# On Idioms and Compositionality

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## 1 Introduction

- The overwhelming majority of theories of semantics presuppose the *Principle of Compositionality* in (1), standardly attributed to Gottlob Frege.

  (1) **Principle of Compositionality**
  The meaning of a complex expression is a 'function of'

     (i)  the meanings of its component expressions and
     (ii) their mode of syntactic composition.

- Within Montague Grammar, this principle is implemented as a homomorphism between the syntax and the semantics (Montague 1970). The definition in (2) is from Westerståhl (1998: 635f.).

  (2) **Compositionality as a Homomorphism**
  Given the syntactic algebra $\mathbf{A} = (A, (F_\gamma)_{\gamma \in \Gamma})$ and a meaning function $m$ from $A$ to a set of meanings $M$. Let $F$ be a $k$-ary operation of $\mathbf{A}$. $m$ is *F-compositional* if there is a $k$-ary partial function $G$ on $M$ such that whenever $F(a_1, \ldots, a_k)$ is defined,
  $$m(F(a_1, \ldots, a_k)) = G(m(a_1), \ldots, m(a_k)).$$
  With $G$ as above we say that $m$ is *F-compositional with G*, and we say that $m$ is *compositional* if it is *F-compositional* for all operations $F$ of $\mathbf{A}$.

- **The Problem with Idioms:**
  Idioms seem to be in direct contrast with the requirement in (2). The meaning of, e.g., *kick the bucket* seems to be unrelated to its parts and their combination.

- **Central Question:**
  Do idioms force us to abandon (2) (and perhaps the basic idea that natural languages are compositional)?

- **A Terminological Point:**
  Given the definition in (2), it does not make sense to ask whether certain expressions are compositional. Only entire interpretations can be. What we can ask is whether we can capture idioms in a compositional semantics.

- **Outlook:**
  Westerståhl (2002) is a detailed study of idioms and compositionality. He argues that idioms are unproblematic for compositionality.

## 2 The Compositionality of Idioms: Westerståhl (2002)

- Westerståhl (2002) develops three ways in which idioms can be implemented in a compositional system. His first develops a system and then shows three ways this system has to be amended to include idioms. We will go through them and then step back to draw some general conclusions about compositionality.

### 2.1 The Basic System

  (3) **Grammar**
  A grammar
  $$E = (E, A, \underline{\alpha})_{\alpha \in \Sigma}$$
  consists of a set $E$ of **expressions**, a set $A \subseteq E$ of **atomic** expressions and for each function symbol $\alpha \in \Sigma$ a corresponding **syntactic rule**: a partial map $\underline{\alpha}$ from $E^n$ to $E$, for some $n$.

  (4) **Grammatical Terms**
  The set $GT(E)$ of grammatical terms and the function $val : GT(E) \rightarrow E$ are given by:

     a. $\alpha \in A$ is an **atomic** grammatical term, and $val(a) = a$.
     b. Suppose $\alpha \in \Sigma$ in an $n$-ary function symbol, and $p_1, \ldots, p_n \in GT(E)$ with $val(p_i) = e_i$. If $\underline{\alpha}(e_1, \ldots, e_n)$ is defined, say $\underline{\alpha}(e_1, \ldots, e_n) = e$, the term $\alpha(p_1, \ldots, p_n)$ is in $GT(E)$, and $val(\alpha(p_1, \ldots, p_n)) = e$.

- **Note:**
  NB: grammatical terms are analysis trees/derivations; *val* gives back the string associated with an analysis tree; $E$ is the set of surface expressions

(5) **SEMANTICS**
  A semantics for $E$ is a function $\mu$ whose domain is a subset of $GT(E)$. $p \in GT(E)$ is $\mu$-MEANINGFUL if $p \in dom(\mu)$.

(6) **COMPOSITIONALITY**
  $\mu$ is compositional if $dom(\mu)$ is closed under subterms and for each $\alpha \in \Sigma$ there is a function $r_\alpha$ such that, whenever $\alpha(p_1, \ldots, p_n)$ is $\mu$-meaningful,

$$\boxed{\mu(\alpha(p_1, \ldots, p_n)) = r_\alpha(\mu(p_1), \ldots, \mu(p_n))}$$

## 2.2 Treating Idioms 1: Atomic Extensions

- **Intuition:**
  Idioms are syntactically unanalyzable atoms.

(7) **GRAMMAR**
  Let $e_0 \in E - A$. The the new grammar $E^a$ is defined as
$$(E, A \cup \{e_0\}, \underline{\alpha})_{\alpha \in \Sigma}.$$
  $E^a$ is the ATOMIC EXTENSION of $E$.

(8) **Example**
  a. $e_0 = kick\text{-}the\text{-}bucket = val(\alpha_0(kick, \beta(the, bucket)))$
  b. 'John kicked the bucket.'
    (i) $\alpha(John, \alpha_0(kick, \beta(the, bucket))) \rightsquigarrow$ literal
    (ii) $\alpha(John, e_0) \rightsquigarrow$ idiomatic

- **Remarks:**
  This treatment is clearly unsatisfactory for the majority of idioms. It leaves entirely unaccounted for the fact that idioms overwhelmingly are syntactically regular, and that parts of them may be targeted by syntactic operations (e.g., *Strings were pulled to secure Henry his position; John kick+ed the bucket*).

- **Possible candidate:**
  *by and large*

## 2.3 Treating Idioms 2: Indexed Operations

(9) **GRAMMAR**
  We define a new grammar
$$E^i = (E, A, \underline{\alpha})_{\alpha \in \Sigma^i},$$
  where $\Sigma^i = \Sigma \cup \{\alpha_0^i\}$, and $\alpha_0^i$ is a new $k$-ary function sumbols such that $\underline{\alpha_0^i} = \underline{\alpha_0}$.
  $E^i$ is called a DUPLICATED RULE EXTENSION of $E$. Let $q_0^i = \alpha_0^i(q_{01}, \ldots, q_{0k})$.

(10) **Example**
  'John kicked the bucket.'
  a. $\alpha(John, \alpha_0(kick, \beta(the, bucket))) \rightsquigarrow$ literal
  b. $\alpha(John, \alpha_0^i(kick, \beta(the, bucket))) \rightsquigarrow$ idiomatic

(11) $s^-$ = the result of deleting all superscripts $^i$ in $s$.

(12) **SEMANTICS**
  The semantics for $E^i$, $\mu^i$, is defined as follows:
  a. Its domain is $K^i = \{p : p^- \in dom(\mu)\}$;
  b. $\mu^i(a) = \mu(a)$ for all $a \in A$ (whenever defined);
  c. Let $p = \alpha(p_1, \ldots, p_n)$ be a complex term in $GT(E^i)$. $p^-$ is of the form $\beta(p_1^-, \ldots, p_n^-)$, where $\beta = \alpha$ if $\alpha \in \Sigma$, and $\beta = \alpha_0^i$ if $\alpha = \alpha_0^i$. If $p^-$ is in $dom(\mu)$ then so is each $p_j^-$, so $\mu^i(p_j)$ is defined, by induction hypothesis, and

$$\boxed{\mu^i(p) = r_\alpha(\mu^i(p_1), \ldots, \mu^i(p_n))}$$

(13) **DEFINITION OF $r_{\alpha_0^i}$**

$$r_{\alpha_0^i}(m_1, \ldots, m_k) = \begin{cases} m_0 & \text{if } m_j = \mu(q_{0j}), 1 \le j \le k \\ r_{\alpha_0}(m_1, \ldots, m_k) & \text{otherwise} \end{cases}$$
  where each $q_{0j}$ is a specified meaning (e.g., $\mu(kick)$, $\mu(the\ bucket)$).

- **Consequence:**
  Nothing bad happens if $\alpha_0^i$ applies to elements that lack an idiomatic interpretation (e.g., *see John*). In this case $r_{\alpha_0^i} = r_{\alpha_0}$.

- **A Drawback:**
  Because the definition of $r_{\alpha_0^i}$ is stated in terms of the output of $\mu$, i.e., in meaning, it follows that substitution of synonymous expressions should preserve the idiomatic interpretation. If $q$ and $q_{01}$ are synonymous, then

$$\mu^i(\alpha_0^i(q_{01}, q_{02}, \ldots, q_{0k})) = \mu^i(\alpha_0^i(q, q_{02}, \ldots, q_{0k})) = m_0$$

- If, e.g., *bucket* and *pale* are synonymous, then *kick the pale* should mean *die*. Likewise, *cemetery shift* or *burial ground shift* should mean what *graveyard shift* means.

## 2.4 Treating Idioms 3: Indexed Terminals

- Many idioms, like *pull strings*, may appear in various syntactic constructions:

  (14) a. Strings were pulled to get John his position.
      b. Mary tried to pull a lot of strings.
      c. We could pull yet more strings.
      d. Those strings, he wouldn't pull for you.

- **Analysis:**
  There are special homophones of *pull* and *string*—*pull$^i$* and *strings$^i$*, respectively—that give rise to the idiomatic meaning.

- Similar accounts have been argued for by Nunberg et al. (1994) for some and by Marantz (1996, 1997) for all idioms.

  (15) **Grammar**
  We first adopt a new general definition of a grammar
  $$((E, A, \underline{\alpha})_{\alpha \in \Sigma}, v)$$
  where $E$ and $\Sigma$ are as before but $A$ no longer has to be a subset of $E$. Instead there is function $v$ from $A$ to $E$.

- We now slightly revise our definition of $GT(E)$ (only the clause for simplex expressions changes):

  (16) **Grammatical Terms**
  The set $GT(E)$ of grammatical terms and the function $val : GT(E) \rightarrow E$ are given by:
      a. $\alpha \in A$ is an ATOMIC grammatical term, and $val(a) = v(a)$.
      b. Suppose $\alpha \in \Sigma$ in an $n$-ary function symbol, and $p_1, \ldots, p_n \in GT(E)$ with $val(p_i) = e_i$. If $\underline{\alpha}(e_1, \ldots, e_n)$ is defined, say $\underline{\alpha}(e_1, \ldots, e_n) = e$, the term $\alpha(p_1, \ldots, p_n)$ is in $GT(E)$, and $val(\alpha(p_1, \ldots, p_n)) = e$.

  NB: grammatical terms are analysis trees; *val* gives back the string associated with an analysis tree

(17) **Idioms**
We then add new, idiomatic, elements $a_1^i, \ldots, a_k^i$ to $A$ such that
$$v(a_j^i) = v(a_j), 1 \le j \le k$$
That is, superscripted elements are syntactically identical to their non-indexed counterpart.

(18) The **final grammar** has the form
$$E^* = ((E, A \cup \{a_1^i, \ldots, a_k^i\}, \underline{\alpha})_{\alpha \in \Sigma}, v^*)$$
where $v^* \supseteq v$ and $v^*(a_j^i) = v(a_j)$.

(19) **Example**
'Mary tried to pull several strings.'
    a. $\alpha(Mary, \alpha_0(\delta(try\text{-}to, pull), \gamma(several, strings))) \rightsquigarrow$ literal
    b. $\alpha(Mary, \alpha_0(\delta(try\text{-}to, pull^i), \gamma(several, strings^i))) \rightsquigarrow$ idiomatic

(20) **Semantics**
The semantics for $E^*$ is $\mu^*$, which has the following properties:
    a. Its domain is $K^* = \{p : p^- \in dom(\mu)\}$,
    b. $\mu^*(a_j^i) = m_j^i$
    c. $\boxed{\mu^*(\alpha(q_1, \ldots, q_n)) = r_\alpha(\mu^*(q_1), \ldots, \mu^*(q_n))}$

- **A Problem:**
  How do we constrain the distribution of indexed expressions? In particular, how we make sure that *strings* in *Mary tried to tie several strings* does not get an idiomatic interpretation.

- **Westerståhl's Solution:**
  Make the occurrence of *strings$^i$* dependent on the occurrence of *pull$^i$* and vice versa.

  (21) A term in $GT(E^*)$ is meaningful iff it belongs to $K^*$ and for each subterm of the form $\alpha(p, \alpha_0(q_1, q_2))$ it holds that *pull$^i$* occurs in $q_1$ iff *strings$^i$* occurs in either $q_2$ or $p$.

- **What about Passives?**
  Passives are treated as underlyingly active and then derived by applying a passive rule $\alpha_P$. Thus, *Several strings were pulled by Mary* would have the structure
  $$\alpha_P(\alpha(Mary, \alpha_0(\delta(pull^i, \gamma(several, strings^i)))))$$
  and (21) is respected.

- **More Serious Problem**

  (21) is arguably too lax as it allows *pull*[i] to be licensed by *strings*[i] in subject position. Moreover, (22), from Nunberg et al. (1994), shows that elements can be interpreted as *strings*[i] even if they are not syntactically identical to *strings* and even in the absence of *pull*[i] in the required position.

  (22) a. Pat got the job by pulling strings that weren't available to anyone else.
  b. Kim's family pulled some strings on her behalf, but they weren't enough to get her the job.
  c. I would not want you to think that we are proud of our ability to pull strings, such as the ones we pulled to get you down here.

## 3 What This Tells Us About Compositionality

- **Question:**
  Is there anything we could **not** do in a compositional system?

- **Answer:**
  No. Compositionality is formally vacuous: Any semantics can be implemented as a compositional one, as proven by Janssen (1986), Groenendijk & Stokhof (1991) and Zadrozny (1994). If we have unlimited freedom in our syntax, compositionality is also empirically vacuous.

- As a result, it not surprising that idioms are unproblematic for compositionality. In fact, since compositionality is empirically vacuous, nothing could ever be an empirical problem.

- **Strengthening Compositionality:**
  In light of this, one might impose constraints on the syntactic rules (Partee 1979, Szabó 2013, and also Dowty 2007).

- **Problem:**
  Constraints on syntactic rules do not seem to rule out any of the accounts discussed here.

- **Consequences of Homomorphism:**
  Requiring every semantic operation to be mirrored by a syntactic one arguably inflates our syntax beyond what is syntactically reasonable. It also renders this framework incompatible with a wide range of declarative or representational theories of syntax, like HPSG (Pollard & Sag 1994), LFG (Bresnan 2001) or variants of MP (Brody 2002). Furthermore, if movement reduces to Merge (Chomsky 2004), it is unclear how to implement it.

- **Conclusion:**
  Implementing compositionality as a homomorphism between the syntax and the semantics is empirically vacuous. It is also at least not directly compatible with several types of syntactic frameworks.

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