Processing light verb constructions

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In light verb constructions, such as *Henry gave Elsa a kiss*, Henry is the kisser, and Elsa the 'kiss-ee', even though the main verbal predicate is *give*, not *kiss*. In these constructions, argument linking results from joint predication between *give* and *a kiss*, which reveals mismatching syntactic and semantic structures.

We test two approaches to light verb constructions: (1) joint predication in light verb constructions is stored as pre-specified, and their high frequency predicts less processing cost. (2) Joint predication in light verb constructions is built in real-time. The entailed extra-syntactic composition predicts greater cost.

Results from a cross-modal lexical decision task show delayed, higher reaction times for light verb constructions, supporting (2), which is consistent with a linguistic architecture that has partly autonomous lexico-semantic storage and processing.

Keywords: light verb construction, processing, linguistic architecture, cross-modal lexical decision, argument structure, syntactic composition, semantic composition

An enduring challenge to research in the mental lexicon is modeling the representation and processing of phrasal expressions such as idioms, which have a many-to-many correspondence between their semantic representation and corresponding syntactic structure. Whereas there has been much work on so-called noncompositional idioms (Sprenger, Levelt, & Kempen, 2006; Swinney & Cutler, 1979; Tabossi, Fanari, & Wolf, 2008), less is known about constructions that are not idiomatic, yet are also non-compositional in a Fregean sense: Expressions that fail to show a one-to-one correspondence between their syntactic and semantic representations.[1]

This kind of phrasal expression is manifested in light verb constructions. Compare a non-light sentence like *Henry gives Elsa a rose* to a light verb construction like *Henry gives Elsa an order*. In the non-light sentence, *Henry* is the 'giver' (the Agent), *Elsa* the Recipient, and *a rose* is the entity that undergoes transfer

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(the Theme). In the light verb construction, the noun complement contributes additional semantic roles in the event representation: *Henry* is the *orderer*, and thus the Agent of *ordering*, and *Elsa* is the person ordered to do something. However, *the order*, in addition to being a participant in the event representation of the sentence, is part of a complex predicate that licenses semantic roles to the other participants in the sentence. With these observations in mind, two of the questions posed by light verb constructions are: 1) what is the lexical representation of the verbs that engage in this kind of construction? and 2) what are the principles of combination that enable the kind of joint predication exhibited here? Building on previous work by others and by our lab we present two views of light verbs that address these questions and that make processing predictions that we then proceed to test.

Two main approaches have been proposed to model the representation of light verbs in the lexicon. In one approach, the light verb has a lexical entry distinct from its non-light counterpart (e.g., [*give* +$NP_{deverbal\ arg}$]$_{light}$ vs. [*give* NP_{theme}-PP_{goal}]$_{nonlight}$). Lexical retrieval of the light version is independent from the lexical retrieval of the nonlight counterpart. In the other approach, the light verb interpretation arises from the composition of a semantically underspecified verb and its (deverbal) noun complement (e.g., [$give_{\pm light}$ NP_{theme}-NP_{goal}]. Lexical retrieval of the noun complement triggers the specification of either the light or nonlight version of the verb.

An example of the first approach, which we term the Separate Entry approach, is found in Goldberg (2003) in the context of Construction Grammar, and in Hale & Keyser (1993, 2002) in the context of the Minimalist Program. We briefly discuss each in turn.

Lacking a distinction between syntax and the lexicon, Construction Grammar proposes that multi-word expressions are stored as units. The lexical items entering these expressions are either stored with the construction, as in idioms, or connect to the construction through "variable slots". Accordingly, in this approach, light verb constructions are stored in the mental lexicon as separate entries with each verb and noun fully specified (e.g., *take a walk/guess/shower*…). Support for such an approach is found, for example, in the observation that light verb constructions can be idiosyncratic, and can exhibit a high co-occurrence frequency (see Goldberg, 2003, for a discussion of Persian light verbs along these lines).

Although by different reasoning, Hale and Keyser (1993, 2002) converge on a similar representation. Their approach takes all non-light verbs, for example, *to order*, to originate from a light-verb construction, for example, *to give an order*. The verbal form *to order* is connected to the nominal form *order* by syntactic derivation, which crucially for present purposes takes place within the lexicon. Accordingly, and just like in the constructional view, light verbs are stored in the

mental lexicon with their noun complements as a single entry, so joint predication is achieved through the syntactic representation of the expression that is stored as a fixed, dedicated structure: *order* in *to give an order* has a position on the syntactic tree from which it can license semantic roles to the participants in the sentence.

Examples of the second approach, which we term the Underspecification approach, are found in various guises throughout the literature (e.g., Butt, 2003; Butt & Lahiri, 2002; Culicover & Jackendoff, 2005; Grimshaw, 1997; Müller, 2010; Pustejovsky, 1995; Wiese, 2004). These approaches derive light verb constructions by semantic composition as sentence formation takes place. As the sentence unfolds, syntactic and semantic structures get composed in parallel and synchronized through linking rules, guided by the particular semantic and syntactic information deployed with each lexical item in the sentence.

This view proposes that the light semantic representation is a subset of the non-light counterpart (see Butt & Lahiri, 2002, for extensive discussion of the semantic contributions which light verbs bring to the event representation, e.g., perfectivity). In this model, the verb, underspecified for argument structure, is retrieved from the lexicon and its semantic resolution (light or non-light) is defined by the noun complement. If the complement does not have an argument structure of its own (e.g., *orange*), the semantics of the verb (e.g., *take*) will be disambiguated towards the non-light version, resulting in a non-light interpretation for the given sentence (*take an orange*). By contrast, if the complement does have an argument structure of its own (e.g., *order/walk/shower*), then the semantics of the verb will be disambiguated towards the 'light' semantic representation, which will then be composed with the argument structure of the complement noun, creating a light interpretation (e.g., *take a shower*). Thus, on this view, light and non-light verbs are only different 'levels of resolution' of the same lexico-semantic representation, which gets disambiguated during the sentence composition process.[2]

Psycholinguistics of light verb constructions

One of the most interesting challenges in linguistic and cognitive science research is how to connect representational proposals of linguistic structure to psychological and neurological models that then allow for testable predictions at the experimental level (e.g., Phillips & Lewis, to appear; Piñango, 2006; Townsend & Bever, 2001). Even though neither Hale and Keyser's (1993, 2002) nor the constructional approach make any explicit predictions about how light verb constructions might be processed, both models conceive of light verb constructions as lexical units with their own dedicated entry; thus, a determining factor in their processing load is frequency of use, which would then be the determining factor to calculate the

retrieval cost of these complex lexical items. As it turns out, light verb constructions are extremely frequent, not only in English (Piñango, Mack, & Jackendoff, in press) but also in German (see Methods section). This allows for a straightforward prediction: light verb constructions should be retrievable faster than their non-light counterparts. Thus, all else being equal, the Separate Entry approach predicts decreased processing costs at the licensing point (i.e., right at the offset of the object noun) for light verb constructions as compared to nonlight verb+object counterparts.

The Underspecification Approach makes a different prediction: When the verb is retrieved from the mental lexicon, it is still underspecified. Retrieval of an underspecified verb predicts less processing costs for the verb (see Briem et al., 2009, for experimental evidence to this effect, and Shapiro, Zurif & Grimshaw, 1989, for the general observation that argument structure complexity modulates cost during lexical retrieval). Yet, once the deverbal noun complement is retrieved, triggering the light interpretation processing, cost is induced. The source of the cost is the (real-time) composition of joint predication between the argument structure the verb and the noun complement. For the sentence 'Sue gives a lecture" joint predication would result from: give <*agent, theme, goal*> + lecture <*agent, recipient*> yielding the following semantic role assignment:"Sue" as the *agent* of both *give* and *lecture*, "the (content of the) lecture" as a (kind of) *theme*, and "the audience" a combination of *goal+recipient*. On this view then, joint predication is an extra-syntactic *semantic* computation that must be implemented incrementally (i.e., in parallel with syntactic composition).[3] Accordingly, the comprehension process of light verb constructions is expected 1) to be more costly than that of non-light phrases, where semantic roles are assigned canonically, in line with syntactic composition and 2) the cost is non-immediate, since it should take some time for the joint predication to be implemented.

In sum, we seek to adjudicate between two approaches to light verb representation by testing their corresponding processing predictions: the Separate Entry approach, which predicts less cost for the light condition at the licensing point, and no difference anywhere else; and the Underspecification approach, which predicts more cost for the light condition but only some time after licensing, because the semantic nature of the joint predication formation requires time to fully implement itself. In what follows, we present previous experimental work, Piñango et al. (in press), which our present effort builds on, as a way of introducing the general experimental design and task that we also use here.

In Piñango et al.'s (in press) study, participants listened to three types of sentences: *Mr. Olson gave an order/gave an orange/typed an order to the produce guy*. The first construction (*gave an order*) was a light verb construction; the second (*gave an orange*) was non-light, but used the same verb as the light verb

construction; the third (*typed an order*) was non-light, using the same noun as the light verb construction. After the noun complement was heard, a visual probe, on which the participants were asked to make a lexical decision, appeared on the computer screen. This methodology assumes that the load incurred by hearing and processing a sentence will interfere with executing the lexical decision task. Accordingly, the higher the processing load on the primary task (sentence comprehension), the longer it takes to press the 'yes' button to make the lexical decision (secondary task).

Piñango et al.'s (in press) results show that when comprehension is probed right at the offset of the object head noun (e.g., *order*), participants were equally fast at simultaneously making a secondary lexical decision in the light context *give an order* as well as in the non-light context *type an order*. However, when the lexical decision probes are placed 300ms *after* the offset of the object head noun, reaction times to the lexical decision were significantly increased for the light *give an order* context, compared to the non-light *type an order* context. This difference in reaction times was interpreted as the effect of the semantic processing required by the additional integration of the argument structure of the verb and noun.[4]

Table 1. Example Sentences in German, English Literal Translation, and English SVO Word Order Translation.

(1) Light Verb Construction:	
German:	*Weil der Student seiner Kommilitonin vor dem Seminar eine Zusammenfassung gab, spendierte sie ihm letzte Woche einen Kaffee.*
English (literal):	"Because the student to his fellow student before class a summary gave, she bought him coffee last week."
(2) Same Noun Construction:	
German:	*Weil der Student seiner Kommilitonin vor dem Seminar eine Zusammenfassung kopierte, spendierte sie ihm letzte Woche einen Kaffee.*
English (literal):	"Because the student for his fellow student before class a summary copied, she bought him coffee last week."
(3) Same Verb Construction:	
German:	*Weil der Student seiner Kommilitonin vor dem Seminar einen Kugelschreiber gab, spendierte sie ihm letzte Woche einen Kaffee.*
English:	"Because the student to his fellow student before class a pen gave, she bought him coffee last week."
English word order:	"Because the student gave/copied an abstract/pen to his fellow student before class, she bought him coffee last week."

Note that the German dative (seiner Kommilitonin) can be translated into English both as "for his fellow student" and "to his fellow student".

Building on these findings, the present study takes advantage of the Subject-Object-Verb (SOV) word order in German, which is the default word order in subordinate clauses. Crucially, SOV word order allows us to obtain reaction times at the verb (*an order give* vs. *an orange give*) instead of at the object head noun (*give an order* or *give an orange*). Since the choice of verb determines whether the argument structures of noun complement and verb need to be integrated, joint predication is expected to be observable after the verb has been retrieved (i.e., the licensing position is right at the offset of the verb). Table 1 shows example sentences of the experimental conditions used in this experiment.

In the first example (1), the combination of *summary* and *give* results in a light verb interpretation. Non-light interpretations using the same noun (2) and the same verb (3), respectively, require only the deployment of the argument structure associated with the verb. As can be seen, in all three conditions, the syntactic structure is the same. In what follows, we present the methods in detail.

Methods

Task and Procedure

Following Piñango et al. (in press), we used the cross-modal lexical decision task in the interference paradigm.[5] As explained, the premise of this task is that the load incurred by interpreting the Light, Same Noun, and Same Verb sentences (primary task) will interfere with executing the lexical decision (secondary task). The greater the computational complexity of a given condition, the longer it should take to perform the corresponding lexical decision. Hence, the reaction time (RT) to the lexical decision is an indicator of the processing load of a given sentential condition.

The sentences were presented auditorily. RTs were obtained at two positions for each sentence at a given time, either immediately (right at the offset), or 300ms after the verb was heard. We call the two positions "LC" (Licensing Condition) and "LC+300" (300 ms after the Licensing Condition), respectively.

At either LC or LC+300 positions, a letter-string (probe) was flashed on a computer screen for 400ms. The participants then had to decide whether the probe was a German word or not. The time it took the participants to make this decision was recorded and constitutes the RT, our dependent measure of processing load.

Materials

In order to minimize confounding factors, we controlled for frequency of the critical verbs and nouns used (McDonald, Pearlmutter, & Seidenberg, 1994). To this end, we used the German COSMAS II Corpus, which is a collection of written documents from Germany, Austria and Switzerland. We restricted the corpus to about 19 million words, excluding anything but newspapers from the past twenty years. The newspapers sample represented all regions of Germany.

Our corpus analysis of the selected verbs and nouns showed that overall the nouns of the Light and Same Noun condition occurred more often than those used in the Same Verb condition (see Table 2). Also, the verbs in the Light or Same Verb condition were much more frequent than the verbs in the Same Noun condition. In addition, the verbs were checked for numeric frequency and for sense frequency. The selected verbs occurred significantly more often in the light sense than in the literal sense (manually counted): $\text{Mean}_{\text{Light}} = 127$, $\text{Mean}_{\text{SameVerb}} = 20.3$, Pearson correlation = .829, $p = .04$. Moreover, the noun-verb co-occurrence frequency in the light interpretation was significantly higher than that of the other object-verb combinations: on average, the light verb interpretation occurred 51 times in the corpus, the Same Verb and Same Noun combination never or just once ($p = .001$). We conclude that in line with the findings for English, for German frequency of the Light condition was significantly higher than the Same Noun or Same Verb counterparts, both for the noun complement and verb separately, and in co-occurrence of the object and the verb.

For our experimental stimuli and to control for differences in cost of the noun complements and verbs, we pre-tested all verbs and nouns in isolation in an auditory lexical decision task. 214 letter strings, half of them existing German lexical items — among those all the verbs and nouns employed in the three conditions —, half of them non-words that respected German morpho-phonological restrictions, were recorded and presented to twenty native German speakers. The subjects were between 18 and 25 years of age with self-reported normal hearing. Reaction times for the lexical decision were measured from the onset of the word, using TEMPO (Motta, Rizzo, Swinney, & Piñango, 2000). Wrong answers and outliers more than

Table 2. Frequencies and Reaction Times to Noun Complements and Verbs in Isolation.

	Object		**Verb**	
	Light/Same Noun	**Same Verb**	**Light/Same Verb**	**Same Noun**
Frequency	1441	282	4,250	712
Reaction Times	1,052ms	1,016ms	1,043ms	1,012ms

Note. While the differences in frequencies were significant, the differences in reaction times were not.

three standard deviations from each subject's individual mean reaction time were removed from the data set, resulting in a 2.1% loss.

Table 2 shows the mean reaction times to the lexical decision to nouns and verbs across conditions. An ANOVA revealed that the difference between mean reaction times to verbs in the Light or Same Verb conditions compared to verbs in the Same Noun condition was not significant ($F(1, 19) = .21$, $p = .65$) and neither was the difference between the mean reaction times to objects in the Light or Same Noun condition compared to verbs in the Same Verb condition ($F(1, 48) = 1.04$, $p = .32$). These results thus show that reaction times for the relevant noun complements and verbs did not correlate with frequency measures across conditions (noun complements: Pearson correlation = 0.116, $p = .321$; verbs: Pearson correlation = 0.119, $p = .311$). Given that our experimental task is based on lexical retrieval, lack of correlation with frequency measures reassures us that any potential difference to be found between sentential conditions from the cross-modal lexical decision task cannot be attributed to unintended co-occurrence frequency, sense frequency, or morpho-phonological frequency factors.

The experimental sentences were composed into a script of 25 sentence triplets, as in (1), (2), and (3). (A full list of the stimuli can be found in the Appendix). For each triplet, verbs and noun complements were selected on the basis of the word pretest and the corpus analysis. Pretest reaction times of verb and noun complement were added to get an approximation of an accumulated processing load. If the conditions in a triplet were to differ in terms of this composed RT this difference was always in favor of the light condition (RT-light < RT-nonlight), and never greater than 40ms. This was done to avoid a potential confound created by differences in reaction time from the object noun and or from the verb in isolation, rather than from the compositional process itself of building the light verb interpretation.

To maximize homogeneity within the light verb condition, all sentences had to meet the following criteria: a) the sentences could undergo passivization, b) the noun complement could be modified by adjectives or adverbs, and c) the verb phrase could undergo negation by the word *kein* ('none'). Additionally, all light verb sentences had to have a direct verbal counterpart (e.g. *Zusammenfassung geben — zusammenfassen*; 'give a summary' — 'summarize'). Meeting these requirements showed that the specific sentences chosen were minimally different syntactically from their non-light counterparts (Helbig & Buscha, 2001; van Pottelberge, 2001; Zifonun, 1997).

Once constructed, the experimental stimuli were subjected to an acceptability test. Ten German native speakers judged them acceptable in a randomized questionnaire (acceptance rate: 98%, with no significant difference between construction types; $p > .05$).

Each sentence appeared with a different probe word. The probe words, which were matched within triplets, were German words for which reaction times based on lexical decision had already been obtained (Wiese & Piñango, 2001). For each triplet, the probes were matched for reaction time within each set, and selected in a way that they were not semantically related to the sentence. Lack of semantic relatedness was confirmed to 99% by 15 German native speakers in a separate test (see stimuli list in the Appendix for all experimental sentence-probe pairings).

Approximately half of the probes presented were words (including those created for the filler sentences) and half were nonwords that were created according to the phonotactics of German. Altogether this resulted in a final script of 250 sentences, half of which was paired with words (experimental sentences and filler sentences) and half with non-words (filler sentences).

Based on the final script, two pseudo-randomized lists for each position were constructed. The lists were created based on the following constraints: (a) for each list, sentences of the Same Verb/Same Noun conditions preceded the Light condition only half of the time; (b) three filler sentences were placed at the beginning of the list (to give the subject time to adjust to the rhythm of the task); (c) no more than three consecutive sentences were followed by a filler with a nonword probe, and (d) at least one filler sentence appeared between any two experimental sentences.

Twenty comprehension questions were inserted into the script, each querying the immediately preceding filler sentence. Before and after each question there was at least one filler sentence.

In the LC position, the probes to the experimental sentences were placed at the offset of the verb. In the LC+300 position, the probes to the experimental sentences were placed 300ms after the offset of the verb. For all other sentences (fillers), the probes (word and nonword) were placed at various random points including the offset of the verb. Probes were triggered using TEMPO (Motta et al. 2000–2004).

A male native speaker of standard German recorded the sentences. All sentences were digitized at 22,000 samples per second.

Participants

44 native speakers of German between the ages of 18 and 35 participated in this study. Twenty-two of them were randomly assigned to the LC list (where probes appeared at position LC), and twenty-two of them were assigned to the LC+300. Eight of the subjects were tested in one position only, either LC or LC+300. Sixteen of them were tested twice, i.e. in both positions; half of these were presented with the LC position first, and half of them with the LC+300 position. For those

subjects who were tested for both positions, at least three weeks passed between the two sessions. Each session lasted about 45 minutes.

Analysis

Participants were allowed a maximum of two seconds to respond to the probes. Two participants had to be excluded from the data analysis because their performance in word probes and comprehension questions was lower than 60% (suggesting that they were not paying the required attention to the task). Eight data sets were also excluded due to problems with the word probes.

Figure 1 plots reaction times in position LC. A repeated measures ANOVA reveals that the mean reaction time for Light verbs is similar to that to Same Verb and Same Noun verbs, $F(2, 816) = 0.08$, $p = 0.91$.

Figure 2 displays reaction times in position LC+300. The data show no significant difference in reaction time between conditions Same Noun and Same Verb. However, the reaction time for lexical decisions in the Light condition is significantly longer than that in the Same Noun and Same Verb conditions. A repeated measures ANOVA reveals a significant main effect of condition between Light, Same Noun, and Same Verb sentences, $F(2, 798) = 3.23$, $p = 0.04$, as well as between Light and Same Noun, $F(1, 532) = 4.64$, $p = 0.03$, and Light and Same Verb, $F(1, 532) = 4.87$, $p = 0.03$.

For each position, and to rule out any idiosyncratic subject bias, we performed an ordinary least squares multivariate regression that decomposes individual subjects, each set and every condition into separate factors by including dummies for each of these variables. The results pattern with those from the ANOVAs: At

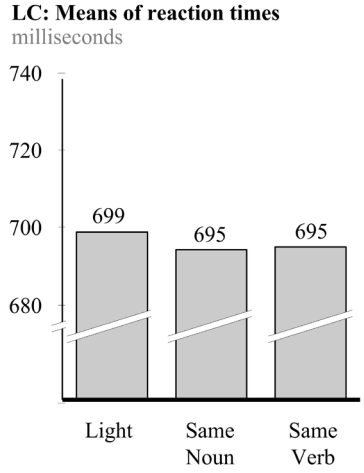

Figure 1. No significant differences in RTs at position LC.

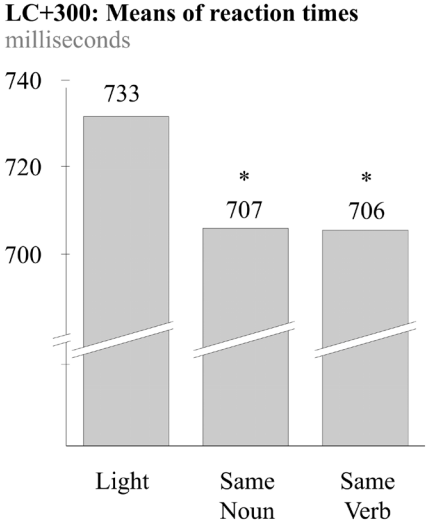

Figure 2. Reaction times are higher for light verb constructions (Light condition). The difference is significant at the 5% level ($p = .04$).

the LC position, no difference in RT is found for Light, Same Noun, and Same Verb: $F(34,784) = 11.61$; $p_{\text{SameNoun}} = .65$; $p_{\text{SameVerb}} = .69$). At the LC+300 position, however, there was a statistically significant effect showing that the Light condition resulted in significantly slower reaction times than the Same Noun and the Same Verb conditions, RTs to which were similar to each other, $F(34,766) = 7{,}15$; $p_{\text{SameNoun}} = .015$; $p_{\text{SameVerb}} = .013$.[6]

The interaction between probe positions for the Light condition was significant (albeit marginally), which suggests that the difference in reaction times between LC and LC+300 is robust, $F(40, 661) = 6.86$; $p = .06$. No such effect was found for the Same Verb, $F(40, 661) = 7.12$; $p = .99$, or the Same Noun conditions, $F(40, 661) = 6.61$, $p = .38$. This confirms that the reaction times to light verb constructions were significantly different between LC and LC+300, but not those to Same Verb or Same Noun constructions.

Summary and Discussion

In this paper, we explored the processing costs associated with the interpretation of light verb constructions, as compared to non-light counterparts. Two representational analyses were considered: a Separate Entry approach and an Underspecification approach. These two approaches share the notion that the light verb representation is a variant of the non-light one. They differ however in how the variants come about and are stored in the mental lexicon: the Separate Entry approach

treats the two variants as two distinct lexical entries (Goldberg, 1995, 2003; Hale & Keyser, 1993, 2002). The Underspecification approach, in contrast, treats the light variant as a lexical subset of the non-light, resulting in only one lexical entry for both interpretations (e.g., Pustejovsky, 1995; Butt, 2003; Butt & Lahiri, 2007; Culicover & Jackendoff, 2005; Grimshaw, 1997; Müller, 2010; Wiese, 2004). From these lexical storage implications, two distinct psycholinguistic claims follow: for the Separate Entry approach, access to the light verb construction interpretation is a function of *frequency*, which makes the non-light interpretations immediately more costly. It also predicts no difference between conditions at a later point (LC+300ms), since at this point all necessary lexical retrieval for that interpretation has already taken place.

For the Underspecification approach, access to the light verb interpretation is a function of *composition,* which might be less costly immediately upon licensing, since the verb is retrieved semantically underspecified. As comprehension unfolds, however, the composition of verbal and nominal argument structures is expected to take up additional processing resources. This predicts cost for the light interpretation, which would only be detectable sometime *after* the deverbal noun and verb have been combined.

Consistent with the Underspecification approach and replicating the findings already observed for English (Piñango et al., in press), our results show that comprehension of light verb constructions is correlated with longer reaction times 300ms after the verb is heard. The results are not consistent with the Separate Entry approach, because there was no difference between conditions at the LC position. At LC+300, the longer RTs for Light went against the Separate Entry approach.

One factor that could be claimed to contribute to the increased reaction times for the light condition is the ambiguity observed in many such constructions: *give an order*, for instance, is ambiguous between 'handing over a physical object' (nonlight reading), such as *The general gives the soldiers a secret order that must be shredded,* and 'uttering a request to do something', such as *The general gives the soldiers a secret order that must be obeyed*. Indeed, in many instances of light verb constructions, the deverbal noun complement (*order, promise, speech, presentation* etc.) is used to refer simultaneously to the piece of content *and* the physical object that holds that content. An ambiguity approach would predict greater load for one of two reasons: either (a) the two interpretations would be built simultaneously, or (b) one interpretation would be built (nonlight) which would later on have to be revised (to the light version).

In reference to (a) we note that independent experimental evidence has already shown that multiplicity of senses will only elicit increased processing load if there is insurmountable inconsistency between the interpretation of current material and the interpretation of material already processed (e.g., Frazier & Rayner,

1990; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982; Swinney, 1979). That is not the case for the light verb constructions tested here. That is, all of the experimental noun complements tested that have this duality of reference (*order/promise/sermon*…) allow an interpretation where the noun complement can refer *simultaneously* to content and physical entity. This predicts sense consistency and therefore no load (see Appendix for a complete list of items).

In reference to (b) we point out that for the light verb constructions tested, the light interpretation was the preferred interpretation. This predicts that for the sentences of the light condition, the light interpretation would be the one retrieved first, trumping any possibility for a garden-path.

More generally, it has been shown in this respect that the presence of a biasing context eliminates or reduces processing difficulty for homophones and homographs for lesser and equally likely senses (e.g., Kambe, Rayner, & Duffy, 2001; Pirog Revill, Tanenhaus, & Aslin, 2008). Given the pre-existing preference for the light interpretation we expect that this would be the interpretation first built by the processor thus eliminating any potential cost arising from any potential sense-ambiguity alone.

Finally, our results connect in an interesting way to the magnetoencephalography (MEG)-based findings reported in Briem et al. (2009). Those data show that at the point of the verb (verb *onset*), light verbs in isolation as well as in disambiguating contexts (OVS order) elicit less activation than non-light counterparts.[7] In contrast to the present work, Briem and colleagues reported only on the processing of the light verb itself, not on the implications of the semantic composition with the complement noun.

Nevertheless, even though their findings do not tell us about any delayed effects associated with joint predication, they support a depiction of the time-course of composition for light verb construction interpretation, consistent with our findings, which is rooted in the characterization of the lexical representation for light verbs and the compositional nature of the joint predication that they elicit. Such a time-course would proceed as follows: at the onset of the potentially light verb (e.g., "give" in "an order *give*"), semantic underspecification of the verb prevents immediate combinatorial computation. This results in no observable cost (or even less cost) as compared to the non-light counterpart (e.g., "an order *type*") for which full argument structure representation is already specified, paralleling our findings at LC (and also consistent with Piñango et al., in press). However, sometime *after* the deverbal noun and the light verb have combined, joint predication is fully observable. Being purely extra-syntactic (that is, not fully supported by syntactic composition), this process increases the computational demands on the comprehension system over and above the cost provided by syntactic composition alone. Such semantic composition is observed here as delayed cost at LC+300.

Initial ERP findings suggest that this chart of the time course may be on the right track. Those findings, which are also based on German with the same sentential structure as the one used here, show sustained increased negativity for the light condition as compared to non-light counterparts (Wittenberg, Paczynski, Wiese, Jackendoff & Kuperberg, 2011).

In conclusion, our results show that interpreting light verb constructions is correlated with higher processing cost, even though light verb interpretation is preferred and very frequent. This suggests that the process by which this light interpretation is generated is combinatorial and built in real-time, not the retrieval of an idiomatic or otherwise fixed expression. We have provided here a model that roots this effect in an independently motivated lexical underspecification approach to the light verbs themselves.

Altogether, our results contribute to the understanding of the encoding and processing of argument structure as semantic in nature, and lend support to a linguistic architecture with partly independent "tracks": one that allows lexico-semantic storage and computation to be at least partly independent from those processes underlying syntactic composition.

Authors Note

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Notes

1. Even though the distinction between an idiomatic expression and a non-idiomatic one can sometimes be difficult to draw, for present purposes the label 'idiom' refers to that phrasal expression whose meaning is not predictable from the meaning of its component constituents. On this definition, 'give a hand (to someone)' (as in 'help someone') is an idiom, whereas 'give a kiss' is not.

2. Although the precise characterization of the semantic information that light verbs bring to the joint predication is still an open question, the nature of this semantic information has been argued persuasively to be lexical (vs. functional), and the process of combination identified as "complex predication" (see Butt & Geuder, 2001, and Butt & Lahiri, 2002 for synchronic and diachronic arguments in support of this analysis).

3. The sentence "Bill got the order from Sue to finish the proposal" illustrates joint predication at a greater level of complexity; one that crucially appears at odds with (syntactic) word order expectations:

ARGUMENT STRUCT. : <recipient$_{Bill}$, theme$_{order=finish\ proposal}$, source$_{Sue}$>$_{get}$
<agent$_{Sue}$, recipient$_{Bill}$, theme $_{finish\ proposal}$>$_{order}$

GRAMMATICAL RELs. : [SUBJ$_{Bill}$ [PRED$_{got}$ OBJ/PRED$_{an\ order}$]]$_{got}$
[PRED$_{order}$ SUBJ$_{Sue}$ COMP$_{finish\ prop.}$]$_{order}$

SYNTACTIC STRUCT.: [NP$_{Bill}$ [$_{VP}$ V$_{got}$ [$_{NP}$ Det$_{an}$ N$_{order}$ PP$_{from\ Sue}$ IP $_{to\ finish\ the\ proposal}$]]]$_{IP}$

What we see in the structure above is the (minimal) description of the various layers of representation involved in joint predication and their correspondence. The latter is denoted by the specific lexical items involved. For instance the phrase "an order" is syntactically a NP, semantically it is the *theme* for the predicate "get" and contains the head for the second predicate "order". The predicate "order" licenses in turn a SUBJECT "Sue" (the *agent* for "order") and an infinitival complement "to finish the proposal" (the *theme* for "order"). At minimum, joint predication demands that these correspondences be established for the light interpretation to obtain. And it is this, the process claimed to be observable as computational cost during the comprehension process.

4. This finding gives support to a psycholinguistic generalization of semantic composition whereby semantic processing is isolable in the form of increased processing cost within a time window around 300ms after licensing (e.g., Boland, 1996; Downey, 2006; McElree & Griffith, 1995; Piñango, Zurif, & Jackendoff, 1999; Piñango, Winnick, Ullah, & Zurif, 2006). So this does not appear to be an isolated phenomenon. Instead, the compositional processes underlying its interpretation could be viewed as part and parcel of potentially related principles of semantic combination (see Piñango & Deo, 2010, and Deo & Piñango, 2011, for analyses seeking to bring about this connection in an approach that unifies model-theoretic and conceptual semantics).

5. The cross-modal lexical decision task (interference paradigm) has been claimed to have limitations that may be thought to compromise the validity of the data that it generates (see Pickering, McElree, Frisson, Chen, & Traxler, 2006, for a critique). One important criticism raised is that on this task, naturalistic sentence comprehension might be disturbed due to the secondary task. Two arguments have been brought to address this claim: first, experimental results have shown that subjects are able to compartmentalize the two tasks in a way that each does not unpredictably impact the other (Nicol, Fodor, & Swinney, 1994). Second, even if the task disrupted naturalistic comprehension, it should do so equally for both conditions. But what is observed is an asymmetric reaction to probes such that longer RTs are systematically observable for the experimental condition predicted to elicit greater processing cost (see also Shapiro, Brookins, Gordon, & Nagel, 1991, for discussion on the factors that play a role in bringing about an interference effect.) This said, no task is able to offer a complete picture. The goal is therefore to find converging results from a variety of complementary tasks. In this respect, the findings that we report here already find support from ERP- and MEG-based evidence (see Summary and Discussion section).

6. Including log frequency (as in the logarithmic transformation of the added frequency of noun and verb) as a predictor did not change the outcome of the regression, as seen by the identical R^2 for the regression with and without frequency as a predictor (both 30.35). The density

function of the residuals remained the same, too. Thus, including frequency as a predictor does not make the regression model a better fit for our data. This is confirmed by the high *p*-value of Frequency (.987).

7. Specifically, Briem et al. (2009) report that "whenever 'light' verbs were presented in sentence context, the disambiguating context modulated left temporal activity around 300 ms (270ms-340ms) after the onset of the verb. This strengthens the hypothesis that disambiguating context changes the verb's feature despite of identical morphological form: context-induced 'heavy reading' specified a 'light' verb sufficiently to evoke similar responses as a specific 'heavy' verb." (p. 177).

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Appendix

Experimental sentences and probes (in capital letters), together with an English translation. The first nouns and verbs of the alternates constitute the light verb constructions. Probes were rotated for each participant.

1. Als die Mutter ihrem Sohn für den Schulausflug die Erlaubnis/Thermoskanne gab/reichte, war dieser schon genervt von ihren ständigen Ermahnungen. GEBÄCK, RAUCH, RINDER *(When the mother gave/handed the permission/thermos flask for the school excursion, he was already annoyed by her repeated admonitions. PASTRIES, SMOKE, CATTLE)*
2. Obwohl die Angestellte nach dem Produktionsausfall den Kunden sofort die Mitteilung/Einkaufsgutscheine gab/schickte, waren diese mit dem Service nicht zufrieden. ERDBEEREN, TÖCHTER, BLUMEN *(Although the employee gave/sent immediately notice/vouchers to the customers after the production downtimes, they were not happy with the service. STRAWBERRIES, DAUGHTERS, FLOWERS)*
3. Als der feindliche Spion auf der Diplomatenparty dem mysteriösen Gast schnell einen Bericht/Ausweis gab/zeigte, wurde er vom Geheimdienst beobachtet. GEPÄCK, GEFLÜGEL, ZWEIGE *(When the adversarial spy gave/showed a report/a passport to the mysterious guest at the diplomat's party, he was observed by the secret service. LUGGAGE, POULTRY, TWIGS)*

4. Als der bestechliche Polizist dem inhaftierten Verbrecher vor der Gerichtsverhandlung eine Warnung/einen Lageplan gab/zeigte, bereitete dieser seine Flucht vor. ERBSEN, SEKT, MARMOR *(When the corrupt policeman gave/showed a warning/floor plan to the arrested criminal before the trial, he prepared his escape. PEAS, CHAMPAIGN, MARBLE)*
5. Weil der Student seiner Kommilitonin vor dem Seminar eine Zusammenfassung/einen Kugelschreiber gab/abschrieb, spendierte sie ihm letzte Woche einen Kaffee. OBST, TRINKWASSER, FLEISCH *(Because the student gave/copied an abstract/pen to his fellow student before class, she bought him coffee last week. FRUIT, DRINKING WATER, MEAT)*
6. Während der erschöpfte Chirurg seinem Assistenten nach der Operation eine Anweisung/eine Schere gab/reichte, wachte der Patient wieder aus der Narkose auf. SPIELZEUG, SPEICHEL, KIES *(While the exhausted surgeon gave/handed an assignment/scissors to his assistant after the surgery, the patient came out of anesthesia. TOYS, SALIVA, GRAVEL)*
7. Während die Assistentin in der Kinderklinik für den erkälteten Professor gestern einen Vortrag/ein Kleinkind hielt/kopierte, dachte sie an etwas ganz anderes. ZINK, ESSIG, MEHL *(While the assistant in the children's hospital held (=gave)/copied a speech/a baby for the ill professor, she though of something completely different. ZINC, VINEGAR, FLOUR)*
8. Als der gestresste Theologiestudent vorhin im Klassenzimmer für den Religionslehrer die Predigt/das Lesebuch hielt/abschrieb, klingelte plötzlich laut sein Handy. VIEH, SAUERSTOFF, GETREIDE *(When the busy theology student held/copied the sermon/the school book for the religion teacher a little while ago in the classroom, suddenly his cellphone rang loudly. LIVESTOCK, OXYGEN, GRAIN)*
9. Als die langjährige Sekretärin für ihren scheidenden Chef gestern mittag im Büro eine Ansprache/eine Akte hielt/abschrieb, freute sie sich schon auf ihre eigene Rente. KLEINGELD, BESTECK, LAUB *(When the longtime secretary held(=gave)/copied a speech/a file for her retiring boss in the office yesterday at noon, she was already happy for her own retirement. COINS, SILVERWARE, FOLIAGE)*
10. Als die umweltbewusste Studentin bei der Kundgebung für Solarenergie eine Rede/ein Spruchband hielt/hörte, entdeckte sie eine alte Schulfreundin in der Menge. BLEI, BETTWÄSCHE, SCHRÄNKE *(When the environmentalist student held(=gave)/heard a speech/banner at the demonstration for solar energy, she saw an old classmate in the crowd. LEAD, BED SHEETS, CUPBOARDS)*
11. Während der Schüler auf der Versammlung vor dem Rathaus gestern früh ein Referat/eine Flagge hielt/hörte, stahl eine Mitschülerin sein Fahrrad. KLEE, ROSENKOHL, FRÜCHTE *(While the pupil held(=gave)/heard a presentation at the gathering in front of the city hall yesterday morning, a fellow student stole his bike. CLOVER, BRUSSEL SPROUTS, FRUITS)*
12. Als die Studentin nach einer durchfeierten Nacht im Hörsaal die Präsentation/die Kaffeetasse hiel/hörte, entdeckte sie einen Rotweinfleck auf ihrer Jacke. SCHMIERÖL, KISTEN, SELLERIE *(When the student held/heard a presentation/coffee cup in the classroom after a party night, she saw a stain of red wine on her jacket. GREASE, BOXES, CELERY)*
13. Nachdem der überarbeitete Musiklehrer in der Übungsstunde zur Gitarre genervt Aufgaben/Lautsprecher stellte/verteilte, konnte jeder Schüler selbst einmal spielen. LEHM, SCHLAGSAHNE, GRÄSER *(After the overworked music teacher in the lesson about/next to the guitar irritatedly put/distributed assignments/loudspeakers, every pupil could play by herself. MUD, WHIPPING CREAM, GRASSES)*
14. Seit die bekannte Künstlerin in der Staatsoper endlich seit dieser Saison eine Aufführung/einen Schreibtisch hatte/leitete, beantwortete sie zuverlässig Fanpost. NEKTAR, NACHWUCHS, BAUSTEINE *(Since the famous artist finally had/directed a performance/desk in*

the opera since this season, she reliably answered fan letters. NECTAR, OFFSPRING, BUILDING BLOCKS)

15. Als der vorbestrafte Demonstrant auf der illegalen Demonstration vor dem Bundestag letzte Woche die Initiative/das Spruchband ergriff/plante, schritt die Polizei sofort ein. SCHREIBPAPIER, MAGERMILCH, SCHWEFEL *(When the previously convicted demonstrator seized/planned the initiative/banner at the illegal demonstration in front of the parliament last week, the police intervened immediately. STATIONARY, SKIM MILK, SULFUR)*
16. Als der exzentrische Künstler in seinem Atelier zum Thema "Irakkrieg" eine Bemerkung/eine Skulptur machte/hörte, geriet er mit seinem Assistenten in Streit. UNKRAUT, MÖHREN, GABELN *(When the eccentric artist made/heard a remark/sculpture about the Iraq war, he got into a fight with his assistant. WEEDS, CARROTS, FORKS)*
17. Als der geständige Verbrecher in der Talkshow vor laufender Kamera die Flucht/das Kleinkind ergriff/berichtete, riefen Hunderte Zuschauer beim Sender an. SCHMUCK, SPARGEL, PRALINEN *(When the confessing criminal seized/reported the escape/the baby in the talk show on air, hundreds of viewers called the TV station. JEWELERY, ASPARAGUS, CHOCOLATES)*
18. Als die geduldige Lehrerin mit den Kindern nach der Pause ein Spiel/einen Tee machte/aufräumte, fingen zwei Jungen einen Streit miteinander an. MOBILIAR, PETROLEUM, BAUHOLZ *(When the patient teacher made/cleaned up a game/tea with the children after the break, two boys started a fight. FURNITURE, PETROLEUM, TIMBER)*
19. Als der erfahrene Therapeut mit der nervösen Patientin gestern einen Spaziergang/eine Bastelarbeit machte/plante, kam ein wirklich gutes Gespräch zustande. GESCHOSSE, SPARBÜCHER, LAVA *(When the experienced therapist made(=took)/planned a walk/handicrafts with the nervous patient yesterday, a really good conversation came about. BULLETS, SAVINGS, LAVA)*
20. Weil die Frau nach dem Lesen der Frauenmagazine immer für nur drei Tage begeistert eine Diät/eine Bastelarbeit machte/lobte, lachte ihr Mann sie aus. ANSCHAUUNG, LANDKARTE, SCHRANK *(Because the woman made/praised a diet/handicrafts only for three days after reading the women's magazines at the hairdresser's, she was laughed at by her husband. OPINION, MAP, CUPBOARD)*
21. Als die gelangweilte Praktikantin ihrer Freundin während der Arbeit für ihren Geburtstag einen Vorschlag/eine Collage machte/schickte, kam ihr Chef ins Büro. MUNITION, ZUGLUFT, LATTEN *(When the bored intern made/sent a proposal/collage to her friend for her birthday during work, her boss came into the office. AMMUNITION, DRAFT, SLATS)*
22. Weil die Schülerin in der Pause immer Hausaufgaben/Papierflieger machte/abschrieb, ass sie ihr Pausenbrot auf dem Heimweg. KLIPPEN, KALZIUM, BÜGELBRETTER *(Because the pupil always made(=did)/copied homework/paper planes during the break, she ate her sandwich on the way home. CLIFFS, CALCIUM, IRONING BOARDS)*
23. Während der neue Angestellte der Firma auf dem Tag der offenen Tür Werbung/Brötchen machte/verteilte, spielten seine Kollegen Skat im Bierzelt. NEUSCHNEE, HENNEN, HELIUM *(While the new employee of the company made/distributed advertisement/sandwiches at the open house, his colleagues played cards in the beer tent. FRESH SNOW, HENS, HELIUM)*
24. Als der berühmte Arzt in seinem Labor dem Patienten zur neuen Therapie Angaben/Arzneien machte/zeigte, wirkte er sehr zuversichtlich. GESINDE, MÄGDE, SIRUP *(When the famous physician made/showed statements/medicaments for the patient about the new therapy in his lab, he was very optimistic. SERVANTS, MAIDSERVANT, SIRUP)*

25. Bevor die Apothekerin im Labor letzten Montag die Änderungen/Arzneien machte/entdeckte, hatte sie mit ihrem Chef telefoniert. POSTER, VILLA, ZEITUNG *(Before the pharmacist made/discovered the changes/drugs in the lab last Monday, she had talked to her boss on the phone. POSTER, VILLA, NEWSPAPER)*

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