RUNNING HEAD: Explicit and Emergent Mechanisms

Explicit and Emergent Mechanisms of Information Status

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ABSTRACT

It is well established that language production and comprehension are influenced by **information status**, for example whether information is given, new, topical, or predictable, and many scholars suggest that an important component of information status is keeping track of what information is in common ground (i.e., what is shared), and what isn’t. Information status affects both speakers’ choices (e.g., word order, pronoun use, prosodic prominence) and how listeners interpret the speaker’s meaning (e.g., Chafe, 1994; Prince, 1981). While there is a wealth of scholarly work on information status (for a review, see Arnold, Kaiser, Kahn, & Kim, 2013), there is no consensus on the mechanisms by which it is used, and in fact relatively little discussion of the underlying representations and psycholinguistic mechanisms. Moreover, a major challenge to understanding information status is that its effects are notoriously variable. This paper considers existing proposals about information status, focusing on two questions: 1) how is it represented, and 2) by what mechanisms is it used? I propose that it is important to consider whether representations and mechanisms can be classified as either explicit or emergent. Based on a review of existing evidence, I argue that information status representations are most likely emergent, but the mechanisms by which they are used are both explicit and emergent. This review provides one of the first considerations of information status processing across multiple domains.

INTRODUCTION

Speakers and writers have numerous choices in the form of their speech, for example one could say *The dog chased the cat* or *The cat ran from the dog* to describe the same situation, and refer to the dog as *Fido*, *that beast*, or just *it.* Linguistic theories explain these choices in terms of **information status**, which refers to the cognitive status of information in the minds of the discourse participants, such as its availability in memory or degree of attention allocated to it (Chafe, 1976; Prince 1981; Halliday, 1967; see Arnold, Kaiser, Kahn, & Kim, 2013 for a review).

Table 1. Examples of linguistic variation that corresponds to information status.

|  |  |
| --- | --- |
| **PHENOMENON** | **EXAMPLE** |
| Word Order: Given and accessible tends to precede new and less-accessible  (e.g., Arnold et al., 2000; Bock & Irwin, 1980; Chafe, 1994). | Look at the dog. The dog is chasing the cat.  Look at the cat. The cat is running away from the dog. |
| Acoustic prominence: Given and accessible information is expressed with reduced forms, new and less-accessible information is expressed with acoustically prominent and accented forms  (Halliday, 1967) | I saw a dog in the kitchen, and the dog (acoustically reduced) was eating.  I walked into the kitchen, and the DOG (acoustically prominent) was eating. |
| Reference form: Pronouns and zero forms are used for given and accessible information, while full names or descriptions are used for less-accessible and new information.  (e.g., Chafe, 1976) | I saw a dog in the kitchen, and it was eating.  I walked into the kitchen, and the dog was eating. |

There is a substantial research on the ways in which information structure can affect linguistic form (see Table 1 for examples). Yet there is little consensus in the psycholinguistics literature about the mechanism by which information status works, or even what the critical dimensions are. One problem is that the effects of information status are highly variable. For example, following *The dog chased the cat,* there is a robust tendency for speakers to use a pronoun for subsequent reference to the dog: *And it almost caught it*, which has been attributed to the salience of the grammatical subject position of *The dog* in the first sentence (Chafe, 1976; see Arnold, 2010 for a review). However, this preference is not absolute. This calls for an explanation for this variability.

A second open question is: whose knowledge matters for representing information status? The function of language is to communicate, which has led to the general assumption that information status reflects **shared** knowledge, that is, information in **common ground** (e.g., Chafe, 1976; Clark & Haviland, 1979; Gundel et al., 1993). One expression of this view comes from Vallduvi (1992): “…speakers seem to structure or package the information conveyed by a sentence at a given time point…according to their assumptions about their interlocutors’ beliefs or knowledge and attentional state.” Yet current research reveals variability in the degree to which speakers keep track of their addressee’s knowledge, and use it to shape their utterances. Some work shows how speakers track feedback from their listeners and use it to adjust their speech on a moment-by-moment basis (e.g., Clark & Krych, 2004), while other work identifies ways in which speakers ignore evidence about their listener’s knowledge, and choose forms based on what they know themselves (Ferreira & Dell, 2000; Horton & Keysar, 1996; Wardlow Lane, Groisman, & Ferreira, 2006). This requires an explanation of both when and why common ground information is used.

The goal of this paper is to advance this discussion by considering proposals about the mechanisms by which information status guides language production. Although information status effects are widely studied, very few researchers explicitly consider the mechanisms by which information status is represented and used. Thus, this paper provides a step toward filling the information-status gap in the psycholinguistics literature. A special focus of this discussion concerns the role of common ground assessment and its role in language form. Although the use of common ground has received considerable attention (among others: Bard et al., 2000; Barr, 2008; Brown-Schmidt, Gunlogson, & Tanenhaus, 2008; Brennan & Clark, 1996; Clark & Marshall; Horton & Gerrig, 2005; Keysar,et al., 2000; Pickering & Garrod, 2004), its relationship to information status representations has not been developed explicitly.

There are three levels of information relevant to the current model: 1) Conceptual representations, which are nonlinguistic, and include distinctions in information based on psychological states such as what is in working memory or in the focus of attention, 2) The linguistic form itself, and 3) The grammar, which includes procedures or rules for translating between conceptual representations and linguistic form.

Figure 1. The three levels of information in this model.

This paper focuses on the following question: to what extent is information status an explicit property of mental representations and mechanisms, and to what extent do the effects of information status emerge from other processes of memory, attention, and speech production? This question is addressed both in terms of a) representation, and b) mechanism.

WHAT IS INFORMATION STATUS?

Before we consider how information status is represented, we must consider what the relevant dimensions of information status are. This is not a trivial question, in that numerous information status categories have been proposed. Some scholars have proposed categorical divisions of information. One classic division is between given (or old) information and new (e.g., Chafe, 1976; Prince, 1981). Given information has been evoked in a situation, typically because it was mentioned linguistically, but possibly also evoked nonlinguistically (Prince, 1981). New information has not been evoked in the current or relevant situation. Prince (1981, 1992) introduced a third status, “inferrable”, for information that has not been mentioned but can be assumed based on the situation. This status helps explain why definite NPs are preferred in cases where the referent can be inferred from the context. For example, once the Bastille has been mentioned, the speaker can refer to “the door”, even though the door was not given itself (see also Clark & Haviland, 1979 for bridging inferences).

Other researchers have instead proposed that information status falls on a gradient. For example, Gundel, Hedberg, and Zacharski’s (1983) Givenness Hierarchy proposes that there are six cognitive statuses that guide referential form, as shown in Table 2.

Table 2. The Givenness Hierarchy proposed by Gundel et al. (1993). The top row indicates the cognitive status that determines reference form, and the bottom row provides English examples of the referring expressions that correspond to each status.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| in focus | activated | familiar | uniquely identifiable | referential | type identifiable |
| *It* | *This*  *That*  *This* N | *That* N | *The* N | Indefinite *this* N | *a* N |

These statuses characterize the speaker’s assumption about the cognitive status of information in the listener’s mind. They range from “in focus” (in the center of attention) to simply “type identifiable”, which means that the listener knows the meaning of the word, but the specific referent is not known in context. Their proposal is that each status determines the conditions necessary for a particular form, where that each status also entails the lower levels. In this proposal, cognitive statuses are distinct categories, but provide more of a gradient than binary categories like given and new.

Other researchers instead suggest a fully continuous range of cognitive status, using terms like salience, prominence, accessibility, or topicality (Ariel, 1990; Arnold, 1998; Givon, 1983). These concepts are not equivalent, but they have all been used to explain why some information in a coherent discourse is treated as backgrounded, familiar knowledge, while other information is highlighted and treated as new information. Under these proposals, linguistic forms (for example pronouns, or early word order) are determined by the relative degree of salience/accessibility. The terms “salience” and “prominence” refer to the perceptual properties that lead to specialized cognitive status, while “accessibility” evokes the ease of retrieving information. All of these properties have been identified with discourse topicality, i.e. the idea that some entities are considered more central to a linguistic discourse. Topical/salient/accessible information is that which is considered backgrounded in a discourse (Ariel, 1990).

A related dimension is predictability, where salient and topical information is likely to be mentioned again (Arnold, 1998, 2010; Givon, 1983; Grosz et al, 1995; Brennan, 1995). In fact, Prince (1981) suggests that one component of “given” status is defined in terms of predictability: “The speaker assumes that the hearer can predict or could have predicted that a particular linguistic item will or would occur in a particular position within a sentence,” (p. 226). It is worth noting that Prince’s definition is framed in terms of the predictability of the linguistic item itself, suggesting that information status is defined in terms of language. Yet the spirit of Prince’s treatment of givenness seems more in line with the idea that givenness is best considered a part of a conceptual representation of information, not a linguistic one. It is this idea that I adopt below, when I consider the representations of information status.

Predictability also plays an important role in computational approaches to linguistic variation, which adopt an information-theoretic approach, suggesting that the probability of a word in context reflects the amount of information that the word represents. Word probability has been shown to predict the degree to which a word is pronounced with a reduced form, including shorter word duration and less phonological detail (e.g., Aylett & Turk, 2004; 2006; Bell et al., 2009; Frank & Jaeger, 2010). What is notable about this approach is that it defines information in terms of predictability of the lexical item. This raises questions about whether information status is a property of the nonlinguistic, conceptual representation, or a property of words. If a content word is predictable (e.g., *Obama*), probably the concept of Barack Obama is predictable too. But the reverse relationship is only partial – if Obama is predictable as a concept, a variety of words may be partially expected, including *Obama, Barack, Mr. President, that man,* or *he.* Thus, predictability needs to be defined at multiple levels, including the referential level (Arnold, 1998; Kahn & Arnold, 2012; Watson, Arnold, & Tanenhaus, 2008).

In sum, the concept of “information status” is intimately tied to the mental state of the discourse participants. Information is important to language, because the function of language is to communicate, and most of language is used to communicate information. Information status has to do with what we know, what is familiar, and what we can predict based on other information.

Given that information status reflects cognitive states, a natural question to ask is: whose mental states matter? Does “given” information count as given if it is only given to the speaker, and not the addressee? Does the speaker’s focus of attention drive their representation of information status even if the addressee has no evidence of it? Most descriptions of information status, especially those from the linguistics literature, assume that information status is defined with respect to common ground, i.e. shared information (Chafe, 1976, 1994; Clark & Marshall, 1981; Clark, 1976; Gundel et al., 1993; Prince, 1981). Yet none of these works directly address questions of cognitive mechanism, raising questions about how information status is represented, and the extent to which different perspectives are incorporated.

Despite the heterogeneity of existing treatments of information status, I argue that research in this area converges on the assumption that the key to understanding linguistic variation is the conceptual representation. That is, information status is a property of the mental model, represented nonlinguistically. If I say “pizza!”, this concept will be perceived as given (and probably topical) by all discourse participants. But givenness does not have to originate from speech: if I walk in the room carrying a stack of steaming pizzas, and set them down with a flourish, the concept of pizza will similarly be evoked, and also recognized as a part of common ground. In keeping with this, the majority of information-status scholars make reference to psychological statuses. For example, Chafe (1976) defines Givenness in terms of consciousness, and several scholars use psychological attention to define cognitive status (e.g., Brennan, 1995; Chafe, 1976, 1994; Gundel et al., 1983).

On the other hand, the treatment of givenness in the field leads to the impression that “given” information has been mentioned linguistically. If a psycholinguistic experiment manipulates givenness, it almost always does so by manipulating whether the item has been mentioned or not (e.g., Arnold et al., 2004; Cowles & Ferriera, 2011; Dahan et al., 2002). In addition, discussions of predictability (e.g., Prince, 1981) or word probability (see above) focus on the predictability of a linguistic form per se.

However, there is reason to distinguish between conceptually-based information status and linguistically-based information status. Evidence suggests that the “source” of givenness matters, whereby linguistically given information is treated differently than nonlinguistically given information (Kahn & Arnold, 2012; Baumann & Hadelich, 2003). For this reason, I will consider information status primarily in terms of nonlinguistic information, with the acknowledgement that linguistic representations contribute to the effects of information status.

The critical question is, how does cognitive status constrain linguistic form? In the next two sections, I consider proposals about how information status is both represented mentally, and the mechanism by which it constrains linguistic form. In each case, I consider whether representations and mechanisms are a) explicit or b) emergent.

REPRESENTATION OF INFORMATION STATUS

In the above section, I argued that information status should be considered a property of the conceptual representation. Here I focus on distinguishing between two classes of representation: explicit and emergent representations. An explicit representation would be one that marks information status per se. By contrast, an emergent representation would be an interpretation of existing memory or attentional mechanisms, e.g. whereby information that is already in my memory is considered given, and information that I am attending to is considered focused. This question has two relevant sub-questions: 1) are the representations of information statuses themselves explicit or emergent?, and 2) Does information status reflect explicit or emergent representations of the mental states of other discourse participants?

**Explicit Representations**

If people represent information status explicitly, they would have mental models of discourses and events that categorized or classified information specifically in terms of information status. That is, we would have a representation of the information status itself. This view contrasts with the emergent view (see below), in which a person’s mental state translates into its information status. In an explicit representation, we mentally categorize information in terms of dimensions that are relevant for language, such as Gundel’s six cognitive statuses. The critical property of an explicit representation is that it represents information status itself, and associates it with discourse entities. If we assume that information status is gradient (e.g., Arnold, 2008; Arnold & Griffin, 2007; Brennan, 1995; Givon, 1983), an explicit representation would involve assigning an index to indicate how accessible or topical a referent is at any point in time. If we assume that information status is categorical (Chafe, 1976; Gundel et al., 1983; Prince, 1992), the mental representation might include tags for information statuses, e.g. “in focus”, “activated”, etc. Thus, the question about explicitness is orthogonal to questions about what the relevant representational distinctions are, and whether they are gradient or categorical.

Although few researchers discuss information status representation, work on information status generally takes the form of identifying the informational conditions under which particular linguistic forms are preferred. The simplest approach to instantiating these proposals psycholingusitically would require an explicit representation of information status. E.g., under Gundel et al.’s (1993) Givenness hierarchy, the six cognitive statuses constrain acceptable referential forms. It would be a short step to assume that this proposal is instantiated cognitively by representing each status, classifying discourse entities under a status, and inputting this condition to a rule (see “Mechanisms” section below).

Some examples of explicit representations can be found in computational or theoretical models. For example, in Schmitt et al. (1999) and van der Meulen et al.’s (2001) models of pronoun production, they propose that referents are tagged with an “in-focus” feature that can be either on or off. In a computational model of pronoun comprehension, van Rij, van Rijn, & Hendriks (2011) model the salience of each discourse entity in terms of the amount of activation. Centering theory proposes that entities are ranked in order of prominence (Grosz, Joshi, & Weinstein, 1995), where the existence of the ranking constitutes an explicit representation of information status. However, this type of representation has not been well developed. Most linguistic work on information status does not make explicit claims about representation. The Schmitt et al. model was not aimed at specifically exploring the representation of discourse status, and thus this decision is may likely a simplifying assumption that enabled the authors to represent the discourse context.

Explicit representations offer a simple way to encode common ground. For example, it is infelicitous to introduce something with a pronoun “She’s here!” unless there is an established reason to expect that one’s interlocutor has enough context to understand the sentence (e.g., one family member to another about a long-awaited guest; Chafe, 1994; Prince, 1981). This constraint would be easy to instantiate by representing whether information is known to the addressee or not, or even marking the speaker’s degree of confidence that the information is in common ground, depending on available information. Indeed, discussions of information status frequently assume that the speaker must make assumptions about the listener’s knowledge, which requires some sort of representation. For example, Clark and Haviland (1979, p. 4) say “The speaker tries, to the best of his ability, to make the structure of his utterances congruent with his knowledge of the listener’s mental world.”

To my knowledge, there is no evidence that specifically bears on whether information-status representations are explicit. In all cases, an explicit representation could work. However, it would be cognitively demanding to represent all known relevant dimensions of information status. Thus, the critical question is whether there is a viable alternative.

**Emergent representations**

Alternatively, there is good reason to support an emergent model, in which information status does not require special representations. Linguistic form appears to rely on 1) knowledge/attention; 2) predictability; and 3) common ground, each of which corresponds to well-known memory and attentional processes.

Givenness / Focus of attention. Many scholars have proposed that people keep track of information that is relevant to the current situation in a situation model, or mental model (Bower & Morrow, 1990; Bransford, Barclay, & Franks, 1972; Johnson-Laird, 1983; Kintsch, 1988; Sanford & Garrod, 1981). This information is typically assumed to be represented in working memory. If the current situation is a linguistic one, this means that the mental model should contain the entities and actions relevant to the linguistic discourse. Thus, anything that is present in the mental model can be considered “given”, or “known” (but see section on Common Ground below). In addition, it has been demonstrated that information in situation models can vary in how accessible it is (Morrow & Bower, 1990).

Predictability. It is well established that linguistic form is correlated with its predictability in the discourse. Information is not predictable outside of the context of a particular event. One can predict the likelihood of (for example) a bump in the road under one’s bicycle tire while cycling. In the context of language, we care about the likelihood of references, words and structures within a linguistic discourse. Thus, linguistic predictability is dependent on the presence of the task goal of communication.

There is precedent for task goals to modulate memory and attention, which suggests that predictability can also be accommodated in an emergent representation of information status. For example, Bower and Morrow (1990) report research in which subjects memorized a spatial layout and then answered questions about it. They assessed the accessibility of spatial information during a narrative by asking participants to respond to probe words. They found that response time was faster when the words were related to the protagonist’s goals, not just the protagonist’s physical location or the places mentioned. Task goals also modulate visual attention (Folk, Remington, & Johnson, 1992). Thus it is likely that the speaker’s attention will be directed toward information that is predictable, where task goals contribute to this computation. This may occur relatively automatically, as representations become stronger when they are supported by the context.

Topicality. Information status has also been described in terms of what the discourse is “about”, i.e. in terms of what is topical. Topicality is related to predictability, for example Givon (1983) argues that predictablity (persistence) is one indicator of topicality. Topicality is also related to attention, in that if the discourse is “about” something, it is drawn into the focus of attention of the speaker, and can be assumed to be in the attention of the listener.

Common Ground. It has been widely proposed that linguistic form is dependent on what the speaker can assume about the attention and knowledge of the listener (Chafe, 1976; Prince, 1981; Gundel et al., 1983). This makes sense, because it is functionally related to the goal of communicating. However, a challenge for this constraint is that the speaker does not have direct evidence about what the listener knows, and instead must make inferences.

In addition, there is a substantial line of literature demonstrating that there are limits to the speaker’s ability to modify their choices about linguistic form on the basis of available information about the addressee’s knowledge (Bard, Anderson, Sotillo, Aylett, & Doherty-Sneddon, 2000; Horton & Keysar, 1996). For example, speakers tend to use reduced pronunciations for information that they have heard, regardless of whether the addressee has also heard it (Bard et al., 2000; Kahn & Arnold, 2013).

The variability of common ground effects has led to at least two proposals that common ground representations emerge automatically out of other cognitive processes. Pickering and Garrod (2004), suggest that discourse participants usually maintain impoverished, automatically-generated representations of their addressee’s knowledge, which they call “implicit” common ground, and that they do not usually calculate “full” common ground, which requires explicitly modeling the mental state of one’s interlocutor. In their interactive alignment model, they argue that successful communication occurs when discourse participants come to an understanding that is consistent with the other’s intentions, i.e. when their mental representations are aligned (see also Garrod & Pickering, 2009). A key mechanism for alignment is automatic imitation. For example, speakers tend to imitate lexical items (Brennan & Clark, 1996) and syntactic structures (Branigan et al., 2000) that they have heard their interlocutor use. This helps support the development of addressee-specific situation models, but without explicit representation of the addressee’s knowledge.

Horton and Gerrig (2002, 2005; see also Brennan & Clark, 1996) present a different view, in which richer common ground representations emerge naturally from known properties of human memory. They propose that a part of ordinary memory involves “commonality assessment”, whereby conversation participants can assess what information is commonly known. They suggest that the discourse participants themselves serve as highly salient cues for retrieval of information in memory. So, for example, if I plan to ask you about a book that I left on the desk, your presence in the conversation would automatically cue me to retrieve the knowledge of whether the book is commonly known to both of us.

This emergent view of common ground has two critical properties (Horton & Gerrig, 2002, 2005). First, the successful use of common ground depends on the strength of the memory cue, and whether it can be retrieved quickly enough to affect utterance form. Consistent with this, research with amnesic patients supports the role of declarative memory in common ground representation (Rubin, Brown-Schmidt, Duff, Tranel, & Cohen, 2011). Second, assessments about common ground can be incorrect, depending on what information is available. This predicts a range of success in using common ground to guide linguistic form, which is indeed what the literature shows.

The approach outlined by Horton and Gerrig is focused on *knowledge*, which is important for using names and definite referential expressions. For example, if I ask you whether Tom called, I need to know that you will identify the correct Tom. Memory representations also encode assumptions about the probable focus of attention of our interlocutors, using information such as eyegaze and gesture (Nappa & Arnold, 2014).

**Summary**

In summary, there are two possible approaches to representing information status conceptually. The approach that is implied by classic information status work is the explicit approach. Under this view, concepts are explicitly marked for information status, either in terms of their position along a relevant gradient, like salience, or tagged for information-status. However, a challenge for explicit representations is that different linguistic phenomena seem to require different informational divisions. If the conceptual representation encodes all relevant divisions, it could create an intractable computational load.

On the other hand, there is substantial evidence for emergent information status representations, in particular with respect to common ground information (Horton & Gerrig, 2005; Pickering & Garrod, 2004). Emergent representations offer the advantage of economy, drawing on cognitive components that are independently motivated (memory, attention, the importance of task goals), while the explicit representations require an additional cognitive structure. In addition, classic linguistic theories highlight the cognitive property of salience, drawing links to cognitive dimensions like memory or attention (Brennan, 1995; Grosz & Sidner, 1986; Gundel et al., 1993). Thus, an emergent representations approach is consistent in spirit with these original models of information status.

At the same time, the emergent representations view goes beyond previous work. Linguistic theories have not made direct claims about how information status is mentally represented. In addition, each cuts up the informational pie in slightly different ways. An emergent view helps avoid this problem by suggesting that fine-grained information is retained in our mental representations. That is, mental models encode our actual attention, as well evidence about the attentional state of one’s interlocutor. This proposal draws on existing work, which suggests that situation models encode the speaker’s knowledge of task-relevant information (i.e., given information), the degree to which it is activated (i.e., accessibility/salience), and memory cues about common ground information.

A critical component of the emergent-representation approach is the assumption that conceptual representations include detailed information about task goals, and that this information changes dynamically. As a conversation unfolds, the speaker’s goals shift. These goals modulate the importance of shared vs. egocentrically available information, and they contribute to the perceived predictability of a word or concept within the context of the discourse.

This approach suggests that the information that is relevant to linguistic form is available in domain-general memory representations. This offers an elegant approach to information status. However, it also means that the conceptual representation itself does not provide any direct signals about whether information is “given”, “new”, “predictable” or other information-status categories. The job of extracting this information is delegated instead to the specific mechanisms that translate conceptual status into linguistic form.

MECHANISMS FOR USING INFORMATION STATUS

The second question is how information status is used to constrain the speaker’s choices in linguistic form. Again, classical accounts of information status do not directly address this question, and instead are aimed at explaining its role in the grammar. The grammar is understood to be a set of rules about how form and meaning relate, but it is not developed explicitly as a mechanism for either production or comprehension. For example, Chafe (1976) says “The principal linguistic effects of the given-new distinction, in English and perhaps all languages, reduce to the fact that given information is conveyed in a weaker and more attenuated manner than new information…. Given information is pronounced with lower pitch and weaker stress than new, and it is subject to pronominalization”.

Here I consider existing proposals for both explicit and emergent mechanisms, examining evidence from three linguistic domains: 1) Word order, 2) Referential choice (e.g., pronouns vs. descriptions), and 3) Acoustic prominence. In addition, I examine the role of 4) Audience design and common ground.

**Explicit mechanisms**

Grammatical theories are well suited to a psycholinguistic mechanism in which the information status is used as a selectional constraint for a particular form (Arnold & Watson, 2015; Arnold, Kaiser, Kahn, & Kim, 2013, Kahn & Arnold, 2012). This means that the grammatical constraint should translate into a production mechanism whereby a particular information status (say, givenness), triggers the selection of a form, like a pronoun. Likewise, language comprehension may be guided by an equivalent process that goes in the other direction, for example where a pronoun signals given information status. Note, however, that this idea represents an extension of most grammatical accounts of information status. Typically a grammatical constraint is expressed in terms of what types of linguistic forms are allowed, as opposed to what types of linguistic forms are required. Yet a straightforward extension of grammatical accounts of information status would encode a rule that uses the conceptual representation as input, and selects a particular form as an output.

Critically, an explicit mechanism does **not** require an explicit representation of information status, nor does it require that the representation be categorical. All it requires is that the mechanism of choosing a particular linguistic form be conditioned on particular criteria, i.e. that the selectional constraints are explicitly encoded into a rule or algorithm. This approach could account for any categorical linguistic choice, such as word order or choice of referring expression. Below I describe example of explicit mechanisms for several linguistic phenomena.

*Word Order.* In many languages, word order is flexible, such as Finnish (Kaiser & Trueswell, 2008). But even in English, which has a relatively fixed word order, speakers have many options that allow them to manipulate the order of utterance elements (Birner & Ward, 2009; see Table 2 for examples).

Table 2. Examples of word order variation in English.

|  |  |
| --- | --- |
| WORD ORDER OPTION | EXAMPLE |
| Active vs. Passive | * The dog chased the cat. * The cat was chased by the dog. |
| Verb choice | * The dog chased the cat. * The cat ran away from the dog. |
| Heavy NP Shift | * The dog chased a small, scrawny, and feisty black-and-white striped cat into the tree * The dog chased into the tree a small, scrawny, and feisty black-and-white striped cat. |
| Dative Shift | * The dog gave a snuffly kiss to the cat. * The dog gave the cat a snuffly kiss. |

Notably, many (but not all) of these contrasts involve a choice between syntactic structures, as opposed to a simple ordering of elements (Bock et al., 2004).

We know that speakers tend to prefer sentences that put given information before new (Arnold et al., 2000; Birner & Ward, 2009), giving rise to the possibility that the information status of the referents is used to select a structure. While these effects also can be explained by emergent mechanism (see below), an explicit mechanism seems required by grammatical rules that encode informational categories like focus state with structural choice, such as the use of clefts, or topicality-marking in languages like Japanese or Korean (see Arnold et al., 2013).

An example of an explicit mechanism for word order come from Chang’s dual-path model (Chang, 2009, 2015), which accounts for a wide variety of linguistic phenomena, including pronoun choice and word order. This model acquires language by learning patterns from input, and uses it to generate utterances. Notably, Chang’s connectionist model uses different mechanisms to account for pronoun choice, voicing choices (active vs. passive) and the preference to order some types of elements before others (like the preference for animate-before-inanimate). Relevant to word order is the choice between actives and passives, which is driven by the representation of event semantics: when the agent is more active than the patient or goal, then the active voice is chosen, and when the patient or goal is more active, then the passive is chosen. This choice is explicit, in that activation of the event role selects for a particular structure, and this relationship is explicitly encoded in the model.

*Choice of Referring Expression.* The production of pronouns is also known to be highly sensitive to the discourse context. For example, following the question “Where is Fido?”, the given and focused status of Fido would select for a pronoun in the response “He’s outside”. This type of mechanism is an explicit one, because the form is selected based on discourse conditions. Again, this explicit mechanism could function with explicit representations (e.g., the indexing of a referent as highly accessible), or by categorizing entities based on a set of conditions (for example, the presence of a representation for Fido in the situation model, the stipulation that Fido is discourse-relevant and that this information is known to the addressee).

In keeping with this, many researchers have proposed that speakers choose the best expression for the functional and semantic properties of the intended message (e.g., Ariel, 1990, Chafe, 1994; Gundel et al., 1993). This view lends itself to an explicit mechanism. For example, selection of a pronoun is supported by a high degree of activation for the referent, along with evidence that this information is available to the addressee (see Arnold & Griffin, 2007). An alternate view is that speakers choose pronouns for the most topical referent in the context (Kehler & Rohde, 2013). In either case, under these views the primary mechanism for reference form choice seems to be based on the selection of a form based on explicit conditions, regardless of whether the underlying representation is explicit or not.

Similarly, the production of modified expressions (“the little peach”) is supported by contexts where there is another contrasting item in the context (Brown-Schmidt & Tanenhaus, 2006; Olson, 1970; Nadig & Sedivy, 2002; Sedivy, 2003). Speakers are generally pretty good at producing modification when needed, even though they can make mistakes when their own perspective differs from their interlocutor’s (Wardlow Lane, Groisman, & Ferreira, 2006; Ferreira, Slevc, & Rogers, 2005). An explicit mechanism would easily account for this by selecting a modified form when a contrast competitor has been identified in the context. Critically, the question here is not whether this selection is fully informed by common ground, nor whether the identification is categorical or gradient, but whether the modification is the result of an explicit rule or algorithm that is about modification, and not a side-effect of some other mechanism.

Although there are few psycholinguistic models that incorporate information status, several have adopted selectional mechanisms. The critical feature of a selectional mechanism is that it requires explicit representation of the conditions required for selection of a particular form. One such model is the Schmitt et al. model (1999), in which the feature “in focus” is used to select for a pronoun. As mentioned above, Chang’s model (2009, 2015) accounts for several information-status effects, including pronoun selection. In this model, the use of pronouns is restricted to cases where the conceptual node is weak, which reflects the assumption that the concept is already familiar to the addressee and does not require an explicit referring expression. Thus, this mechanism does not draw on representations of discourse accessibility for pronoun use, but rather it selects pronouns based on audience knowledge. Thus, this model encodes an audience design constraint as an explicit constraint, and uses that to explain pronoun choice.

*Acoustic prominence*. Many linguistic distinctions require accenting to distinguish between different meanings, like *DAMON fried an egg* vs. *Damon FRIED an egg* (Breen et al. 2010). Similarly, Baumann and Grice (2006) propose that pitch accent marks the degree of activation of a referent, or serves to highlight information as noteworthy. If these conditions are used to select a particular prosodic structure, this process would be an explicit mechanism.

It has also been argued that some phonological variants are represented separately in the lexicon. For example, Bürki et al. (2010, 2011) suggested that some schwa words in French and English have two alternates, one with the schwa present (mack-e-rel), and one without (mack’rel). They argued that each pronunciation is separately represented in the lexicon. If information status is used to select for one of these forms, this would be an explicit representation.

One domain of acoustic prominence where an explicit mechanism seems particularly needed is contrastive accenting. Contrastive accenting is used to highlight a dimension of contrast within a contrast set, e.g. the *red* car, not the blue one (Baumann, Grice, & Steindamm, 2006; Krahmer & Swerts, 2001; Wagner & Klassen, 2014). This property reflects the relations between information in the discourse model, either implicitly or explicitly referring to a set of items in the context. Because this requires identifying objects as contrastive or not, it is a good candidate for a selectional mechanism, i.e. where the contrast context selects for a particular pitch accent (Baumann et al., 2006).

*Audience design and Common Ground.* Within each of these domains, a relevant question is whether audience design affects form selection, and how it is represented. If linguistic form is selected based on constraints about addressee knowledge, attention, or ease of comprehension, this could potentially be driven by an explicit representation of addressee knowledge. For example, a pronoun is only acceptable if the referent is recoverable by the addressee (Chafe, 1994; Gundel et al. 1993). An explicit mechanism would be one in which an algorithm filters forms based on assumptions about the other’s knowledge or mental state. Likewise, speakers use acoustically prominent pronunciations for distracted listeners (Rosa et al., 2015). In this experiment, distraction did not result in a general effect of slowing speech rate, but specifically applied to the information that the addressee needs to complete a task. This seems to require a process that recognizes the listener’s need for help, and triggers a more explicit pronunciation. Likewise, responses to confusion (“Pardon?”) tend to elicit more careful speech (Labov, 1966), suggesting that a more careful mode was triggered by the addressee’s needs. In addition, social information appears to trigger more explicit speaking modes. For example, noisy environments trigger the use of louder speech and more exaggerated pronunciation (termed the Lombard effect, Lane & Tranel, 1971). Likewise, distracted listeners elicit longer pronunciations for critical words (Rosa et al., 2015).

**Emergent Mechanisms**

Another possibility is that information status has emergent effects. The key difference between an explicit and emergent mechanism is that the emergent mechanism does not explicitly use information status to filter behavior, or select a linguistic form. Instead, the effect emerges “unintentionally”, as a result of some other mechanism. Here I discuss emergent mechanisms that have been proposed in the literature for three effects: a) word order, b) acoustic prominence, and c) choice of referring expression.

*Word Order.* One generalization about word order is that given and accessible information tends to precede less accessible/topical information (Arnold, Wasow, Losongco, & Ginstrom, 2000; Birner & Ward, 2009; Bock & Irwin, 1980; Chafe, 1994, Gundel, 1988). Several researchers have proposed that these effects are driven by the ease of retrieving and producing given information. These are emergent mechanisms in that they do not select for structures on the basis of information status, but rather, the word order emerges as a result of the goal of facilitating production processing.

Some researchers focus on the availability of lexical items, suggesting that speakers tend to choose syntactic structures that allow them to place available words early in the sentence (Ferreira, 2003). Other researchers propose that the process is driven by the accessibility of the conceptual or referential representation (see Bock et al., 2004 for discussion). If the concept is highly active, it facilitates the planning of that portion of the utterance, and biases to speakers choose orders that enable them to “offload” the information that is ready to go, in order to devote their working memory resources to the remaining utterance. This is consistent with evidence that word order choices correlate with fluency, and with the tendency for speakers to choose sentence structures that postpone syntactically complex information, as in the Heavy NP Shift example in Table 2 (Arnold et al., 2000, MacDonald, 2013). Simple structures are assumed to be easier to plan than complex structures, so both effects could emerge from the same fluency mechanism in English.[[1]](#footnote-1)

However, word order choices are unlikely to rest entirely on accessibility factors. In languages like English, ordering is tightly linked to structural choices, which are necessarily categorical, and reflect semantic and functional distinctions. For example, active voice structures are more common than passives, and speakers are biased to choose active structures independently of information-status considerations (Chang, 2015). Note that word order choices are tightly linked with other choices, such as the assignment of one argument to grammatical subject position. Thus, word order is likely the result of both explicit and emergent mechanisms.

One example of an emergent mechanism for the selection of syntactic structure comes from Pickering and Garrod’s Interactive Alignment model (2004). As described above, this model suggests that implicit common ground results from automatic mechanisms like priming from one’s interlocutor’s speech. For example, Branigan et al. (2010) found that after hearing someone else use a prepositional construction (*The chef giving the jug to the swimmer*), the participant would tend to use a prepositional construction when describing a different picture. This emergent mechanism accounts for the tendency to use parallel constructions in dialog, which represents a different dimension of information status than accessibility considerations. While this claim concerns the selection of syntactic constructions, it has direct consequences for the order of constituents in an utterance.

*Acoustic Prominence.* Emergent mechanisms have also been proposed for variation in acoustic prominence (e.g. the contrast between *The DOG chased the cat* vs*. The dog chased the CAT*). In fact, to a certain extent all scholars agree that some aspects of acoustic variation emerge from non-linguistic or processing mechanisms. For example, paralinguistic factors determine speech rate, which strongly determines word duration (Bell et al, 2009; Shriberg, 2001). Disfluency can also have implications for the prosody of an utterance, which affects the prominence of individual words (Bell et al., 2003). Disfluency is one of the hallmark metrics of speech difficulty, and thus indicates a relationship between production ease and acoustic prominence. Each of these examples can be considered emergent, because they result from other processes. For example, disfluency results from a failure to prepare speech in time to meet the social expectations of fluent delivery, but it has consequences for prosody.

However, the critical question for the current discussion is not just whether acoustic variation is sensitive to emergent mechanisms. Rather, the question is whether information status effects can also be characterized as emergent, or whether they reflect a different, linguistic form of acoustic variation. For example, F. Ferreira (2006) seeks to differentiate “performance” effects (i.e., emergent effects) from “prosody” effects, a term that she restricts to the grammatical effects of prosody per se.

Several authors have argued that information status effects are systematically related to performance effects on acoustic prominence (Arnold & Watson, 2015; Gahl, Yao, & Johnson, 2012; Kahn & Arnold, 2012, 2015; Watson, Buxo-Lugo, & Simmons, in press). One of the best-known effects on acoustic prominence is that of repeated mention: after mentioning a word once, the next mention tends to be shorter, less articulated, and lower in pitch (e.g., Bard et al., 2000). As my colleagues and I have argued (Arnold & Watson, 2014; Kahn & Arnold, 2012), this is likely to be due to the fact that the second mention is simply easier, and likely to be more fluent. The word is activated conceptually, lexically, and is more predictable, all of which facilitate planning and production.

One piece of evidence to support this view is that word duration is influenced by fine-grained distinctions in information status: Speakers use a shorter word duration for information that has been primed conceptually (and made predictable) than information that is completely new, but they use an even *shorter* duration if the word has also been primed lexically (in addition to becoming conceptually primed and predictable; Kahn & Arnold, 2012). Evidence also suggests that repeating a word (even if it refers to a different person) results in reduced duration, but referring to a person with a different term does not elicit reduction (Lam & Watson, 2013). These findings suggest that hearing the word itself has a central role in acoustic reduction, and that all types of informational givenness are not equal. Watson, Luxo-Bugo and Simmons (in press) propose that durational reduction emerges from phonological encoding processes, such that the more difficult portion of a word is pronounced more slowly to give the system time to converge on the correct sequencing of phonemes.

Fluency-based emergent mechanisms also provide a plausible account for predictability effects on acoustic prominence. There is substantial evidence that the duration of spoken words is influenced by the degree to which the word is predictable from the words or structures in the surrounding context (Bell et al., 2009; Gahl & Garnsey, 1996). When information is predictable, it is redundant with the context, which should support faster lexical access and facilitate utterance planning. This leads to fluent articulation, and attenuated pronunciation of predictable elements. In support of this, priming a word often leads to faster utterance initiation times as well as shortened pronunciation of the word itself (Kahn & Arnold, 2012).

*Choice of Referring Expression.* Information status has strong effects on reference form choice. When speakers refer to accessible information, they tend to use attenuated expressions, like pronouns (e.g., *Jane arrived, and then she left)* or zeros (…*and then Ø left)*, (Arnold, 1998, 2008, 2010), and they tend to produce additional modification (e.g., *the big* peach) when there is a potential ambiguity in the context (Brown-Schmidt & Tanenhaus, 2006). Classic accounts of this choice imply a selectional mechanism. However, recent evidence has also demonstrated that processing factors matter too. For example, in Arnold and Griffin (2007), we demonstrated that speakers are more likely to use a pronoun when there is a single character in the discourse (*Mickey went for a walk in the hills one day. He…*) than when there is a competitor present (*Mickey went for a walk in the hills one day with Daisy. Mickey…*), even though the referent was highly salient in both cases, and the pronoun was unambiguous. We concluded that the presence of a second character competed for memory resources, reducing the accessibility of the referent. Other works suggests that that individuals with poor working memory resources, like children or Alzheimers patients, may use pronouns that are not interpretable in context (Almor et al., 1999, Hendriks et al., 2014).

Could this work indicate an emergent mechanism for the process of selecting referential forms? One possibility is that speakers simply choose pronouns because they are easier, similarly to the proposal that word order is driven by ease of production. This is consistent with evidence that pronouns are selected more often when speakers are under working memory load (Vogels, Krahmer, & Maes, 2014). However, it is implausible to assume that the only (or even primary) constraint on the use of pronouns is one of economy. First, some studies have found that cognitive load has the opposite effect, driving speakers instead to use more explicit expressions (Rosa & Arnold, 2011, see Arnold, 2010 for discussion). Second, if ease of production were the primary determinant of pronoun use, we would predict pronouns for all entities that the speaker is attending to, regardless of their interpretability.

A more plausible proposal is that competition and cognitive load affect the speaker’s representation of the discourse context. Greater working memory resources should enhance the robustness of the discourse representation (Nozari & Arnold, under review). This should increase the accessibility of each entity, which would be expected to affect pronoun production (Arnold & Griffin, 2007). Alternatively, the availability of cognitive resources could influence the speaker’s ability to represent the addressee’s knowledge as a part of the discourse model. Hendriks et al. (2014) found that young children used pronouns egocentrically, consistent with this possibility.

SUMMARY: REPRESENTATIONS AND MECHANISMS OF INFORMATION STATUS

This paper makes two contributions to the literature on information status. First, it explicitly considers the kinds of cognitive representations and mechanisms that might underlie information status effects in language, considering results from three domains: word order, choice of referential expression, and acoustic prominence. Information status is widely acknowledged to affect language form, where certain conditions are either necessary or sufficient for particular linguistic forms (e.g., pronoun/description use, word order, or acoustic reduction/prominence). The fact that the context selects for a form seems to implicitly suggest that a) the relevant dimension is explicitly represented, and b) the psycholinguistic mechanism involved is a rule or algorithm that selects a form on the basis of the conditioning criteria. Yet these mechanisms are rarely proposed or motivated. The current paper examines this question broadly, considering several different criteria.

Second, I have argued that distinguishing between emergent and explicit effects is necessary to achieve a mechanistic explanation of how language form is influenced by question information status and common ground. This categorization is a useful tool, methodologically, because it enables researchers to tackle general questions about cognitive architecture, categorizing emergent or explicit effects together, which supports the identification of general classes of models.

I have further proposed that these questions can be asked separately about representations and mechanisms. In principle, all information status distinctions could be instantiated with an explicit representation, so the critical question is whether such explicit representations are necessary. Evidence suggests that different linguistic phenomena require different information status distinctions, which means that a) a single universal representation of information status is probably not possible, and b) representing all distinctions would impose a severe cognitive load. Thus, it is important to discover whether information status representations could fall out of other cognitive processes. I argued that it could, drawing on proposals about attention, memory, and the importance of tracking task goals.

The question of whether the mechanisms themselves are explicit or emergent is an orthogonal issue. Again, the default assumption seems to be that selectional criteria are applied as an explicit rule or algorithm. This type of “selectional” mechanism shows up in some computational models (e.g., Chang, 2009, 2015; Schmitt et al., 1999; van Rij et al., 2011), but is typically not compared to alternative emergent possibilities. Here I reviewed a few areas in which emergent mechanisms have been proposed, most notably in the domains of word order and acoustic prominence.

My goal with this paper is to highlight questions about the mechanisms by which information status affects language form. This approach considers questions about common ground within a broader information-status framework. Under this framework, social information, such as the knowledge and attention of ones interlocutors, contributes to conceptual representations, but does not have a special status. This approach shifts questions about audience design away from questions about whether audience design has any effect at all, toward questions about how representations of others’ mental states are used, and whether the mechanisms are selectional or the emergent result of other cognitive mechanisms.

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REFERENCES

Almor, A., D. Kempler, M. C. MacDonald, E. S. Anderson, and L. K. Tyler. (1999). Why do Alzheimer patients have difficulty with pronouns? Working memory, semantics and reference comprehension and production in Alzheimer’s disease. *Brain and Language* 67, 202–27.

Ariel, M. (1990). Accessing noun-phrase antecedents. London: Routledge.

Arnold, J. E. (1998). Reference form and discourse patterns. Stanford University: Unpublished doctoral dissertation.

Arnold, J. E. (2008). Reference production: Production-internal and addressee-oriented processes. Language and Cognitive Processes, 23, 495–527. doi:10.1080/01690960801920099

Arnold, J. E. (2010). How speakers refer: The role of accessibility. *Language and Linguistics Compass*, 4, 187–203. doi:10.1111/j.1749-818X.2010.00193.x

Arnold, J. E. & Watson, D. G. (2015). Synthesizing meaning and processing approaches to prosody: performance matters. *Language, Cognition, and Neuroscience, 30,* 88-102.DOI: 10.1080/01690965.2013.840733

Arnold, J. E., Kahn, J. M., & Pancani, G. C. (2012). Audience design affects acoustic reduction via production facilitation. *Psychonomic Bulletin and Review*, 19, 505–512. doi:10.3758/ s13423-012-0233-y

Arnold, J. E., Wasow, T., Losongco, T., & Ginstrom, R. (2000). Heaviness vs. newness: The effects of structural complexity and discourse status on constituent ordering. *Language,* 76, 28-55.

Arnold, J.E., Kaiser, E., Kahn, J., Kim, L. (2013). Information structure; Linguistic, cognitive, and processing approaches. *WIREs Cognitive Science*, Wiley. doi: 10.1002/wcs.1234

Bard, E. G., Anderson, A. H., & Sotillo C. (2000). Controlling the intelligibility of referring expressions in dialogue. *Journal of Memory and Language, 42*(1), 1-22.

Bard, E. G., Anderson, A. H., Sotillo, C., Aylett, M., Doherty- Sneddon, G., & Newlands, A. (2000). Controlling the intelligibility of referring expressions in dialogue. *Journal of Memory and Language, 42*, 1–22. doi:10.1006/jmla. 1999.2667

Barr, D. J. (2008). Pragmatic expectations and linguistic evidence: Listeners anticipate but do not integrate common ground. *Cognition*, *109*(1), 18-40. doi:10.1016/j.cognition.2008.07.005

Baumann, S., & Hadelich, K. (2003). Accent type and givenness: An experiment with auditory and visual priming. In Pro- ceedings of the 15th ICPhS Barcelona (pp. 1811–1814).

Baumann, S., Grice, M., & Steindamm, S. (2006). Prosodic marking of focus domains – categorical or gradient? Proceedings Speech Prosody 2006 (pp. 301–304). Dresden, Germany.

Bell, A., Brenier, J. M., Gregory, M., Girand, C., & Jurafsky, D. (2009). Predictability effects on durations of content and function words in conversational English. Journal of Memory and Language, 60(1), 92–111. doi:10.1016/j.jml.2008.06.003

Bell, A., Jurafsky, D., Fosler-Lussier, E., Girand, C.Gregory, M., & Gildea, D. (2003). Effects of disfluencies, predictability, and utterance position on word form variation in English conversation. *Journal of the Acoustical Society of America*, 113, 1001–1024. doi:10.1121/1.1534836

Bock, J. K., & Irwin, D. E. (1980). Syntactic effects of information availability in sentence production. *Journal of Verbal Learning & Verbal Behavior* , 19, 467-484.

Bock, J. K., Irwin, D. E., & Davidson, D. J. (2004). Putting first things first. In J. M. Henderson & F. Ferreira (Eds.), The integration of language, vision, and action: Eye movements and the visual world. New York: Psychology Press.

Bock, J. K., Irwin, D. E., & Davidson, D. J. (2004). Putting first things first. In J. M. Henderson & F. Ferreira (Eds.), The integration of language, vision, and action: Eye movements and the visual world. New York: Psychology Press.

Bower, G. H., & Morrow, D. G. (1990). Mental models in narrative comprehension. *Science*, 247(4938), 44–48. doi:10. 1126/science.2403694

Bransford, J. D., Barclay, J. R., & Franks, J. J. (1972). Sentence memory: A constructive versus interpretive approach. *Cognitive Psychology*, 3(2), 193-209.

Breen, M., Fedorenko, E., Wagner, M., & Gibson, E. (2010). Acoustic correlates of information structure. *Language and Cognitive Processes*, 25, 1044–1098. doi:10.1080/01690965. 2010.504378

Brennan, S. E. (1995). Centering attention in discourse. *Language And Cognitive Processes*, *10*(2), 137-167. doi:10.1080/01690969508407091

Brennan, S. E. & Clark, H. H. (1996). Conceptual pacts and lexical choice in conversation. *Journal of Experimental Psychology: Learning, Memory and Cognition, 22*, 482-1493.

Brennan, S. E., & Clark, H. H. (1996). Conceptual pacts and lexical choice in conversation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*(6), 1482-1493.

Brown-Schmidt, S., & Tanenhaus, M. K. (2006). Watching the eyes when talking about size: An investigation of message formulation and utterance planning. *Journal of Memory and Language*, *54*(4), 592-609.

Chafe, W. (1976). Givenness, contrastiveness, definiteness, subjects, topics, and point of view. *Subject and topic*, ed. by C. N. Li, 25–56. New York: Academic Press Inc.

Chafe, W. L. (1994). *Discourse, consciousness, and time: The flow and displacement of conscious experience in speaking and writing*. Chicago, IL: University of Chicago Press.

Chang, F. (2009). Learning to order words: A connectionist model of heavy NP shift and accessibility effects in Japanese and English. Journal of Memory and Language, 61, 374-397.

Chang, F. (2015) The role of learning in theories of English and Japanese processing. In M. Nakayama (Ed), *Handbook of Japanese Psycholinguistics*. Mouton

Clark and Haviland

Clark, H. H. & Krych, M. A. (2004) Speaking while monitoring addressees for understanding. *Journal of Memory and Language, 50*, 62-81.

Clark, H. H. and Haviland, S. E. (1979). Comprehension and the given-new contract. In R. O. Freedle (Ed.), *Discourse Production and Comprehension, volume 1 of Discourse Processes: Advances in Research and Theory* (pp*.* 1-40). Hillsdale, NJ: Lawrence Erlbaum Associates.

Clark, H. H., & Marshall, C. R. (1981). Definite reference and mutual knowledge. In A. K. Joshi, B. L. Webber, & I. A. Sag (Eds.), *Elements of discourse understanding* (pp. 10–63). Cambridge: Cambridge University Press.

Cowles, W. & Ferreira, V. (2011). The Influence of Topic Status on Written and Spoken Sentence Production. Discourse Process, 49(1), 1–28.

Dahan, D., Tanenhaus, M. K., & Chambers, C. G. (2002). Accent and reference resolution in spoken-language comprehension. *Journal of Memory and Language, 47,* 292-314

Ferreira, F. (2007). Prosody and performance in language production. *Language and Cognitive Processes, 22*, 1151–1177. doi:10.1080/01690960701461293

Ferreira, V. S. (2003). The persistence of optional complementizer production: Why saying “that" is not saying “that" at all. *Journal of Memory and Language , 48*(2), 379-398.

Ferreira, V. S., & Dell, G. S. (2000). Effects of ambiguity and lexical availability on syntactic and lexical production. *Cognitive Psychology , 40*, 296-340.

Ferreira, V. S., Slevc, L. R., & Rogers, E. S. (2005). How do speakers avoid ambiguous linguistic expressions? *Cognition, 96,* 263–284.

Folk, C. L., Remington, R.W., & Johnston, J.C. (1992). Involuntary covert orienting is contingent on attentional control settings. *Journal of Experimental Psychology: Human Perception and Performance, 18,* 1030-1044.

Fukumura, K,, van Gompel R., Harley, T., Pickering, M. (2011). *Journal of Memory and Language*, 65, 331-344.

Gahl, S. & Garnsey, S. M. (2006). Knowledge of grammar includes knowledge of syntactic probabilities. Language vol. 82(2), 405-410.

Givón, T. (1983). Topic Continuity in Discourse: An Introduction. In T. Givón (Ed.), *Topic Continuity in Discourse: A Quantitative Cross-Language Study* (pp. 1-42).

Grosz, B; Joshi, A; & Weinstein, S. (1995). Centering: A Framework for Modeling the Local Coherence of Discourse . *Computational Linguistics 2*(21), 203-225.

Grosz, B., & Sidner, C. (1986). Attention, intentions, and the structure of discourse. *Computational Linguistics 12*, 175–204.

Gundel, J. K. (1988). Universals of topic-comment structure. In M. Hammond, E. A. Moravcsik, & J. R. Wirth (Eds.), (pp. 209-239). Amsterdam: John Benjamins.

Gundel, J. K., Hedberg, N. & Zacharaski, R. (1993). Cognitive status and the form of referring expressions. *Language 69*, 274–307.

Halliday, M. A. K. (1967). Intonation and grammar in British English. The Hague: Mouton.

Hendriks, P., Koster, C., & Hoeks, J. J. (2014). Referential choice across the lifespan: Why children and elderly adults produce ambiguous pronouns. *Language, Cognition And Neuroscience*, *29*(4), 391-407. doi:10.1080/01690965.2013.766356.

Horton & Gerrig, 2005

Horton, W. S., & Gerrig, R. J. (2005). Conversational Common Ground and Memory Processes in Language Production. *Discourse Processes*, *40*(1), 1-35. doi:10.1207/s15326950dp4001\_1.

Horton, W. S., & Keysar, B. (1996). When do speakers take into account common ground?. *Cognition*, *59*(1), 91-117. doi:10.1016/0010-0277(96)81418-1.

Johnson-Laird, P. N. (1983). *Mental models: Toward a cognitive science of language, inference and consciousness*. Cambridge, MA: Harvard University Press.

Kahn, J. & Arnold, J.E. (2015). Articulatory and lexical repetition effects on durational reduction: speaker experience vs. common ground. *Language, Cognition, and Neuroscience*, *30,* 103-119. doi: 10.1080/01690965.2013.848989.

Kahn, J., & Arnold, J. E. (2012). A processing-centered look at the contribution of givenness to durational reduction. *Journal Of Memory And Language, 67*(3), 311–325. doi:10.1016/ j.jml.2012.07.002

Kaiser E, & Trueswell J.C. (2008) Interpreting pronouns and demonstratives in Finnish: evidence for a form-specific approach to reference resolution. *Language and Cognitive Processes, 23*, 709–748.

Keysar, B., Barr, D. J., Balin, J. A., & Brauner, J. S. (2000). Taking perspective in conversation: The role of mutual knowledge in comprehension. *Psychological Science, 11,* 32-38.

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A constructive-integration model. *Psychological Review, 95*, 163-182.

Krahmer, E., & Swerts, M. (2001). On the alleged existence of contrastive accents. Speech Communication, 34, 391–405. doi:10.1016/S0167-6393(00)00058-3

Labov, W. (1966). The Social Stratification of English in New York City. Washington: Center for Applied Linguistics.

Lam, T. Q. & Watson, D. G. (2010). Repetition is easy: Why repeated referents have reduced prominence. *Memory and Cognition*, 38, 1137-114

Lane, H., & Tranel, B. (1971). The Lombard sign and the role of hearing in speech. *Journal of Speech and Hearing Research, 14*, 677-709.

Lane, L. W., Groisman, M., & Ferreira, V. S. (2006). Don't Talk About Pink Elephants! Speakers' Control Over Leaking Private Information During Language Production. *Psychological Science*, *17*(4), 273-277. doi:10.1111/j.1467-9280.2006.01697.x

MacDonald, M. C. (2013). How language production shapes language form and comprehension. *Frontiers In Psychology*, *4,* doi:10.3389/fpsyg.2013.00226.

Morrow, D. G., Bower, G. H., & Greenspan, S. L. (1987). Accessibility and situation models in narrative comprehension. *Journal of Memory and Language, 26*, 165–187. doi:10.1016/0749-596X(87)90122-7

Nadig, A. S., & Sedivy, J. C. (2002). Evidence of perspective-taking constraints in children's on-line reference resolution. *Psychological Science 13*(4), 329-336.

Nappa, R., & Arnold, J. E. (2014). The road to understanding is paved with the speaker’s intentions: Cues to the speaker’s attention and intentions affect pronoun comprehension. *Cognitive Psychology, 70*, 58–81. doi:10.1016/j.cogpsych.2013.12.003

Olson, D. R. (1970). Language and thought: Aspects of a cognitive theory of semantics. *Psychological Review, 77*(4), 257-273.

Pickering, M. J., & Garrod, S. (2004). Toward a mechanistic psychology of dialogue. *Behavioral and Brain Sciences, 27,* 169–226.

Pickering, M. J., & Garrod, S. (2004). Toward a mechanistic psychology of dialogue. *Behavioral And Brain Sciences*, *27*(2), 169-226. doi:10.1017/S0140525X04000056

Prince, E. (1981). Toward a taxonomy of given-new information. In P. Cole, (Ed.), Radical pragmatics (pp. 223–256). New York, NY: Academic Press.

Rosa, E. C. & Arnold, J. E. (2011). The role of attention in choice of referring expressions. Proceedings of PRE-Cogsci: Bridging the gap between computational, empirical and theoretical approaches to reference, Boston, 2011.

Rubin, R. D., Brown-Schmidt, S., Duff, M. C., Tranel, D., & Cohen, N. J. (2011). How do I remember that I know you know that I know?. *Psychological Science*, *22*(12), 1574-1582. doi:10.1177/0956797611418245

Sanford, A. J., & Garrod, S. C. (1981). Understanding written language. Chichester, UK: Wiley.

Schmitt, B. M., Meyer, A. S., & Levelt, W. M. (1999). Lexical access in the production of pronouns. *Cognition*, *69*(3), 313-335. doi:10.1016/S0010-0277(98)00073-0

Sedivy, J. C. (2003). Pragmatic versus form-based accounts of referential contrast: Evidence for effects of informativity expectations. *Journal of Psycholinguistic Research, 32,* 3–23.

Shriberg, E. 2001. To “errrr” is human: Ecology and acoustics of speech disfluencies. Journal of the International Phonetic Association 31.1: 153–169

Vallduví, E. (1992). The informational component. Garland Publishers, New York/London, 186pp. ISBN 0-8153-0701-2.

van der Meulen, F. F., Meyer, A. S., & Levelt, W. M. (2001). Eye movements during the production of nouns and pronouns. *Memory & Cognition*, *29*(3), 512-521. doi:10.3758/BF03196402

Van Rij, J. van Rijn, H., & Hendriks, P. (2011). WM load influences the interpretation of referring expressions. In Proceedings of the 2nd workshop on cognitive modeling and computational linguistics (p. 67-75). Portland, OR: Association for Computational Linguistics

Vogels, J., Krahmer, E., & Maes, A. (2014 online). How cognitive load influences speakers’ choice of referring expressions. Cognitive Science, 1-23. DO!: 10.1111/cogs.12205.

Wardlow Lane, L., Groisman, M & Ferreira, V. S. Don’t talk about pink elephants! Speakers' control over leaking private information during language production. *Psychological Science, 17*, 273-277.

Watson, D. G., Buxó-Lugo, A., & Simmons, D. C. (in press). The effect of phonological encoding on word duration: Selection takes time. In E. Gibson & L. Frazier (Eds.), *Explicit and Implicit Prosody in Sentence Processing.*

1. This may not hold for all languages, however. For example, Japanese and Korean structure syntactically complex phrases before simple ones (Chang, 2009; Yamashita & Chang, 2001; Choi, 2007). [↑](#footnote-ref-1)