Compounds and the limits of compositionality
Chris Potts, Ling 130a/230a: Introduction to semantics and pragmatics, Winter 2021
Feb 9

1 Goals

• Take lexical meaning more seriously.
• The dark side of compositionality? (Move to a more flexible notion of compositionality?)
• Levin et al. 2019 as an outstanding example of
  – Complementary empirical methods in linguistics (intuitions, corpora, experiments)
  – Semprag interacting with general cognition
  – Open science: https://osf.io/6rgse/

2 The basics of English compounds

(1) Stress pattern: on the head in modifier constructions (general for English) but generally on the modifier for compounds.

<table>
<thead>
<tr>
<th>Modifier-head</th>
<th>Compound</th>
</tr>
</thead>
<tbody>
<tr>
<td>black BIRD</td>
<td>BLACK bird</td>
</tr>
<tr>
<td>black BOARD</td>
<td>BLACK board</td>
</tr>
<tr>
<td>white HOUSE</td>
<td>WHITE house</td>
</tr>
<tr>
<td>toy STORE</td>
<td>TOY store</td>
</tr>
<tr>
<td>brick FACTORY</td>
<td>BRICK factory</td>
</tr>
</tbody>
</table>

(2) Adverbial modifiers block compound readings:

a. really white house
b. light blue bird

(3) Contrastive readings with compounds will tend to sound like language games:

a. [Inspecting photos of famous houses]
   # The president lives in the WHITE house and Mark Twain lived in the BROWN one.
b. Blackbirds are rarer than bluebirds.
c. ?? Blackbirds are more common than green ones.

(4) Entailment:

a. That blackbird is green!
b. # That black bird is completely orange!
3 Partee (1995) on compounds and compositionality

(5) **Compositionality:** The meaning of a whole is a function of the meanings of the parts and of the way they are syntactically combined.

(6) Partee (1995:341): “In compounds, on the other hand, there is no general rule for predicting the interpretation of the combination [...]. A TOY store (in typical contexts) is a store that sells toys, a TOY box is a box that holds toys, and so on. Semanticists in general do not expect a semantic theory to provide a compositional semantics for compounds but do expect a compositional semantics for modifier–head construction. The reasoning is that a native speaker cannot generally interpret a novel compound on first hearing on the basis of knowledge of the language alone, but can do so for a novel modifier–noun construction.”

We might question how predictable regular modification actually is (Partee 1984:161):

(7) a. flat surface
b. flat tire
c. flat note
d. flat beer
e. flat file

Our focus, though, is on the degree to which compound meanings are predictable, and on what the answer means for the status of the compositionality principle.

(8) a. Adjectival modification (handled by rule (A) in our grammar):

```
NP
   AP    NP
      |    |
     A    N
     |    |
   white house
```

b. Compound (no parts, hence no compositional analysis):

```
N
   |
white house
```

If syntacticians say that compounds have syntactic structure, then this poses a dilemma for us, as compositionality would compel us to give meanings to the sub-parts and predictably derive the meaning for the whole, but Partee said that that can’t be done – see (6).

4 Levin et al. (2019)

“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.” (Levin et al. 2019)
4.1 Theoretical background

(9) Discussion limited to endocentric compounds – those that entail the property named by the head noun:
   a. \{x : \text{[chocolate cake]}(x) = T\} \subseteq \{x : \text{[cake]}(x) = T\}
   b. \{x : \text{[pinto bean]}(x) = T\} \subseteq \{x : \text{[bean]}(x) = T\}

(10) Exocentric compounds are different:
   a. \{x : \text{[ladyfinger]}(x) = T\} \not\subseteq \{x : \text{[finger]}(x) = T\}
   b. \{x : \text{[paperback]}(x) = T\} \not\subseteq \{x : \text{[back]}(x) = T\}

(11) Natural kinds vs. artifacts:
   a. Natural kind are generally not made by people, and they are defined by their essential physical attributes – animals, minerals, molecules, planets, etc.
   b. Artifacts are generally created with specific purposes in mind – tools, foods, art, etc.
   c. Vagueness alert! The line between natural kinds and artifacts can be hard to draw. Levin et al. (2019:438) consider the challenges posed by living things that are bio-engineered to have specific properties.

4.2 Central hypotheses

(12) Events vs. essences hypothesis (p. 438): 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.

By (9), reference will be determined by the head noun.

(13) Event-related modifier hypothesis (p. 439): 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.

(14) Essence-related modifier hypothesis (p. 440): 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.
4.3 Corpus study

Example sources  Online databases from the domains of food/cooking (utensils, cakes, cookies, greens, and legumes) and jewelry/precious minerals (bracelets, necklaces, rings, earrings, gemstones, pearls, corals, and ebones).

In-class mini-study  We'll do a Zoom poll in which we use Table 2 (p. 445) to classify the following compounds according to their head–modifier relation:

(15) a. kidney bean  
    b. pinto bean  
    c. bundt cake  
    d. depression cake  
    e. charm bracelet  
    f. bubble necklace

Coding  Done by three linguistics graduate students uninformed about the goals of the study (p. 447).

Hypotheses  Table 3 collapses Table 2 into the categories used for analyses:

(16) a. Artifact referent: Event  
    b. Natural kind referent: Perceptual, Environmental, Borrowed

Results (simplified from Table 4):

<table>
<thead>
<tr>
<th></th>
<th>Natural kinds</th>
<th>Artifacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptual/Environmental/Borrowed</td>
<td>548 (84.2%)</td>
<td>369 (36.9%)</td>
</tr>
<tr>
<td>Event</td>
<td>36 (5.5%)</td>
<td>574 (57.4%)</td>
</tr>
<tr>
<td>Other</td>
<td>67 (10.3%)</td>
<td>57 (5.67%)</td>
</tr>
<tr>
<td>Total</td>
<td>651</td>
<td>1000</td>
</tr>
</tbody>
</table>

Statistical analysis  Levin et al. (2019:448) further support these results with chi-squared tests, which in essence test whether the numbers in their Table 4 (or as above) are different from what we would expect if the modifier types and referents were independent of each other, taking into account the different rates at which these are observed (row and column totals).
4.4 Production experiment

Hypotheses

(17) a. Artifact referent: Use (by (13a))
b. Natural kind referent: Appearance or place of origin (by (14a, b))

Example item

(18) i. 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.
ii. What two-word name would you give to this new food?
iii. How much do you think this chickpea would cost? (distractor)
iv. Where would you store this chickpea in your home? (distractor)

(19) Potential responses:
   a. Istanbul pea (place of origin)
   b. green chickpea (appearance)
   c. hummus chickpea (use)

Participants 50 crowdworkers on Amazon Mechanical Turk (p. 455).

Coding Done by the authors, I believe (p. 455).

Results (simplified from Table 6):

<table>
<thead>
<tr>
<th>Modifier</th>
<th>Referent</th>
<th>Artifact</th>
<th>Natural Kind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place/Appearance</td>
<td>83 (48.8%)</td>
<td>151 (95.6%)</td>
<td></td>
</tr>
<tr>
<td>Use</td>
<td>87 (51.2%)</td>
<td>7 (4.4%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>170</td>
<td>158</td>
<td></td>
</tr>
</tbody>
</table>

Statistical analysis Levin et al. (2019:448) present a regression model in which the nature of the object (artifact or natural kind) is used to predict the modifier type (place/appearance or use), together with predictors meant to capture the unanalyzed sources of variation coming from different participants and different experimental items. The analysis further supports the above picture.
4.5 Free-response comprehension experiment

**Norming study**  Designed to find a set of novel compounds that sounded reasonably natural to people. The full set is in Appendix B.

**Example items**  Participants gave free-text responses to prompts. Here are two actual items with 4 randomly sampled responses for each.

(20) Imagine that you encounter the compound *stew skillet*. What would you think this refers to?

a. a skillet used specifically for cooking stew  
b. skillet to use for making stew  
c. A skillet specially made to cook stew in.  
d. A skillet that is used to make stew.

(21) Imagine that you encounter the compound *swamp squash*. What would you think this refers to?

a. squash grown in swamp  
b. A squash grown in swamps.  
c. A type of squash that grows best in swampy conditions.  
d. squash that grows in the swamp

**Design**  Crossed design (p. 459) with randomized order and 20 distractors referring to abstract objects (e.g., *ghost notion*). The crossed-design ensures that, for example, if you saw *bean towel* you did not also see *beer towel*, and that everyone saw a balanced combination of modifier/ head combinations. We'll elaborate on this when reviewing our own study.

**Coding**  Done by the authors using the same protocols as used in the corpus study (p. 459).

**Results (simplified from Table 8):**

<table>
<thead>
<tr>
<th>Modifier</th>
<th>Head</th>
<th>Example</th>
<th>Event</th>
<th>Perceptual/Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artifact</td>
<td>Artifact</td>
<td>stew skillet</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>Natural kind</td>
<td>Artifact</td>
<td>stream wheel</td>
<td>88%</td>
<td>12%</td>
</tr>
<tr>
<td>Artifact</td>
<td>Natural kind</td>
<td>stew chickpea</td>
<td>66%</td>
<td>34%</td>
</tr>
<tr>
<td>Natural kind</td>
<td>Natural kind</td>
<td>stream vegetable</td>
<td>15%</td>
<td>85%</td>
</tr>
</tbody>
</table>

**Statistical analysis**  Levin et al. (2019:448) again use a regression model that tries to control for unanalyzed sources of variation coming from the participants and the items. The model uses the modifier type (artifact or natural kind) and the head type (artifact or natural kind) to predict the overall interpretation (event or perceptual/environmental). It supports the above picture, and they also find evidence of an interaction between modifier and head type that you can see in the above table: the modifier matters more when the head is a natural kind than when it is an artifact.
5  Our forced-choice comprehension experiment

5.1  Design

<table>
<thead>
<tr>
<th>Mod/Head</th>
<th>Question</th>
<th>Perceptual</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>nk/art</td>
<td>What is a bunny cake?</td>
<td>A cake shaped like a bunny</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A cake that bunnies eat</td>
</tr>
<tr>
<td>1a</td>
<td>art/art</td>
<td>What is a stew skillet?</td>
<td>A skillet with a color and texture resembling stew</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A skillet used in the creation of stew</td>
</tr>
<tr>
<td>1b</td>
<td>art/nk</td>
<td>What is a stew chickpea?</td>
<td>A chickpea that tastes like stew</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A chickpea used as an ingredient in stew</td>
</tr>
<tr>
<td>2a</td>
<td>art/art</td>
<td>What are spaghetti scissors?</td>
<td>Scissors shaped like spaghetti</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Scissors used in the creation of spaghetti</td>
</tr>
<tr>
<td>2b</td>
<td>art/nk</td>
<td>What is spaghetti lettuce?</td>
<td>Lettuce shaped like spaghetti</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lettuce made of spaghetti</td>
</tr>
<tr>
<td>3a</td>
<td>nk/art</td>
<td>What is a swamp thermometer?</td>
<td>A thermometer that looks like a swamp</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A thermometer used to study swamps</td>
</tr>
<tr>
<td>3b</td>
<td>nk/nk</td>
<td>What is a swamp squash?</td>
<td>A squash that smells like a swamp</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A squash that grows in swamps</td>
</tr>
<tr>
<td>4a</td>
<td>nk/art</td>
<td>What is a stick whisk?</td>
<td>A whisk that is made of sticks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A whisk that looks like a stick</td>
</tr>
<tr>
<td>4b</td>
<td>nk/nk</td>
<td>What is stick broccoli?</td>
<td>Broccoli that has been cooked on a stick</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Broccoli that is shaped like a stick</td>
</tr>
</tbody>
</table>

*I made a mistake with this one; it's actually Environmental. See sec. 5.6.*

<table>
<thead>
<tr>
<th></th>
<th>Survey A</th>
<th>Survey B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a (art/art)</td>
<td></td>
<td>1b (art/nk)</td>
</tr>
<tr>
<td>2b (art/nk)</td>
<td></td>
<td>2a (art/art)</td>
</tr>
<tr>
<td>3a (nk/art)</td>
<td></td>
<td>3b (nk/nk)</td>
</tr>
<tr>
<td>4b (nk/nk)</td>
<td></td>
<td>4a (nk/art)</td>
</tr>
</tbody>
</table>

5.2  Warm-up item
5.3 Artifact modifier, artifact head

Both examples are consistent with (13a) and (13b), respectively, and aligned with Table 8, row 1:

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5.4 Natural kind modifier, artifact head

The left example is consistent with (13a) and aligned with Table 8, row 2. One person gave a Perceptual example in Levin et al.’s data: ‘A thermometer that has a greenish tint color’. The right example is more ambiguous. For Levin et al. (2019), 14/17 responses were Perceptual for this item. The three others were like my Event; perhaps my prompt made this more salient than it would be otherwise.

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5.5 Artifact modifier, natural kind head

These examples seem to reflect the overall uncertain for this category relative to the others. The left pattern is unexpected given (13) and (14) but consistent with Table 8, row 3. Levin et al.’s data for these examples show the same pattern.
5.6 Natural kind modifier, natural kind head

Both examples are consistent with (14). For the left example, I intended to have an Event choice here, but I got confused and used a location, which falls under Environmental. A better Event might have been ‘a squash used to encourage swamp growth’, which would have led people to favor even ‘a squash that smells like a swamp’, I think, thereby lending more support for Levin et al.’s hypotheses!

6 Conclusion

From the paper’s conclusion (p. 464):

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.

References

