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Of Papers and Pens: Polysemes and Homophones in Lexical (mis)Selection

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Abstract

Every word signifies multiple senses. Many studies using comprehension-based measures suggest that polysemes' senses (e.g., *paper* as in *printer paper* or *term paper*) share lexical representations, whereas homophones' meanings (e.g., *pen* as in *ballpoint pen* or *pig pen*) correspond to distinct lexical representations. Less is known about the lexical representations of polysemes compared to homophones in language production. In this study, speakers named pictures after reading sentence fragments that primed polysemes and homophones either as direct competitors to pictures (i.e., semantic-competitors), or as indirect-competitors to pictures (e.g., polysemous senses of semantic competitors, or homophonous meanings of semantic competitors). Polysemes (e.g., *paper*) elicited equal numbers of intrusions to picture names (e.g., *cardboard*) compared to in control conditions whether primed as direct competitors (*printer paper*) or as indirect-competitors (*term paper*). This contrasted with the finding that homophones (e.g., *pen*) elicited more intrusions to picture names (e.g., *crayon*) compared to in control conditions when primed as direct competitors (*ballpoint pen*) than when primed as indirect-competitors (*pig pen*). These results suggest that polysemes, unlike homophones, are stored and retrieved as unified lexical representations.

Keywords: Language production; Lexical access; Meaning; Polysemy

1. Introduction

There are many words in a language, but there are many more senses, for every word can be used in more than one sense. The multiplicity of meanings is likely an inevitable consequence of using discrete lexical representations (e.g., entries in a dictionary, words in a newspaper) to signify indeterminately bounded referents such as concepts, images, and events. A classic (Caramazza & Grober, 1976) and ongoing (Falkum & Vicente,

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2015) question in psycholinguistics takes the form: How are the multiple senses of an individual word represented in the mental lexicon? Whether an individual word's senses are represented together as "core-lexical representations" or separately as distinct lexical representations may depend on the degree to which the senses are semantically related. A word is a polyseme if it signifies semantically related senses (e.g., *paper* as *printer paper* or *term paper*). A word is a homophone if it signifies semantically unrelated meanings (e.g., *pen* as *ballpoint pen* or *pig pen*).

This is not to say that words are dichotomously categorized as either polysemes or homophones. It is possible for a word (e.g., *bill*) to signify homophonous meanings (*duck bill*; *dollar bill*) as well as polysemous senses (*dollar bill*; *electric bill*). Furthermore, a word's meanings and senses may be related to varying degrees on a continuum of semantic relatedness, ranging from not-at-all related in the case of homophonous meanings to very closely related in the case of polysemous senses (Durkin & Manning, 1989; Evans, 2015; Klepousniotou, 2002). Whereas evidence has shown that homophones' semantically unrelated meanings are represented separately in the mental lexicon (Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982), less is known about the lexical representations of polysemes' semantically related senses. How polysemes' senses are represented in the mental lexicon is the guiding question of this paper. That there exists an important parallel between semantic relatedness and representational unity is the guiding intuition.

In a consensus model of language production (e.g., Levelt, Roelofs, & Meyer, 1999), lexical access starts with a *message* (i.e., conceptual information) that is mapped onto a lexico-syntactic representation termed a *lemma*, which then, secondly, activates a morphophonological representation termed a *lexeme* (e.g., Ferreira & Griffin, 2003). With regard to polysemy, Evans (2015) outlined a theoretical distinction between polysemy at the conceptual level (i.e., a word refers to multiple, related non-linguistic aspects of knowledge, such as concepts) and polysemy at the lexical level (i.e., a word refers to multiple, related linguistically mediated meanings, such as other lexical units). This distinction between the message and lexical levels of representation is important to the question of representational unity: When asking, for example, whether *term paper* is unified with or separate from *printer paper*, the locus of (dis)unity must be specified. Whether polysemes' senses are unified at the conceptual level is an ongoing question. Srinivasan and Rabagliati (2015) observe that the multiple referents evoked by a polyseme may be related experientially. A speaker may, for example, recall memories of printing a *term paper* on a sheet of *printer paper*. However, it is difficult to ascertain whether two concepts are unified because concepts are indeterminately bounded, abound with associative links (Leshinskaya & Caramazza, 2014), and vary as a function of individual experiences (Evans, 2015). The question of representational unity is more straightforward at the lexical level, where representations are discrete: Do a polyseme's multiple senses map onto (i.e., spread activation to) the same discrete lexical representation (i.e., lemma)? This paper investigates (dis)unity at the lexical locus from the side of production.

According to separate-storage accounts of polysemy (Lehrer, 1990), polysemes' senses are stored separately, similar to homophones' meanings (e.g., Fig. 1A). Evidence for the separate-storage view is provided by Klein and Murphy (2001), who showed that

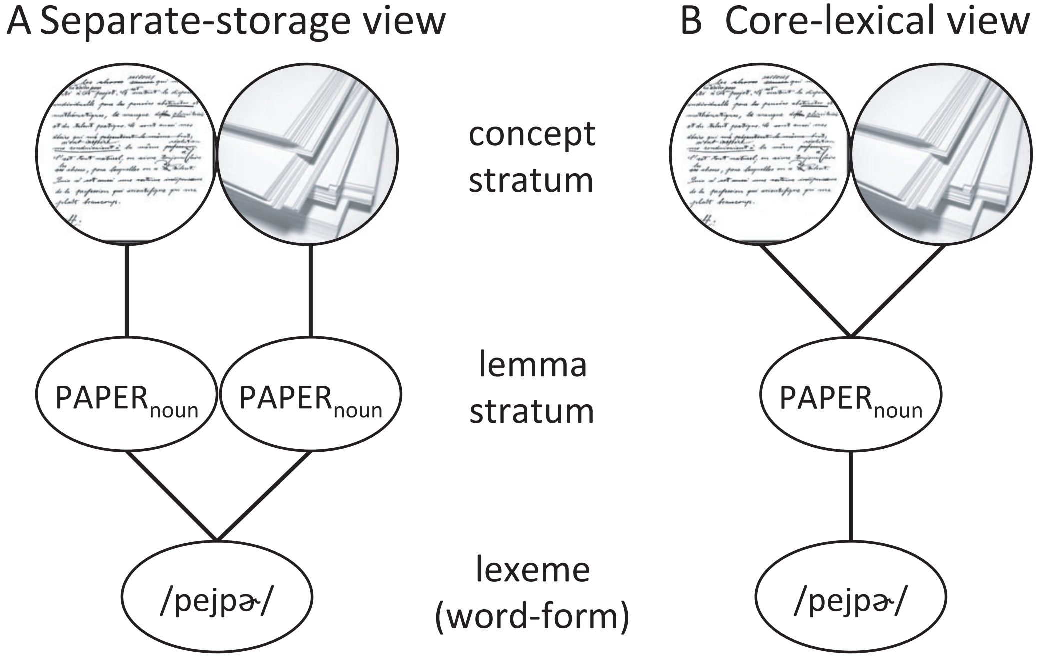


Fig. 1. Separate-storage (1A) and core-lexical (1B) models of the polyseme *paper*.

polysemes and homophones elicit similar responses in a sensicality judgment task. After subjects read a polysemous or homophonous word used in one sense, they were slower to judge whether the same word made sense when it was used in a different sense (e.g., reading the phrase *wrapping paper* and then judging whether the phrase *liberal paper* makes sense). The switching cost between the different meanings or senses of the same word implies that separate lexical representations exist for these different meanings or senses. Put another way, no switching cost would be expected to result from repeated instantiations of the same representation.

Alternately, a core-lexical view of polysemy models a polyseme as a single representation that includes multiple, related senses (e.g., Fig. 1B). By this account, lexical representations may serve as "thin" underspecified points of access to the "rich" multimodal information of the conceptual stratum (Falkum & Vicente, 2015). In this way, a lemma may be a shared locus of convergence of multiple aspects of conceptual information, similar to how a lexeme may be a locus of convergence shared by multiple lemmas. A "core-lexical" lemma representation may be one on which multiple conceptual representations converge. Many studies using comprehension-based measures have provided evidence that polysemes' senses behave like core-lexical representations in comprehension. For instance, young children understand that a novel label for an object can signify polysemous senses of that label, but cannot signify homophonous meanings of that label (Srinivasan & Snedeker, 2011). For example, a novel label *blicket* is understood to mean both *book* as in *bound book* and *book* as in *exciting book*, but a novel label *devo* meaning *bat* as in *baseball bat* is not assumed to also mean *bat* as in *flying bat*.

Other comprehension-based support for the core-lexical view is that adult participants respond faster to polysemes than to homophones on lexical decision tasks (Klepousniotou, 2002; Rodd, Gaskell, & Marslen-Wilson, 2002). Klepousniotou (2002) interpreted this asymmetry to mean that a homophone's meanings reside in separate lexical entries, such that selecting the appropriate lexical entry for a particular context requires a sequential, time-consuming retrieval process. Conversely, a polyseme's senses may belong to one basic semantic value that fits many contexts and thereby bypasses a sequential selection process. Rodd, Gaskell, and Marslen-Wilson (2004) interpreted the asymmetry in lexical decision time in terms of a network model of semantic space, in which polysemes are represented as broad, shallow attractor basins that encompass multiple senses, whereas homophones are represented by separate, deep attractor basins for each meaning. Lexical decision judgments are slower for homophones because the retrieval mechanism, upon encountering a homophone, temporarily settles into a blend state between the meanings' separate attractor basins and must resolve the blend state before making a lexical decision. In contrast, a polyseme's broad, shallow attractor basin enables the retrieval mechanism to more quickly arrive at the minimum threshold level needed to make a lexical decision.

One concern with these studies is that their findings may reflect, at least in part, participants' meta-linguistic knowledge of how polysemes' senses are related. For example, the children in Srinivasan and Snedeker's (2011) study who understood that the polyseme *book* signifies a concrete as well as an abstract sense may have used a meta-linguistic, derivational rule to relate the two senses of *book* to one word-form, without necessarily retrieving one unified representation of *book* from their mental lexicons. In addition, most cognitive research on polysemes has focused on comprehension, so little is known about the representations of polysemous words in the production system.

An investigation from the side of production is especially worthwhile for the question of representational unity. When a language user comprehends an orthographic or phonological representation by way of reading or listening, activation spreads from that target representation to other representations in the person's mental lexicon (Collins & Loftus, 1975). A classic example is the indirect activation of *bug* as in *wiretapping bug* when reading a sentence that constrains toward *bug* as in *winged bug* (Swinney, 1979). Given that the comprehension of a word as it appears in any sense entails a simultaneous activation of the word's other, semantically unrelated senses, it may be in principle not possible to discern, using comprehension-based measures, whether a word's multiple senses are truly unified in representation, or whether the word's multiple senses are separate but consistently co-activated.

However, in production, a speaker begins with a communicative intention in mind that he or she would like to map onto an appropriate lexical representation. What differs between comprehension and production is the locus of ambiguity: in comprehension, the word-form is given and the communicative intention is selected; in production, the communicative intention is given and the word-form is selected. For example, a person who intends to speak about insects is not deciding on whether to say *bug* as in *wiretapping bug* or *bug* as *winged bug*, but has in fact already decided to talk about *bug* as in *winged bug* and is only making a decision on whether to select *bug*, *insect*, *arthropod*, or some other suitable word-form as the means of expression. Importantly, if the representation for *bug* as in *wiretapping bug* is retrieved along with the representation for *bug* as in *winged bug* in the process of fulfilling the communicative intention to talk about insects —in other words, if the two senses of a word can be shown to be retrieved together in production even when there is no communicative intention to retrieve one of the two senses—then it is likely that the two senses are inseparably fused in one unified lexical representation, such that one sense cannot be retrieved without the other.

An error elicitation paradigm is an appropriate way to investigate representational unity in production (cf. Ferreira & Griffin, 2003; Rabagliati & Snedeker, 2013). Measures of unintended speech errors in word production can both inform assumptions about the architecture of the production system and avoid meta-linguistic influences because speech errors, by definition, slip by the influence of meta-linguistic knowledge. Using such a paradigm, Ferreira and Griffin (2003) provided evidence that a homophone's unrelated meanings are represented as separate lemmas (i.e., lexico-syntactic representations) that converge on a shared lexeme (i.e., morphophonological representation) by showing that a homophone's meanings elicit varying degrees of interference in a picture-naming task. Specifically, they asked speakers to name target pictures after seeing incomplete sentences that primed highly predictable completion words (i.e., sentences with *high cloze probability*), then measured how often the speakers accidentally produced the primed words (termed *intrusions*) instead of the picture names. Critically, they manipulated the relationship between primed words and target pictures (as in the upper half of Fig. 2). Unsurprisingly, more intrusions occurred when the primed word and target picture were semantically related (*direct-competitors*) than in control conditions when the primed word

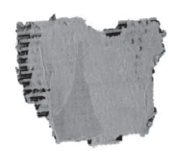
		Competitor	Cloze sentence	Intrusion	Picture Name
Condition	Homophone	Direct	He signed his name with a ballpoint…	/pɛn/	"crayon" 
		Control	The lion got a thorn in its…	/pɔ/	
		Indirect	The pigs were confined to the pig…	/pɛn/	
		Control	In the old days kids called their parents ma and…	/pɔ/	
	Polyseme	Direct	For the printer I bought a stack of bright white…	/pejpɚ/	"cardboard" 
		Control	The camera flash emitted a bright…	/lajt/	
		Indirect	At the end of the semester I had to write a final…	/pejpɚ/	
		Control	The child who wanted to sleep turned off the…	/lajt/	

Fig. 2. Experimental design of the homophone-condition (upper half) and the polyseme-condition (lower half).

and target picture were unrelated. For example, when shown a picture of *crayon*, participants were more likely to accidentally produce an intrusion after reading a sentence that primed the semantic-competitor *pen* (e.g., "He signed his name with a ballpoint...") compared to in a control condition where participants were shown an unrelated picture of a *racquet* after reading the same sentence.

Surprisingly, priming homophones of semantic-competitors to picture names (*indirect-competitors*) also elicited intrusion errors. That is, speakers were also more likely to erroneously say "pen" in response to a picture of *crayon* following the sentence "The pigs were confined to the pig..." than in a control condition. Ferreira and Griffin (2003) theorized that priming a homophone of a semantic-competitor activates a lemma (e.g., *pen* as in *pig pen*), which sends cascading activation to its corresponding lexeme /pɛn/. The target picture (e.g., *crayon*) sends cascading activation to its own lemma and also to semantic-competitors, one of which is the lemma for *pen* (as in *ballpoint pen*), which in turn also spreads activation to the lexeme /pɛn/. Cascading activation from the lemmas of both the target picture and the primed word converge on the lexeme /pɛn/, increasing the likelihood that the intrusion will be uttered.

Importantly, Ferreira and Griffin (2003) found that semantic-competitor (direct-competitor) primes elicited significantly more intrusions than did homophone-competitor (indirect-competitor) primes, which is consistent with the view that homophones' meanings are separately stored. Presumably, a word primed by a homophone-competitor priming sentence elicits fewer intrusions than the same word when it is primed by a semantic-competitor priming sentence because the two sentences are priming two distinct lemmas (schematized in Fig. 1A). Conversely, if the two meanings of a word were unified in a single lexical representation, then the two sentences would be expected to elicit the same number of intrusions, since either sentence would be priming one and the same lemma.

Ferreira and Griffin's (2003) paradigm can shed light on whether polysemes' senses are represented by distinct or shared lemma representations. We ran Ferreira and Griffin's (2003) protocol using their original items involving homophones in addition to new items involving polysemes. The procedure for items involving polysemes was identical to Ferreira and Griffin's (2003) procedure for items involving homophones, except that polyseme-competitor priming sentences (i.e., priming polysemous senses of semantic-competitors to target pictures) were also included. The lower half of Fig. 2 illustrates the experimental design for items involving polysemes. If polysemes' senses map onto separately stored lemmas (Fig. 1A), then the pattern of intrusions for primed polysemes should resemble the pattern of intrusions that was found for homophones in Ferreira and Griffin (2003). As such, polysemes with separately stored senses should elicit more intrusions when primed by semantic-competitor (direct) priming sentences than when primed by polyseme-competitor (indirect) priming sentences. Conversely, if a polyseme's senses converge onto a single lemma (Fig. 1B), then there should be no difference between the number of intrusions elicited by semantic-competitor priming sentences versus polyseme-competitor priming sentences, since the same lemma would be primed by either sentence type.

2. Methods

2.1. Participants

Fifty-six native English-speaking University of Maryland students participated for class credit.

2.2. Materials

The target pictures were 24 full-color pictures of the objects used in Ferreira and Griffin (2003), plus 36 additional pictures selected from images publicly available on the Internet. The homophone-condition was based on materials from Ferreira and Griffin (2003), and paired each of 24 target pictures (e.g., *crayon*) with a direct-competitor priming sentence that primed a semantic-competitor (e.g., *pen* as in *ballpoint pen*) of the target picture (e.g., *crayon*), and also with an indirect-competitor priming sentence that primed a homophonous meaning of the semantic-competitor (e.g., *pen* as in *pig pen*). Analogously, the polyseme-condition paired each of 36 target pictures (e.g., *cardboard*) with a direct-competitor priming sentence that primed a semantic-competitor (e.g., *paper* as in *printer paper*) of the target picture, and also with an indirect-competitor sentence that primed a polysemous sense of the semantic-competitor (e.g., *paper* as in *term paper*). The novel polyseme-condition items were designed to represent a heterogeneous set of polysemous sense-relations such as animal-meat, object-material, building-institution, container-contents, etc. Fig. 2 illustrates the design. In summary, the direct-competitor priming sentence primed a semantic-competitor to the target picture in both the homophone-condition and the polyseme-condition. However, the indirect-competitor priming sentence in the homophone-condition primed a homophonous meaning of the semantic-competitor, but the indirect-competitor priming sentence in the polyseme-condition primed a polysemous sense of the semantic-competitor. All stimuli (as well as cloze probabilities for sentences and name agreement for pictures) are shown in Data S1.

All target pictures and critical sentences were also re-paired to create control sentence-picture pairs, in which sentences and pictures were unrelated (see Fig. 2). Thirty additional sentence-picture pairs (items from Ferreira & Griffin, 2003) were used for practice trials. Eighty high-cloze sentences from Block and Baldwin (2010) were used as fillers and were not paired with pictures.

Each item (i.e., each sentence-completion word) was assigned to four conditions by crossing sentence competitor type (direct or indirect) and sentence relatedness to the picture (related or control). These four types of sentence-picture pairs were counterbalanced across four lists using a Latin square design, such that each item (i.e., each sentence-completion word) occurred only once per list (as a completion to one type of sentence-picture pair), but occurred equally often across lists (as a completion to each of the four types of sentence-picture pairs). Within each list, items were arranged in a fixed, pseudo-random order, constrained such that no more than one critical trial or three filler trials was presented consecutively.

It is worth emphasizing that every sentence (e.g., "The lion got a thorn in its... [*paw*]") was paired to both a related picture (e.g., *hoof*) and an unrelated picture (e.g., *crayon*). Consequently, the number of intrusions produced by a sentence when it was paired with an unrelated picture served as a baseline measure of the sentence's tendency to produce its completion word in the presence of pictures in general but in the absence of, specifically, a semantically related picture. Moreover, the tendency for each sentence to produce its completion word in the absence of any picture was normed using a separate sample of participants.

2.2.1. Sentence-norming

A sample of 34 students from the University of Maryland who did not participate in the main experiment was recruited for a sentence norming task. Each critical homophone-condition sentence from Ferreira and Griffin (2003) and each polyseme-condition sentence newly created for this study was presented to participants one word at a time, and participants were instructed to type the word that would best complete each sentence.

The purpose of the sentence-norming experiment was to create a set of polyseme-condition sentences with cloze probabilities matched to those of the homophone-condition. As such, a set of 48 polyseme-condition sentences (along with those sentences' 24 paired target pictures) was selected from the total set of 72 polyseme-condition sentences and 36 polyseme-condition pictures. To determine whether the cloze probabilities of the 96 critical sentences differed along experimentally relevant dimensions, a logistic mixed effects model was created using lme4 version 1.1-7 (Bates, Maechler, Bolker, & Walker, 2014) in R version 3.2.0. The model, which is presented in Data S1, revealed no differences in cloze probabilities along the experimentally relevant dimensions of *condition* (homophone-condition, polyseme-condition) or *competitor type* (direct, indirect).

2.2.2. Picture norming

To assess whether participants identified the pictures with their intended names and to investigate whether rates of picture name agreement differed systematically between the polyseme-condition and homophone-condition, a separate sample of 25 students from the University of Maryland participated in a picture norming task. Pictures were presented one at a time (using PsychoPy 1.8; Pierce, 2007), and participants were instructed to type the word that would best identify the picture. As with the sentence norming task, a logistic mixed effects model (presented in Data S1) revealed no differences in picture name agreement across conditions (homophone-condition, polyseme-condition).

Based on the norming data, 10 items were excluded from the main analyses reported below: Nine items were excluded because over 50% of participants in the picture-norming task gave incorrect (i.e., unintended) picture labels for those items' pictures and 1 item was excluded because over 50% of participants in the sentence norming task gave incorrect (i.e., unintended) sentence-completions for that item. With these 10 items excluded, there continued to be no significant differences in cloze probability or picture name agreement across the experimental factors (see Data S1 for details). Furthermore, the pattern of results for the main analyses did not differ by whether these 10 items were included or excluded.

Because the cloze probabilities of the sentences and the name agreement for the pictures did not differ by any experimentally relevant dimensions, it follows that any significant effects that are found in the main experiment are likely due to the experimental manipulation, rather than to preexisting biases in the stimuli. The remaining 24 polyseme-condition sentences and 12 target pictures, which were not matched to the homophone-condition items, were included in the main experiment only for exploratory analyses.

2.3. Procedure

The procedure replicated that used in Ferreira and Griffin (2003). Participants were instructed to name target pictures as fast as possible. In each trial, a central fixation point ("+") was presented for 500 ms, and then was replaced by the first word of a sentence. Each word of the sentence appeared in succession for 275 ms in Tahoma 30-point font. The intertrial interval was 1,500 ms. In critical trials, the target picture appeared immediately after the presentation of the sentence's penultimate word, and remained onscreen until the voice-key detected a response. The procedure was identical for filler trials, except that a picture of a blank line appeared, which signified to participants that they should complete the sentence instead of naming the picture. Research assistants administered the experiment using PsyScope X B57 (Bonatti, n.d.) while monitoring picture-naming and voice-key accuracy. This experiment followed another, unassociated study.

3. Results

Speakers' intrusion errors were analyzed with logistic mixed effects models using lme4 version 1.1-7 (Bates et al., 2014) in R version 3.2.0. The design included three deviation-coded fixed-effects factors: *condition* (homophone-condition, polyseme-condition), *competitor type* (direct, indirect), and *relatedness* (related, control), with crossed random effects for participants and items. Models included estimates for all random effects (intercepts and slopes; cf. Barr, Levy, Scheepers, & Tily, 2013), however, estimated correlations among random effects had to be removed for the models to converge. The primary effects of interest were also evaluated with likelihood ratio tests based on single-degree of freedom model comparisons. For ease of understanding, data are described below in terms of relatedness effects: the proportions of intrusions in each *critical* sentence-picture pair type minus the proportions of intrusions from each corresponding *control* sentence-picture pair type. As mentioned above, 10 items were excluded from analyses due to low cloze probabilities or low picture-norms, but including these items did not alter the pattern of results reported below.

As shown in Fig. 3 and Table 1, homophones' directly related meanings elicited a larger relatedness effect (0.165) than did homophones' indirectly related meanings (0.120). Polysemes' directly related (0.092) and indirectly related senses (0.114), however, elicited similar relatedness effects. These observations are supported by a three-way interaction between the fixed-effect factors (significant by model comparison; $\chi^2 = 4.25$, $p < .05$) reported in Table 2.

To better understand this three-way interaction, separate analyses were conducted for the homophone and polyseme conditions (Table 2). For homophones, a marginal relatedness by competitor type interaction (model comparison: $\chi^2 = 3.38$, $p = .066$) revealed a greater relatedness effect for directly related meanings (0.165) than for indirectly related meanings (0.120), which replicates (albeit only with marginal significance) the pattern found by Ferreira and Griffin (2003). However, there was no significant relatedness by competitor type interaction for polyseme-condition items (if anything, the indirect condition was associated with a numerically, but non-significantly, *greater* effect of relatedness; $\chi^2 = 0.69$, *n.s.*), indicating that the relatedness effect was similar for polysemes' directly related senses (0.092) and indirectly related senses (0.114).

One potential concern is the surprisingly high proportion of intrusions (0.059) elicited in the control condition for the homophone-condition's indirect-competitors (see Table 1). In other words, the homophone-condition indirect-competitor sentence fragments were especially likely to elicit intrusion errors even when paired with unrelated pictures. This

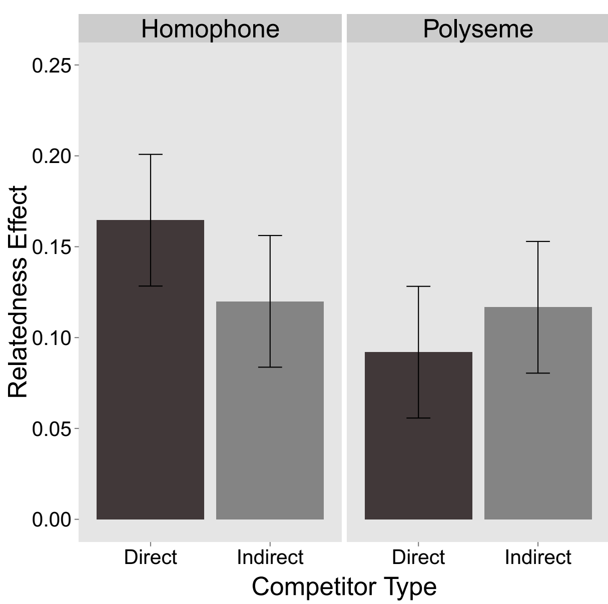


Fig. 3. Relatedness effects (each sentence-picture pair type's net proportion of sentence-completion intrusions after subtracting the proportion of intrusions from each sentence-picture pair type's corresponding control sentence-picture pair type) as a function of condition (homophone, polyseme) and competitor type (direct, indirect). Error bars indicate 95% confidence intervals by subjects (Masson & Loftus, 2003).

Table 1
Mean proportion of intrusion errors (computed across subjects) and relatedness effects by condition, competitor type, and relatedness. Standard errors are in parentheses

	Homophones		Polysemes	
Relatedness	Direct	Indirect	Direct	Indirect
Related	0.175 (0.025)	0.179 (0.025)	0.118 (0.023)	0.137 (0.025)
Control	0.011 (0.008)	0.059 (0.019)	0.026 (0.014)	0.023 (0.019)
Relatedness effect	0.165	0.120	0.092	0.114

Table 2
Statistical results from logistic mixed effects models. (a) Omnibus analysis examining the effects of condition, competitor type, and relatedness, and individual mixed effects analyses for the (b) Homophone condition and (c) Polyseme condition

	Fixed Effects			Random Effects	
Parameters	*b*	*SE*	*Z*	Subjects *SD*	Items *SD*
(a) Omnibus analysis					
(Intercept)	−3.90	0.36	−10.75**	1.13	1.00
Condition	−0.35	0.47	−0.74	0.00	
Relatedness	2.57	0.51	5.00**	0.98	1.89
Competitor Type	−0.41	0.33	−1.24	0.00	0.73
Condition × Relatedness	−0.36	0.93	−0.39	0.86	
Condition × Competitor Type	1.17	0.71	1.66†	1.17	
Relatedness × Competitor Type	0.51	0.63	0.80	0.00	0.56
Condition × Relatedness × Competitor Type	−2.70	1.33	−2.04*	1.46	
(b) Homophone condition					
(Intercept)	−3.53	0.38	−9.24**	0.84	0.58
Relatedness	2.52	0.66	3.80**	1.20	2.07
Competitor Type	−0.91	0.46	−1.99*	0.64	0.93
Relatedness × Competitor Type	1.65	0.87	1.89†	1.25	1.26
(c) Polyseme condition					
(Intercept)	−4.47	0.65	−6.93**	1.56	1.45
Relatedness	2.55	0.73	3.51**	0.00	1.77
Competitor Type	0.22	0.50	0.44	0.00	0.00
Relatedness × Competitor Type	−0.91	1.10	−0.82	0.00	1.63

Notes. **$p < .001$; *$p < .05$; †$p < .10$; Factors were contrast coded as follows: Relatedness (−0.5 = control, 0.5 = related), Competitor Type (−0.5 = direct, 0.5 = indirect), Condition (−0.5 = homophone, 0.5 = polyseme). Intrusions were coded as 1 (intrusion error) or 0 (accurate response), with non-intrusion errors excluded from analysis. All models included the maximal random effects structure (i.e., all random slopes; Barr et al., 2013). However, estimates of the correlations between random effects estimates had to be removed for the models to converge.

discrepancy from the rates of intrusions elicited by the other control conditions attests to the importance of using control conditions (i.e., unrelated sentence-picture pairings) to assess baseline intrusion likelihoods of cloze sentence fragments.

It is not clear why intrusion rates were particularly high for these specific cloze sentence fragments, especially given that these same sentence preambles elicited considerably fewer control condition intrusions in Ferreira and Griffin's (2003) experiments. However, a greater absolute number of intrusions in one condition is not particularly concerning in light of the difference between relatedness effects across conditions. In that respect, these data replicate Ferreira and Griffin (2003) and Severens, Ratinckx, Ferreira, and Hartsuiker (2008): A greater relatedness effect was found for homophone-condition direct-competitors (0.165) compared to homophone-condition indirect-competitors (0.120). Importantly, no unexpected discrepancy between control intrusion rates for direct-competitor and indirect-competitor eliciting sentences was found in the polyseme-condition, where control intrusion rates were similarly low for direct-competitor (0.026) and indirect-competitor (0.023) eliciting sentences. That is, this concern does not impact this paper's primary novel finding, namely, that polysemes' directly and indirectly related senses are equally likely to elicit intrusions.

4. Discussion

Speakers named pictures after seeing sentences that primed semantic-competitors, homophones of semantic-competitors, polysemes of semantic-competitors, or control words. As expected, speakers produced more intrusions, by saying the primed word instead of the picture name (e.g., *crayon*) when the primed word was a semantic-competitor (e.g., *pen* as in *ballpoint pen*) of the picture than when it was a control word. Speakers also produced more intrusions when the primed word was a homophone (e.g., *pen* as in *pig pen*) of a semantic-competitor than when it was a control word. However, the relatedness effect (i.e., the rate of intrusions of related sentences minus the rate of intrusions of control sentences) for homophone-competitors was smaller than the relatedness effect for semantic-competitors.

The homophone-condition data replicate Ferreira and Griffin (2003): Speakers showed a larger relatedness effect when primed with semantic-competitors than when primed with homophones of semantic-competitors. A novel pattern of results was found for items involving polysemes. When naming a picture (e.g., *cardboard*), speakers showed the same relatedness effect whether primed with a direct semantic-competitor (e.g., *paper* as in *printer paper*) or with an indirect polysemous sense (e.g., *paper* as in *term paper*) of a semantic-competitor.

These results show that polysemes of semantic-competitors, just like homophones of semantic-competitors, robustly generate intrusions in a picture-naming task. This is important because not all types of competitors generate intrusions in this picture-naming task (e.g., phonological-competitors to target pictures do not; Severens et al., 2008). Thus, the intrusions observed here likely reflect competition between lexico-syntactic lemma representations rather than competition between morphophonological lexeme representations. Furthermore, the finding that polysemes' directly and indirectly related senses elicited similar relatedness effects suggests that polysemes are not only comprehended as core-representations (e.g., Klepousniotou, Titone, & Romero, 2008), but are also retrieved as core-representations in production.

The findings from this study are compatible with multiple core-representation theories of polysemy that were derived from comprehension-based evidence. If a polyseme is stored as an underspecified core-meaning that encompasses multiple senses (e.g., Frisson, 2009), then retrieval of a polyseme that is activated in any given sense may entail retrieval of an underspecified meaning that encompasses both the contextually relevant and contextually irrelevant senses. Though the contextually relevant sense may not semantically compete with a target picture, semantic competition may occur between the picture and another sense that is implicit in the underspecified core-meaning. Alternately, if polysemes are stored as clusters of specified senses centered around generative core-meanings (e.g., Klepousniotou, 2002), then it is possible that the retrieval of any sense, especially the most generative sense, would pull the entire cluster along with it during lexical access. In short, lexical access in production may involve the retrieval of a polyseme "all at once," with both the senses that are relevant to the context and the contextually irrelevant senses being retrieved.

According to some theorists, however, conceptual information cannot be said to be unified or separate in the same way that lexical representations can be considered unified or separate. Instead, information at the conceptual stratum may be multimodal and non-linguistic, as opposed to lexical representations that serve only as access points to semantic meaning, rather than as containers of semantic meaning (e.g., Evans, 2015; Falkum & Vicente, 2015). Although future studies will be necessary to determine whether a polyseme's representational unity at the lemma stratum necessarily entails a representational unity at the conceptual stratum, or whether separately stored units of multimodal conceptual information may converge on one lexico-syntactic representation, the data presented above suggest that polysemes' *lexical* representations, at least, are shared.

The claim that homophones' meanings are stored in distinct lemmas while polysemes' senses are stored in unified lemmas implies that a given word is either one or the other. However, word meanings seem to lie on a continuum of semantic relatedness, with unrelated homophonous meanings at one endpoint and closely related polysemous meanings at the other endpoint (Durkin & Manning, 1989; Evans, 2015; Klepousniotou, 2002). What remains to be investigated is how the lemmas of irregular polysemes (i.e., words with idiosyncratically related senses) may be represented. Comparing different types of polysemy in production, Rabagliati and Snedeker (2013) found that speakers are relatively good at recognizing that a to-be-spoken word is ambiguous when that word is a regular polyseme (i.e., polysemes with senses that are related via regular patterns such as *clucking chicken* and *tasty chicken*), but are relatively bad at recognizing the ambiguity inherent in irregular polysemes (i.e., polysemes with senses that are not related in a systematic, generative way but are instead related idiosyncratically such as *sheet of glass* and *drinking glass*). Thus, while regular polysemes appear to share lemmas, irregular polysemes like *glass* may be represented by distinct lemmas, effectively acting as homophones.

An interesting possibility is that an irregular polyseme's multiple meanings are, in fact, entirely distinct or entirely shared *for a given speaker*, depending on whether the person perceives the word's senses to be related or not. Similarly, whether a given word is represented by a single lemma or by multiple lemmas may change with experience or across contexts, which is consistent with the view that lemma representations are relatively underspecified and flexible (Evans, 2015; Falkum & Vicente, 2015). Another possibility is that the so-called core-representation of an irregular polyseme does not actually constitute a *single* shared lemma representation, but rather separate lemmas that are inexorably retrieved together whenever one of the related senses is activated. By this account, the extent to which an irregular polysemes' lemmas are retrieved in unison may vary as a function of the semantic relatedness between the polyseme's senses. In light of the growing evidence that the extent of representational unity is different for words with unrelated meanings compared to words with related senses, a fruitful direction for future research may be to investigate the extent of representational unity in words with weakly related senses—in words, such as irregular polysemes, which fall in the middle of the spectrum of semantic relatedness between senses.

Another topic worthy of future research is the connection between orthographic and lexical levels of representation for words with multiple meanings or senses. The connection between a homophone's lemmas may be diminished if there are orthographic differences between the homophones' meanings (e.g., *flour, flower*), as was the case with some of the stimuli in this study. Given evidence that activation proceeds from orthographic units to lexical units in word production (e.g., Li, Wang, & Idsardi, 2015), a worthwhile direction for future research may be to investigate whether differences in the orthography of homophones' meanings affect the relative activation among lexical representations. Research in this direction would inform theories about the architectural interconnections between different levels (e.g., orthographic, phonological, lexical, and semantic) of representation.

Unexpectedly, in this study, the relatedness effects of polysemes' direct-competitor and indirect-competitor priming sentences bore a closer resemblance to the relatedness effect of homophones' indirect-competitor priming sentences than to the relatedness effect of homophones' direct-competitor priming sentences. A priori, it might be expected that the polyseme-conditions' direct-competitor and indirect-competitor sentences would generate relatedness effects of the same magnitude as that of the homophone-condition's direct-competitor sentences. One explanation for the lower relatedness effects from the polyseme-condition sentences comes from Rodd et al.'s (2004) prediction that "different word senses will compete with each other and produce a sense disadvantage" (p. 101) in a task, such as ours, that requires retrieval of a particular sense of a polysemous word, as opposed to in a lexical decision task, as in Rodd et al.'s (2004) study, where the broad, shallow nature of a polyseme's attractor basin would facilitate the retrieval mechanism's arrival at the minimum threshold amount of semantic information needed to make a lexical decision. Although Rodd et al. (2004) predicted a sense disadvantage among competing senses in terms of slower reaction time, it is plausible that in an error elicitation paradigm, as well, the competition between polysemes' senses would lead to interference in retrieval and thereby to diminished rates of utterance production. Of course, this difference might also simply be due to the use of different items in the two conditions. Using the same words in both the homophone-condition and the polyseme-condition may be one way to control for differences between items. A word such as *bill*, for example, encompasses both homophonous meanings (e.g., *duck bill*; *dollar bill*) and polysemous senses (e.g., *dollar bill*; *electric bill*). Would such a word be represented with the polysemous senses fused together, but with the homophonous meanings set apart? The representations of words with both polysemous senses and homophonous meanings are worth investigating because many of the words encountered in everyday experience are not only polysemous or homophonous, but both.

By relying on an error elicitation paradigm in production, this study lends support to comprehension-based views of core-lexical polysemy, while also addressing the concern that the perceived unity of polysemes' senses, as evidenced by comprehension-based paradigms, could be an artifact of meta-linguistic knowledge or spreading activation between related, but separate, lexical representations. We show that contextually relevant and irrelevant senses of polysemes exert equal effects in an error elicitation paradigm, which suggests that a polyseme's multiple senses are unified both in lexical representation and in lexical retrieval. These data suggest that polysemes, unlike homophones, share lexical (lemma-level) representations in the production lexicon.

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Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article:

Data S1. Supplemental material including (a) analyses of the sentence norming task, the picture norming task, and "other" responses, and (b) all sentence and picture stimuli, including sentence cloze probabilities and picture name agreement for each item.