the lme4 library; Bates and Sarkar 2007) on these data to determine if the nature of the object being described (kitchen utensil vs. food item) predicted its log odds of being named for use vs. appearance/place (again, these were grouped together as a single outcome, reflecting our prediction that they are both ways of capturing the essence of a natural kind).

There is some debate in the literature about the best way to analyze data using mixed-effect models: whether the model should always use the maximal number of parameters justified by the study design (Barr et al. 2013)\(^{22}\) or whether several different models should be run, deciding on a case-by-case basis which parameters actually contribute to the model (Bates et al. 2015).\(^{23}\) We tried both approaches; we ran several different models, all with the nature of the object described (artifact vs. natural kind) as a fixed effect. This effect was always highly statistically significant ($p < 0.001$). In some models, we also included as a control a fixed effect for the order of the descriptors in the stimulus (Order 1 = place, appearance, use; Order 2 = appearance, use, place; Order 3 = use, place, appearance).

The most conservative model that converged on our data included a fixed effect for the nature of the object being described (artifact vs. natural kind), a fixed effect for the order of the descriptors, and an interaction term between the two.

\(^{22}\) Such a model is the most conservative: it attributes variance in the data to each of these parameters, thus attributing less variance to the independent variable. Such a model, then, is the least likely to identify a spurious effect.

\(^{23}\) This method avoids a problem that maximally conservative models have, failing to converge because there is insufficient data to estimate so many parameters.
This model also allowed random intercepts for both item and subject. According to this model, as hypothesized, the nature of the object was a highly significant ($p < 0.01$) predictor of the dimensions that are highlighted in its name ($\beta = -2.29$, standard error $= 0.63$).

Because order was not a significant predictor, we ran a less conservative model without it. This model had a single fixed effect for the nature of the object being described (artifact vs. natural kind), as well as random intercepts for both items and subjects. According to this model, the nature of the object was again a highly significant predictor ($p < 0.001$) of whether its compound name would reflect event-related or essence-related qualities. This is the model reported in Table 7.

<table>
<thead>
<tr>
<th>Novel entity type</th>
<th>Entity description</th>
<th>P(name evokes use)</th>
<th>P(name evokes place or appearance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artifact</td>
<td>blue spoon from Berlin used to mold cookies</td>
<td>51.2%</td>
<td>48.8%</td>
</tr>
<tr>
<td>Natural kind</td>
<td>green chickpea from Istanbul used to make hummus</td>
<td>3.5%</td>
<td>96.5%</td>
</tr>
</tbody>
</table>

This model predicts (using the \texttt{plogis} function, which turns log odds into regular percentages) that an artifact (e.g., the blue spoon from Berlin used to mold cookies) has a 51.2% chance of being named for its use (cookie molder, cookie spoon), and a 48.8% chance of being named for its appearance or origin (blue spoon, Berlin spoon). In contrast, a natural kind (e.g., the green chickpea from Istanbul used to make hummus) has a 3.5% chance of being named for its use (hummus chickpea) and a 96.5% chance of being named for its appearance (green chickpea) or origin (Istanbul/Turkish chickpea).

5.1.3 Discussion

This study found that when people give compound names to novel objects, the head-modifier relations in these compounds display the same tendencies we
found in our corpus study. When the novel object is an artifact, the compound’s modifier tends to reference its use; when it is a natural kind, the modifier tends to reference the object’s appearance or place of origin.

5.2 Experiment 2: A comprehension study

5.2.1 Methods

Experiment 2 tests whether the pattern found in Experiment 1 works in reverse: that is, when people encounter a novel compound, the head-modifier relation that they posit depends on whether the compound refers to an artifact or a natural kind. Participants were given a novel compound and asked to describe the object that this compound refers to. We hypothesize that when the compound’s head is an artifact, the object will be described in terms of an event associated with its creation or use, whereas when its head is a natural kind, the object will be described in terms of its essential properties. For example, the established compound butter knife uses the modifier butter to evoke the event the knife is used for, whereas the compound butter bean uses the same modifier to evoke the bean’s perceptual properties, that is, a creamy taste. We predict that this pattern would be manifested in novel compounds as well as established ones.

We constructed pairs of novel compounds that shared the same modifier but differed as to whether they had an artifact or a natural kind head, as in beer towel/beer bean or sand hammer/sand mushroom. This structure, which holds the modifier constant, allows us to isolate the effect of an artifact head vs. a natural kind head. Moreover, as these pairs show, in half of our stimuli, the modifier was an artifact (beer, in beer towel/beer bean) and in the other half, the modifier was a natural kind (sand, in sand hammer/sand mushroom). Participants saw each modifier in only one condition: either with an artifact head (beer towel, sand hammer) or with a natural kind head (beer bean, sand mushroom). For each novel compound, participants were then asked to describe briefly what it might refer to:

(10) Imagine that you encounter the compound beer bean/beer towel. What would you think this refers to?

(11) Imagine that you encounter the compound sand mushroom/sand hammer. What would you think this refers to?

In creating each pair of stimuli (beer towel/beer bean, sand hammer/sand mushroom), we ensured that the pair of heads (towel/bean, hammer/mushroom)
were roughly matched for their frequency (per million words) as nouns in the CELEX database (Baayen et al. 1995), a database of English spoken and written word frequencies by lexical category.

We also wanted to ensure that it was roughly equally easy to imagine a referent for each member of a pair (beer towel/beer bean). That is, we wanted to avoid pairs in which one member was much more fantastical than the other, such as the easily imaginable thunderstorm movie vs. the less plausible thunderstorm cat. Therefore, we began with 46 pairs of items (of the form beer towel/beer bean and sand hammer/sand mushroom). We then ran a norming study on Mechanical Turk in which subjects were asked to rate each member of each pair (92 items total) on a Likert scale (1–5) for how easily they could imagine what it might refer to. These 46 pairs were then ranked in reverse order of their average difference in plausibility, so that the pairs with members having the most comparable average plausibility were at the top of the list. From this ranked list, we chose the 10 best pairs with artifact modifiers (beer towel/beer bean), and the 10 best pairs with natural kind modifiers (sand hammer/sand mushroom), for a total of 20 pairs (40 items out of the original 92 piloted). These pairs served as our experimental stimuli. In the analysis, one pair of compounds (desert pea/desert shield) was excluded because we realized that one member was an established name for a war operation (Desert Shield), leaving us with 19 pairs for analysis out of the original 20 pairs tested.

Participants saw one randomly chosen member of each pair, either the member with an artifact head (beer towel) or the member with a natural kind head (beer bean). Stimuli were presented in random order and interspersed with 20 fillers, which all referred to abstract objects (ghost notion, nanny problem, librarian lie) to avoid priming participants with either artifacts or natural kinds. Sixty people participated for pay on Amazon’s Mechanical Turk. As in Experiment 1, all of them used US IP addresses, and at the end of the experiment all indicated that their native language was English after being advised that they would be paid regardless of their answer.

5.2.2 Results

We coded each description of the target compound using the same coders’ manual that we used for the corpus study. We excluded any descriptions that named the modifier rather than the head of the compound (e.g., describing brandy olive as ‘brandy that has a slight olive taste’ or jam apple as ‘jelly’), as well as descriptions that were so vague or puzzling as to be uncodable (e.g., describing jam apple as ‘a type of apple’). We also excluded any results that would be coded as “other”
according to our coders’ manual. In total, we excluded 141 of 798 responses, leaving us with 657 analyzable data points. Some sample descriptions from the participants follow:

(12) **beer towel**: a towel that is used for beer; a towel with a beer logo; a towel that beer companies give away

(13) **beer bean**: a bean used to make beer; a bean that tastes like beer; a bean you eat while you’re drinking beer

In Table 8, we present the counts and percentages of descriptions that fall into the event meta-relation and the perceptual and environmental meta-relations, the two meta-relations associated with essences. These show that a compound is more likely to be described in “event” terms (referring to its event of creation or use) if its head is an artifact, and it is more likely to be described in “essence” terms (referring to its origin or appearance) if its head is a natural kind.

Table 8: Percentage of novel compounds that are understood to display head-modifier relations evoking events of the referent’s use vs. perceptual or environmental qualities of the referent, depending on whether the modifier refers to an artifact or a natural kind, and on whether the head refers to an artifact or a natural kind.

<table>
<thead>
<tr>
<th>Compound type</th>
<th>Example</th>
<th>Event</th>
<th>Perceptual</th>
<th>Environmental</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>art mod, art head</td>
<td>e.g. stew skillet</td>
<td>93%</td>
<td>7%</td>
<td>0%</td>
<td>N = 195</td>
</tr>
<tr>
<td>nk mod, art head</td>
<td>e.g. stream wheel</td>
<td>88%</td>
<td>12%</td>
<td>0%</td>
<td>N = 157</td>
</tr>
<tr>
<td>art mod, nk head</td>
<td>e.g. stew chickpea</td>
<td>66%</td>
<td>34%</td>
<td>0%</td>
<td>N = 157</td>
</tr>
<tr>
<td>nk mod, nk head</td>
<td>e.g. stream vegetable</td>
<td>15%</td>
<td>34%</td>
<td>51%</td>
<td>N = 148</td>
</tr>
</tbody>
</table>

As in Section 5.1.2, we conducted a series of more and less conservative mixed-effects logistic regression models (once again using the *glmer()* function in R’s *lme4* library). Our models all assessed whether the novel object was characterized differently depending on whether its head, its modifier, or both were artifacts or natural kinds. In all the models that converged on our data, there was a highly significant effect (*p* < 0.001) of head type (whether the compound’s head was an artifact or a natural kind) and its interaction with modifier type (whether the compound’s modifier was an artifact or a natural kind).

The model M1 that we report in our tables included a fixed effect for head type (artifact vs. natural kind), modifier type (artifact vs. natural kind), and their interaction. As random effects, we allowed different intercepts for each particular head, each particular modifier, and each subject. A model M2 with even more conservative mixed-effects structure, allowing different slopes for each subject.
depending on the head type, modifier type, and their interaction, failed to converge on these data. We also ran a different model M3 which did not include a random effect for the head or the modifier, but did allow the slope as well as the intercept to vary for each subject depending on the head type; our results were significant according to that model as well.

According to our main model M1, there is a significant effect of head type ($\beta = 2.38$, standard error $= 0.68$, $p < 0.001$), meaning that when the head of the compound is a natural kind, the compound has a significantly greater chance of being described in terms of the properties we associate with natural kinds. An artifact modifier combined with an artifact head (stew skillet) has a 2.7% chance of being described in terms of environmental or perceptual properties, whereas an artifact modifier combined with a natural kind head (stew chickpea) has a 23.1% chance of being described in these terms; see Table 9.

Table 9: Probability, according to model M1, that the head-modifier relation in a novel compound in Experiment 2 will be interpreted to evoke the referent’s essence or associated event, depending on the nature of its head and modifier.

<table>
<thead>
<tr>
<th>Modifier = Natural kind</th>
<th>Head = Natural kind</th>
<th>Head = Artifact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stream vegetable</td>
<td>92.3%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Stream wheel</td>
<td>7.7%</td>
<td>96.4%</td>
</tr>
<tr>
<td>Modifier = Artifact</td>
<td>Stew chickpea</td>
<td>Stew skillet</td>
</tr>
<tr>
<td>P(essence interpretation)</td>
<td>23.1%</td>
<td>2.7%</td>
</tr>
<tr>
<td>P(event interpretation)</td>
<td>76.9%</td>
<td>97.3%</td>
</tr>
</tbody>
</table>

The effect of modifier type is not significant on its own ($\beta = 0.23$, standard error $= 0.96$, $p > 0.05$). An artifact modifier combined with an artifact head (stew skillet) has a 2.7% chance of being described in terms of environmental or perceptual properties; a natural kind modifier combined with an artifact head (stream wheel) has a 3.6% chance of being described in terms of these properties – not significantly different.

However, although modifier type is not significant on its own, there is a highly significant interaction between head type and modifier type ($\beta = 3.45$, standard error $= 1.05$, $p < 0.01$). When the head and modifier of the compound are both natural kinds (stream vegetable), the compound has a 92.3% chance of being described in terms of environmental or perceptual properties – far more than would be predicted based on the simple additive effect of a natural kind modifier and natural kind head together.

In other words, when the head and modifier differ (when one is an artifact and the other is a natural kind), the head matters more. When the head is an
artifact, the modifier does not significantly \((p > 0.5)\) affect the types of relations that are ascribed to the referent; thus, the effect of an artifact head is so strong as to neutralize the effect of the modifier. When the head is a natural kind, the modifier does matter; if the modifier is also a natural kind (stream vegetable), the referent has a 92.3\% chance of being ascribed the head-modifier relations we associate with natural kinds, whereas if the modifier is an artifact (stew chickpea), this chance declines to 23.1\%, a significant difference \((p < 0.01)\). The fact that the head matters more than the modifier fits with our hypothesis: since the referent of an endocentric compound is a subtype of the head, the head determines whether the referent is an artifact or a natural kind, and therefore influences how the compound is understood.

5.2.3 Discussion

This study presented participants with novel compounds and asked them to describe what each compound refers to. Consistent with our hypotheses, our corpus findings, and Experiment 1, we find that participants tend to describe the novel compound in terms of an associated event if it refers to an artifact and in terms of its perceptual or environmental features if it refers to a natural kind. This finding comes out in the effect of the head type, since the head of the compound determines whether its referent is an artifact or a natural kind. Moreover, we found that participants also take the modifier into account when they posit a relationship between head and modifier: when the modifier and head are both natural kinds, the referent is even more likely to be described using the head-modifier relations predicted to hold of natural kinds than when only the head is a natural kind.

Although we did not consider the nature of the modifier in formulating our hypotheses in Section 3, the observed asymmetries make sense. Some artifacts are designed to be used on artifacts (pie crust cutter), while others are designed to be used on natural kinds (lemon juicer), so both artifact and natural kind modifiers are expected. Yet our results suggest that in some instances, combining a natural kind head with an artifact modifier (stew chickpea) is enough to push participants to describe the compound’s referent in terms of an event.\(^{25}\) That is, the referents of

\(^{25}\) Although consultants took the head-modifier relation to evoke an event over 75\% of the time when a natural kind noun had an artifact modifier, we do not take this finding to vitiate the Events vs. Essences Hypothesis and its corollary, the Essence-Related Modifier Hypothesis. Natural kind heads occur considerably more often with natural kind than artifact modifiers. Thus, only 10 out of 286 greens and legumes compounds and 19 out of 365 precious mineral compounds in our corpus had artifact modifiers, and further, only 5 of these 29 compounds involved head-modifier
such compounds are apparently construed as artifacts by taking the kind to have been cultivated, bred, trained, or otherwise recruited for human use. Once again, this underscores our point in Section 3 that the artifact–natural kind distinction is not always solely a matter of biological fact.

In contrast, natural kinds pre-exist artifacts, so perhaps it is unsurprising that they are most often described in terms of other natural kinds rather than in terms of artifacts. Furthermore, the distinctive perceptual properties reflective of certain natural kinds’ essences can make the names of certain natural kinds particularly well-suited as modifiers. Such names can be used metonymically to highlight a comparable property of a second natural kind. Thus, the choice of the modifier *daffodil* in *daffodil cake* allows the distinctive yellow color of a daffodil to be used to evoke the distinctive color of a particular cake, while in *zebra jasper* the reference to a zebra, with it distinctive black and white stripes, is used to evoke the distinctive appearance of a particular precious mineral.

6 Conclusion

We have identified a clear pattern within the notoriously idiosyncratic domain of compounding: that the head-modifier relation used in a compound depends largely on whether the referent of the compound is an artifact or a natural kind. Drawing on insights from the literature, we have argued that compounding is an act of naming and categorizing entities which is shaped by the way we interact with those entities. Therefore, we have suggested that a compound name for an entity will tend to highlight the properties of that entity that are salient for human interaction with it, and that these properties depend on whether the referent is conceptualized as an artifact or as a natural kind.

We have argued that artifacts are conceptualized in terms of events, either the event in which the artifact is created or the event in which it is intended to be used. We therefore predicted that compound names for artifacts would tend to make reference to such events, as in *wedding cake* (specifying the occasion when this cake is consumed), *icing spatula* (specifying a key participant in the event that the spatula is designed for), and *loaf cake* (specifying the type of pan used in the event of creating this cake).

relations falling under the event meta-relation. See also Keane and Costello (1996: 4) for further corroborating evidence.

26 Modifiers referring to artifacts can figure in the types of head-modifier relations characteristic of natural kinds, especially if the artifact has distinctive perceptual features (*lyre bird*, a bird whose tail is shaped like a lyre).
As for natural kinds, we have shown that these are conceptualized in terms of an essence, reflected in a set of distinctive properties of that kind. We therefore predicted that compound names for natural kinds would attempt to capture the essence of the kind by alluding to its perceptual features or typical habitat, or by using a word borrowed from another language, as in green bean (naming a distinctive color that sets this kind apart from other beans), Belgian endive (naming a region where the kind may have evolved its unique traits), or garbanzo bean (using a borrowed word as a stand-in for the ineffable distinctive traits of this type of bean).

We have tested these hypotheses in a corpus study and two experiments. Our corpus study shows that there are indeed distinct preferences as to which head-modifier relations are found in compound names for artifacts vs. natural kinds: artifacts tend to be named for events, whereas natural kinds tend to be named for essential properties. Our corpus study also illustrates diversity within these categories as well as between them: we found that although pieces of jewelry qualify as artifacts, they are often named for their perceptual features as if they were natural kinds, because their appearance is highly salient for their function as adornment. This nuance within the category of artifact is consistent with our broader claim that compound names highlight the attributes of the referent that are salient for our human interaction with it, which depends on the specific way we use the referent. We use artifacts for a purpose, so they tend to be named for this purpose. We use jewelry for a decorative purpose, so pieces of jewelry tend to be named for their appearance because this is relevant for their purpose. Our experiments show that the differential preferences exhibited in the naming patterns for artifacts and natural kinds extend beyond existing compounds; they also shape the way that we create and interpret novel compounds.

More broadly, we hope that this study exemplifies that the challenges posed by semantic context-dependence can and should be tackled. Dowty (1979) and Partee (1995) suggest that a fully compositional account of compound interpretation is not possible, as it requires context to precisely identify the relationship between a compound’s head and the modifier. Here we have developed an account of this form of context-dependence by showing that the relationship posited between a compound’s head and modifier depends largely on whether the compound’s referent is an artifact or a natural kind, and specifically on the features salient to human interaction with that particular type of referent. More generally, we suggest that any time a semantic analysis depends heavily on context, it should be taken as a challenge to explain how. This paper has tried to respond to one such challenge.
Acknowledgment: We thank Harald Baayen and two reviewers for their detailed comments on an earlier version of this paper. We have presented this material in a number of venues and we have benefited from the questions and comments of the audiences. We are very grateful to Simon J. Todd for guidance on statistics and Katherine Hilton for assistance with coding the data.

Appendix A. Head-modifier relations used in the corpus study

Meta-relation and relations associated with events (i.e. artifacts)

<table>
<thead>
<tr>
<th>Meta-relation: Event</th>
<th>Subtype: Event of Creation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Made of</td>
<td>The modifier describes a salient material or component of the head; note that the head does not need to be entirely made of this material/component for this relation to apply</td>
</tr>
<tr>
<td></td>
<td>Almond biscotti, [brown sugar] cookies, cocoa brownies, chrome tourmaline, leather bracelet, rubber spatula</td>
</tr>
<tr>
<td>Method</td>
<td>The modifier evokes the method by which the item is created</td>
</tr>
<tr>
<td></td>
<td>Skillet cookies, minute cake, refrigerator cake, cultured pearl, engraved toe ring, split pea</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subtype: Event of Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Time</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Used-by</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Object-nom</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Note: In this table we have separated the head-modifier relations according to whether they involve an event of creation or an event of use, although we subsume all of them under the event meta-relation.
### Meta-relations and relations associated with essences (i.e. natural kinds)

<table>
<thead>
<tr>
<th>Meta-relation: Borrowed</th>
<th>Pignoli cookies, bundt cake, keshi pearl, trapiche emerald, civet bean, palmier bracelet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borrowed</td>
<td>The modifier is borrowed from another language</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Freshwater pearl, toe ring, garden pea, water spinach, upland cress, kitchen shears</td>
</tr>
<tr>
<td><strong>Social/political</strong></td>
<td>Moravian [sugar cookies], Greek cookies, Russian [tea cake], [Turquoise Mountain] turquoise, Australian opal, Carolina bean</td>
</tr>
<tr>
<td><strong>Meta-relation: Environmental</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Color</strong></td>
<td>White cake, black amber, champagne pearl, brown lentil, rainbow chard, cranberry bean</td>
</tr>
<tr>
<td><strong>Dimension</strong></td>
<td>Long bean, deep spoon, narrow spatula, monster cookies</td>
</tr>
<tr>
<td><strong>Distinctive part</strong></td>
<td>Charm bracelet, anchor earrings, [red eye] bean, red-leaved chicory, stem lettuce, [blunt end] spoon</td>
</tr>
<tr>
<td><strong>Taste/smell</strong></td>
<td>Sweet bean, sugar pea, pepper cress, sour dock, butter lettuce, [piña colada] cake</td>
</tr>
<tr>
<td><strong>Visual</strong></td>
<td>Lace cookies, [stained glass] cookies, coin pearl, dalmatian jasper, bubble necklace, kidney bean</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>The other meta-relation and the head-modifier relations it subsumes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meta-relation: Other</strong></td>
</tr>
<tr>
<td><strong>Named after</strong></td>
</tr>
<tr>
<td><strong>Other property</strong></td>
</tr>
</tbody>
</table>
Meta-relation: Other

| Whole–part | The modifier describes a whole of which the head is a part (not to be confused with distinctive part) | Elephant ivory, walrus ivory, beet green, pumpkin green, taro leaf, turnip top |
| Value | The modifier describes a subjective value judgment associated with the head | Dream bar, wacky cake, fancy jasper, precious coral, wonder bean, ultimate [citrus tool] |

Note: This table brings together the remaining head-modifier relations that we coded; none of them is uniformly associated with events (and, hence, artifacts) or essences (and, hence, natural kinds).

Appendix B. Experimental stimuli

Experiment 1

The order of the three descriptors (place of origin, appearance, use) was randomized.

Natural kind descriptions. You subscribe to a service that sends you new food items every month.

(14) This month, you receive a new type of bean. {It comes from Peru. It is brown in color. You use it to make soup.}
(15) This month, you receive a new type of chickpea. {It comes from Istanbul. It is green in color. You use it to make hummus.}
(16) This month, you receive a new type of cabbage. {It comes from Guatemala. Its leaves are shaped like hearts. You use it to make coleslaw.}
(17) This month, you receive a new type of chard. {It comes from Zurich. Its leaves are shaped like triangles. You use it to make quiche.}

Artifact descriptions. You subscribe to a service that sends you new household tools every month.

(18) This month, you receive a new type of pan. {It comes from Naples. It is shaped like a diamond. You use it to bake pizza.}
(19) This month, you receive a new type of ladle. {It comes from Texas. It is black in color. You use it to serve chili.}
This month, you receive a new type of spoon. {It comes from Berlin. It is blue in color. You use it to mold cookies.}

This month, you receive a new type of rack. {It comes from Iran. It is shaped like a V. You use it to roast meat.}

Experiment 2

Artifact modifier. In each pair, the item on the left has a natural kind head, while the item on the right has an artifact head.
1. beer bean / beer towel
2. brandy olive / brandy spoon
3. butter lentil / butter pick
4. jam apple / jam pan
5. spaghetti lettuce / spaghetti scissors
6. stew chickpea / stew skillet
7. vinegar chard / vinegar colander
8. salad weed / salad glove
9. champagne herb / champagne jar
10. panini leaf / panini tool

Natural kind modifier. In each pair, the item on the left has a natural kind head, while the item on the right has an artifact head.
1. duck potato / duck screen
2. sand mushroom / sand hammer
3. stream vegetable / stream wheel
4. swamp squash / swamp thermometer
5. field sprout / field tongs
6. water endive / water spatula
7. stick broccoli / stick whisk
8. shrimp kale / shrimp rack
9. oyster radish / oyster ladle
10. desert pea/ desert shield (pair excluded since Desert Shield has an established use)

References


