

Production of complex sentences: Studies across languages and development

By

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Abstract

This dissertation investigates structure choice of complex sentences across three languages and across development. The goal of this work was to identify factors that motivate production choices and what these factors suggest about the knowledge and processes that underlie sentence production. In three studies, participants saw scenes depicting people acting on other people and inanimate objects. They answered questions about the entities that were acted upon, which elicited either active object relative (“the toy/man that the girl is hugging”) or passive relative (“the toy/man that is being hugged by the girl”) utterances. In Chapter 1, I investigated structure choices made by English speakers as a function of the visual environment. Speakers almost always produced passive utterances when describing animate entities, and produced a mix of object and passive relatives when describing inanimate entities. Further, less visually salient inanimate entities tended to more often be described with passives. This is interpreted as evidence of the linguistic *and* visual context affecting production choices. In Chapter 2, I investigated differences in structure choice by speakers of English, Japanese and Korean. All speakers produced more passive utterances when describing animate entities, but the absolute rates of passives varied across languages. Crucially, rates of passives in main clauses were a better predictor of the rate of passives in relative clauses than was language typology. Finally, In Chapter 3, I investigated differences in structure choice of eight-year-old children, twelve-year-old children and adults. Two corpus analyses showed that passive relatives are far more common in children’s literature than in child-directed speech. While all age groups produced more passive utterances when describing animate entities, overall rates of passives increased with age. Consistent with the results of the corpus analyses, increased text exposure in eight-year-old children and adults was associated with a greater proportion of passive

utterances. These studies suggest a number of factors that affect production choices. Specifically, these studies provide evidence that constraints on the speaker affect production choices, and when possible, speakers learn to use the flexibility afforded by language to make the production process easier.

Introduction

Language use has two components, production and comprehension. During sentence production, speakers must quickly select one word or sentence out of a near infinite number of alternatives while simultaneously executing a complex motor plan to articulate those selected words. When comprehending sentences, listeners must decode a noisy acoustic signal and extract meaning from words and phrases which may be ambiguous or occasionally unintelligible. The field of psycholinguistics aims to understand the knowledge and processes that underlie these behaviors. However, the two topics are typically studied independently, and far more research has focused on the mechanisms on sentence comprehension compared to those of production. This separation and asymmetry is unfortunate, because understanding production and comprehension jointly may help us understand the knowledge and processes that underlie human language behavior.

My research program has focused on investigating adult sentence production and comprehension as processes that can be better understood when investigated together. To this end, much of my work has investigated various predictions made by the Production-Distribution-Comprehension (PDC) framework (MacDonald, 2013). The PDC framework is a theoretical framework that proposes that production and comprehension should be studied in tandem because they are both components of an interactive system in which outputs from one (production) serve as inputs to the other (comprehension).

The PDC framework suggests that the ease or difficulty with which something is comprehended is predicted by one's experiences with their linguistic environment. This hypothesis is no longer controversial in the sentence processing literature, and work done explicitly within the PDC framework is consisted with dozens or even hundreds of papers that

suggest a role for experience in sentence comprehension. For example, corpus frequencies of sentence structures, including both relative clauses (Gennari & MacDonald, 2009) and verb modifying phrases (e.g., *John said that Mary left yesterday*; MacDonald & Thornton, 2009), two very well studied sentence types in the sentence processing literature, reliably predict comprehension behavior. In addition to corpus frequencies, participant-generated sentence completions of sentence fragments, for example, the frequency with which participants complete a sentence fragment with a relative clause, also predict comprehension difficulty, (Gennari & MacDonald, 2008). There is strong evidence, from both work within the PDC framework and otherwise, suggesting that experience better predicts comprehension behavior than syntactic complexity, or other innate constraints on comprehension ability.

However, this claim, that comprehension difficulty is predictable in terms of linguistic distributions, raises a question. Why are a language's distributions the way they are? One possible answer is that these linguistic distributions are shaped by speakers' production choices. On one hand, speakers say the things they do because there is a message they are trying to communicate. However, even within the constraints of a particular message, there are often many ways that a particular idea can be expressed. One possible reason that speakers make the choices they do is to alleviate production difficulty and make the production process easier (Ferreira & Dell, 2000). If comprehension reflects learning the statistics of input over time, and these statistics derive from speaker's choices to alleviate production difficulty, then it is critical to investigate both why people say what they do, and how people react to the statistics they are given.

The PDC framework stands in contrast to many other prominent lines of work in psycholinguistics that discount the notion that a better understanding of the production process

can help us understand comprehension behavior, or even the origin distributional patterns in the language. Some theories suggest that because the same brain is both producing and comprehending sentences, the same constraints that make a sentence hard to comprehend ought to also make it hard to produce, so little additional explanation is to be gained by studying comprehension and production together (Frazier, 1995). Other lines of research suggest that production choices are made purely on the basis of communicative efficiency, with the physical process of planning and articulation irrelevant to the choices being made. For example, some theories suggest that speakers' production choices are made based largely on the needs of the listener (Brennan & Clark, 1996; Pickering & Garrod, 2004). This "audience design" hypothesis suggests that speakers want to be helpful and understood, so factors relating to the nature of the discourse or the listener drive production choices. Other hypotheses suggest that speakers are not making choices explicitly for the benefit of the listener, but to be maximally communicative in a mathematical sense. These theories often invoke information theory, and suggest that in order to be most efficiently understood through a noisy channel, information (speech) should be uniformly complex. This "uniform information density" hypothesis (Jaeger, 2010) proposes that speakers make the choices they do to keep the information contained over time in the signal uniform. As a consequence, choices are not made based on internal constraints or demands on the speaker, but to adhere to mathematically derived measures of efficiency. These two approaches both suggest, for different reasons, that investigating production choices is not informative, or even relevant, to understanding comprehension patterns.

In contrast to work that proposes that understanding production choices is not relevant or necessary for understanding the distributional patterns of a language, the PDC framework suggests that production choices made by speakers is exactly the origin of those distributional

patterns. Previous work within the PDC framework also suggests a number of factors that affect production choices, and thus the distributional patterns of words and sentences in a language. Speakers' past experiences with distributional patterns in their language affect production choices (Haskell, Thornton & MacDonald, 2010), suggesting that certain agreement errors that speakers make reflects the repetition of high-frequency patterns in situations in which that pattern is not relevant. There is also evidence that regardless of language typology, semantic factors such as animacy affect production choices across languages in predictable ways (Gennari, Mirkovic & MacDonald, 2012). Speakers of different languages also seem to encounter similar production or lexical retrieval difficulties associated with planning an utterance with two semantically similar nouns, and they avoid producing the optional semantically similar competitor in order to avoid the semantic interference (Gennari, Mirkovic & MacDonald, 2012). There has been significant progress made, in this and other work investigating the factors that affect production choices, but the production process is still poorly understood. My dissertation attempts to continue this investigation of the knowledge and processes that humans employ when they produce language.

In my dissertation, I build upon these findings and investigated the motivations behind choices that speakers make when producing sentences. This dissertation also introduces new research questions not previously addressed by past work within the PDC framework, by investigating how human production abilities develop in children, and how age and experience related factors might contribute to production choice and abilities.

The dissertation consists of three production studies, all of which attempt to answer questions about why people say what they do when they produce language. All three studies are picture-description studies, in which participants answer questions about visual scenes. The task

is designed so that when participants describe the pictures, they must choose between either an object relative clauses (1) or a passive relative clauses (2). In an object relative clause sentence, the head noun, which is the entity that the relative clause is modifying (in this example, *the book*), is the grammatical object of the sentence. The passive relative clause (2) is a passive version of the object relative clause, the embedded verb (in this example *hold*) is passive, not active. The head noun (*The book*) is now the subject of the sentence, which would technically make a passive relative a type of subject relative clause, though that term is typically reserved for relative clauses in which the subject of the sentence is the head noun and the embedded verb is active (for example, *The woman that is holding the book*).

(1) The book (that) the woman is holding

(2) The book (that is) being held by the woman.

These sentences are particularly informative of sentence production processes for a number of reasons. First, relative clauses have been extensively studied since Chomsky and Miller (1963) identified them as structures that tax human memory abilities, and since then they have been the domain in which theories of language use have been tested or pitted against each other. Second, these sentences convey a similar meaning, so they are available to speakers as competing choices when a speaker intends to convey that message. We can investigate why speakers might choose one alternative or the other, based on aspects of the message he or she wishes to convey, or planning and articulation difficulty encountered during the production process. Using object and passive relative clauses as a test case, the three studies in this dissertation investigate the reason that speakers make particular choice they do when the speak.

Chapter 1 investigates the role of visual scene properties in production choices of relative clauses that modify either animate or inanimate target entities. We know that animacy affects

production choices (Ferreira, 1994; McDonald, Bock & Kelly, 1993), but it is unclear why. It may be due to semantic differences between animate and inanimate entities, or it could reflect distributional differences between animate and inanimate entities in language. In addition to this animacy manipulation, target entities vary in visual salience, which past work has shown to affect production choices (Gleitman, January, Nappa & Trueswell, 2007; Tomlin, 1995), but again, it is unclear why this effect exists. It may reflect low-level perceptual processes—things that are easy to see may be easier to plan and produce, or visual properties may shift in the message that the speaker intends to convey, so that the effect of visual salience is task specific. Production patterns suggest that animacy affects production choices in that participants produce more passive relative clauses when describing animate entities. Second, visual properties of the scene affect production choices. I find that visual properties of the scene being described subtly change the intended message in consistent ways, which affects speaker's choice of an object or passive relative clause utterance. This suggests that speakers are sensitive to even very fine-grained detail about how their language codes a message and use this knowledge when producing sentences. Participant productions also replicate a number of classic measures of production difficulty, including relative pronoun use (Ferreira & Dell, 2000; Race & MacDonald, 2003) and agent dropping in passive relative clauses (Gennari, Mirkovic & MacDonald, 2012) suggesting that this production task is a valid representation of human speech. This study shows that speakers learn fine-grained detail about how their language codes messages, and apply this knowledge in online production.

Chapter 2 investigates if and how production choices in three languages vary as a function of typological and idiosyncratic differences across languages, by investigating production choices in native speakers of English, Japanese and Korean. Cross-linguistic

investigations can be powerful tools to employ to understand language production (and comprehension) processes. These studies can help the researcher distinguish between language-specific and general cognitive mechanisms that underlie language behavior and they can allow researcher to test predictions or perform manipulations that would not be possible in a single language. Chapter 2 employs an identical task to that of Chapter 1. The choice of an object or passive relative exists in all three of these languages, but the three languages vary in typology and thus the planning demands may vary across the three languages. In Japanese and Korean, the word order of the object and passive relative clause sentences are identical, and these sentence types vary only in case marking and inflection morphology of the verb. The object and passive relative clauses are also typologically identical in Japanese and Korean, but passive sentences are overall quite rare in Korean (Song & Choe, 2007). This sample of languages allows us to separately investigate the effects of message, language typology and idiosyncratic language patterns on structure choice. We find that some factors affect production choices in all three languages. For example, animacy seems to have a similar effect on production across all languages, suggesting that accessibility-driven noun ordering cannot account for the animacy effect in this task. However, speakers are also sensitive to patterns within their language. Despite the typological similarity of Japanese and Korean, Korean speakers tend to produce fewer passive relatives because there is a general restriction on passives. Participant choices of active or passives in a main clause production task mirror participant choices of active object or passive relative clauses in the relative clause production task. This provides evidence for generalization across sentence structures, as production patterns of main clause sentences seems to affect similar, but nonetheless different relative clauses.

Chapter 3 investigates motivations of structure choice not previously investigated within the PDC framework, by looking at how developmental and experience-related individual differences affect production choices. Complex patterns that dictate how a language codes a particular message (investigated in Chapters 1 and 2) take time to learn, so it is possible that children, who have less experience with the statistics of their language, might make systematically different production choices than adults while they are still learning the patterns of their language. Another important change across the developmental trajectory is the emergence of literacy, as distributions of sentence structures in written and spoken language tend to vary dramatically (Biber, 1988; Reali & Christiansen, 2007; Roland, Dick & Elman, 2007), and as a result, literate children may encounter a qualitatively different set of statistics than pre-literate children. There is little work that investigates the learning mechanisms that drive language production choices, though children must learn to produce language in the same sense that they must learn how to comprehend language. Understanding the developmental trajectory of sentence production can help us understand the statistics and patterns that children learn and which informs their production choices. A powerful feature of the PDC framework, and other experience-based approaches to language use, is that they make predictions about the developmental trajectory of the language behaviors. Previous work within the PDC framework has generally focused on production choices that arise from production difficulty demands on the speaker, which are undoubtedly an important aspect of production choices (and also reflects strategic planning that must be learned) but relatively little work has investigated the learning that contributes to production choices, and the role of learning in production difficulty. In a task similar to those used in Chapters 1 and 2, but simplified for use with eight and twelve year old children, I elicited object and passive relative clauses from children to investigate how children's

productions of these complex sentences might differ from adults' production. I also performed a corpus analysis of these object and passive relative clauses in children's literature and child-directed speech in order to make predictions about how adult and child productions might vary if emerging literacy and increasing text exposure were playing a role in developmental changes in this behavior. I find that children's productions in this relative clause production task indeed tend to differ from adult productions in ways that are consistent with differences between written and spoken languages. Further, along with group differences, individual differences in text exposure also predict production choices. This suggests that language statistics that a speaker encounters through reading may affect spoken language choices that speakers make. This suggests another source of language statistics that speakers may be learning, that should be incorporated into learning-based theories of language use. It is also consistent with a role of literacy in adult-like language use, even spoken language, which has both theoretical and practical implications.

Taken together, these three studies investigate multiple factors that affect production choices. Some production choices reflect choices that speakers make to alleviate difficulty associated with online sentence production, and other choices reflect the language patterns that speakers learn over their lifetimes. Understanding these two contributions to structure choice, and how they are learned is crucial for understanding the knowledge and processes that underlie sentence production. Within the PDC framework, understanding the production choices that people make is particularly important, because these production choices help us understand why the distributional patterns of language have the structure they do, which has implications for both language comprehension and language change over time.

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Chapter 1: Visual salience modulates structure choice in relative clause production

Speakers who want to convey an idea generally have many alternative utterance forms to accomplish their goal. For example, an English speaker may describe a single scene in a number of different ways: *The dog is chasing the cat, the cat is being chased by the dog, the cat is fleeing from the dog*, and many other variations. The availability of multiple syntactic and lexical alternatives offers speakers a great deal of flexibility but also a challenge, in that successful communication requires converging on only one utterance plan, and not a nonsensical blend of alternative forms, such as *the chasing cat the dog*. The mechanisms by which speakers settle on one utterance form are therefore an important component of research in language production, particularly in grammatical encoding, the early stage in which lexical and grammatical choices are made.

One component of this process of converging on an utterance plan appears to derive from the *accessibility* of concepts and their related words, where accessibility can be defined as the ease with which the entity can fit into a developing utterance plan. Thus accessibility can vary with factors such as conceptual prominence or frequency, and more accessible elements are thought to enter into planning earlier. A number of studies have suggested that speakers tend to place more salient entities, such animate (Bock, Loebell & Morey, 1992; F. Ferreira, 1994; McDonald, Bock & Kelly, 1993; Tanaka, Branigan, McLean & Pickering, 2011), prototypical (Onishi, Murphy & Bock, 2008), or imageable nouns (Bock & Warren, 1985), as well as more easily articulated (Bock, 1987) words and phrases earlier in an utterance plan and/or in a prominent syntactic position (such as grammatical subject) during utterance planning. Immediate conversational context may also modulate the relative accessibility of sentence elements. For example, *given* information, which has previously been mentioned in the discourse, is more accessible than new

information (presumably via a mechanism such as lexical/conceptual priming), and so gets placed earlier in the sentence than new information (Bock & Irwin, 1980; V. Ferreira & Yoshita, 2003; MacWhinney & Bates, 1978; Prat-Sala & Brannigan, 2000).

Other external factors, such as qualities of the visual environment, can also affect production choices when speakers are referring to visible entities and events, as in picture description tasks. Obviously the visual scene must play a major role in the sentence used to describe the scene; if the scene consisted of a dog chasing a squirrel rather than a cat, that aspect would be reflected in the utterance. However, more subtle aspects of the visual scene also affect production choices. For example, Bock, Irwin, Davidson & Levelt (2003) examined Dutch and English speakers' preferences for producing absolute reports of time (e.g., *It's ten fifteen*) vs. relative reports (*It's a quarter after ten*) as a function of the visual environment—whether the speakers were looking at a digital or analog clock. The digital display increased the rate of absolute time reports, but the effect of the display varied as a function of the language spoken, as Dutch and English differ in the relative frequency of absolute vs. relative time usages. These results suggest that visual and linguistic influences interact during the formation of an utterance plan.

Macdonald (2013) suggested that accessibility effects are emergent from the gating functions of attention, which prioritize easily-retrieved elements from long term memory during the development of the utterance plan. If so, variation in visual salience, the extent to which elements of a visual scene can attract a speaker's attention, should affect the accessibility of visual elements and thereby affect utterance form. For example, when visual cues are provided that deliberately (Tomlin, 1995; 1997) or implicitly (Gleitman, January, Nappa & Trueswell, 2007) draw speakers' attention to one pictured element, that entity tends to be mentioned early in subsequent utterances, affecting the structure of utterances. For example, for a picture of a dog

chasing a mailman, when Gleitman et al. used a subliminal flash of light near the dog, implicitly drawing attention to this element, descriptions tended to be in the active voice, with the dog as the sentence subject (*The dog is chasing the mailman*), but when attention was drawn to the mailman, descriptions tended to be passive, with the mailman as subject, as in *The mailman is getting chased by the dog*. Gleitman et al. suggested that the attention-directing cue affected the order of object recognition processes, so that the cued element was recognized first, which in turn affected the accessibility of the linguistic labels for entering an utterance plan. These visual cuing effects on utterance form vary in strength as a function of the language spoken; they appear to be weaker in languages in which the passive voice is a less viable alternative than in English (Gennari, Mirković & MacDonald, 2012; Kaiser & Vihman, 2006; Myachykov & Tomlin, 2008). Cross-linguistic differences in cuing effects add more evidence for an interaction between visual, conceptual and linguistic influences during utterance formation.

Although the visual cuing affecting the order of elements in an utterance can be interpreted as the effects of attentional capture (via a flash of light or other visual cue), the effect of visual cuing on structure choice can also be interpreted as altering the message of the utterance. When an object is cued, it becomes the topic or focus of the sentence, and that shift in topic is reflected in the structure choice. Thus visual salience can interact with the linguistic context of a message, and the nature of the visual salience effect can vary depending on other aspects of the task or context in which the utterance is produced.

Taken together, these results suggest that the visual salience of elements in view clearly affects people's descriptions of those elements, but the effect is not a simple linkage between visually salient elements and early sentence positions. Instead, the effect of visual salience appears to be task dependent, so that visual information may be viewed or interpreted differently

depending on the goals of the task. For example, in another study in which speakers reported the time while looking at clocks, Kuchinsky, Bock and Irwin (2011) found that speakers' eyegaze patterns differed when they were asked to read the time normally (small clock hand for the hour, big hand for the minutes) or reversed (big hand minutes, small hand hours). Their results suggest that top-down, goal-directed factors affect visual gaze patterns in seeking information from the visual scene, so that the effects of visual salience on production choices can be modulated by the speaker's task and goals, and by the language that is being spoken.

The studies described above show how the form of utterances is shaped by the complex interactions between visual salience, task goals, and language spoken, but they do not address one additional potential complication, linguistic context. That is, most language production in the context of a visual environment is also conducted in a linguistic environment, such as a conversation about the visible objects and events, which affect the speaker's goals and intended message in several ways. First, interaction with an interlocutor (such as a question or comment about the visual scene) can affect the speaker's communicative goals, with consequences for the utterance plan (Christianson & F. Ferreira, 2005; Prat-Sala & Brannigan, 2000). Second, linguistic context of this sort has powerful effects on visual attention and eye movements (e.g. Altmann & Kamide, 2007), and so it is reasonable to expect that hearing a question or other comment about a scene could influence the speaker's visual search of the scene and thus the relative salience of scene elements. We see from previous results that the effect of visual salience varies based on aspects of the task goals and language, and that linguistic context has a profound effect on gaze and direction of attention to visual information. Thus if we are to understand visual salience as one of many factors that affect production choices, we must investigate the role of visual salience in various task contexts. In line with these goals, our study

investigates the joint effects of linguistic context and visual salience in the context of language production, which has not been extensively investigated. Here we present a study that begins to address these issues, with a task that investigates the role of visual salience on production choices in a linguistic context that is unlike that of previous studies.

In our study, native English speakers described pictures in answer to a spoken question such as “what is red?” Such questions do not directly name elements in the visual environment but provide a linguistic context, directing speakers’ attention and search of the scene. To formulate their answer, speakers had to focus on an element in the picture and describe its relationship to some other pictured participants. On some trials, the spoken questions lead to descriptions of a visually and conceptually salient animate entity, and on other trials, the description target was an inanimate entity, which varied in visual salience across pictures. We investigated the kinds of structures speakers produced in their descriptions, and we also collected measures of production difficulty, such as initiation latencies.

We used a relative clause picture description task developed by Gennari, et al. (2012). In this task, participants viewed pictures and responded to spoken questions about animate or inanimate entities that were the patient/theme of some pictured action. These questions served to focus the entity in question so that this animate or inanimate element was the head of (i.e., was modified by) a relative clause. Several types of relative clauses can be used to describe this relationship. Speakers can say either sentences containing active object relative clauses or passive relative clauses when describing these animate or inanimate target nouns (Table 1). Previous studies show that, speakers’ structure preferences are strongly affected by the animacy of the entity being described by the relative clause, among other factors (Gennari & MacDonald, 2009; Gennari, et al., 2012; Roland, Dick & Elman, 2007). Relative clauses headed by an action’s

animate patient tend to appear primarily in a passive form in English, in which the patient of the action (*baby*) is the subject of the relative clause and very rarely as active object relatives, or center-embedded relatives, in which the head of the relative clause (*book*) is the direct object of the relative clause verb. Inanimate-headed relatives routinely appear in both passive forms and in active forms. By eliciting relative clause descriptions of animate and inanimate entities such as *baby* and *book*, we can explore the effect of conceptual factors (animate vs. inanimate entities) and visual salience on utterance planning.

Table 1: Sample utterances in the Gennari et al., 2012 relative clause production task from which our task is adapted

| | Inanimate Target: Book | Animate Target: Baby |
|------------------------|--|--|
| Active Object Relative | The book (that) the woman carried | The baby (that) the woman carried |
| Passive Relative | The book (that was) carried by the woman | The baby (that was) carried by the woman |

Relative clauses are a good choice for investigating these phenomena, for two reasons. First, there are well-known patterns of structure biases (in English, passive bias for animate heads and a fairly even passive/active split for inanimate heads) from which to evaluate the effects of salience (Gennari & MacDonald, 2009; Gennari, et al., 2012; Roland, Dick & Elman, 2007). Second, the relative clause structure unconfounds surface word order and grammatical role assignments to nouns in the sentence. In English main clauses, the grammatical subject appears first in the sentence, and when a passive form is uttered (e.g., *The baby was carried by the woman*), it is unclear whether high accessibility of *baby* yielded a passive because the assignment of the subject role to *baby* or through a process that placed *baby* early in the linear order, forcing a passive (see Tanaka et al., 2011 for discussion). In both the passive and active object relative forms in relative clauses, however, the head noun described by the relative clause remains in the same early position in the utterance (e.g. *baby* is in the same location in *The baby*

that was carried by the woman and *The baby that the woman carried*). Thus the higher rate of passive relatives describing animate nouns than for inanimate nouns cannot be attributed to early placement of this noun in the linear sequence of words. Instead, the effect appears to owe more to the tendency to assign animate nouns to prominent grammatical roles such as subject (Bock & Levelt, 1994; Bock & Warren, 1985; F. Ferreira, 1994).

Figure 1 illustrates this hypothesized process of grammatical role assignment in the case of an animate (on the left) or inanimate (on the right) object of the action. When a speaker is charged with answering a question about an animate entity such as *baby*, this noun is both animate and the focus of the utterance being formulated, and both of these factors contribute to the prominence of the noun. As a result, *baby* is assigned to the most prominent grammatical role, subject, yielding a passive relative clause utterance. In a condition in which speakers are requested to answer a question about an inanimate target item, which is shown on the right of Figure 1, speakers must balance two conflicting grammatical role assignments to place the focal entity (*book*) or the animate agent (*woman*) in subject position. If there is inconsistency in how this conflict is resolved, across speakers and/or across particular pictures/events as a function of the salience of the elements or other factors, then inanimate focused entities should yield a combination of active object and passive relative clause utterances. This conflict might be expected to increase the difficulty of settling on an utterance form, but measures of planning difficulty, such as initiation latency, have not been collected in prior work.

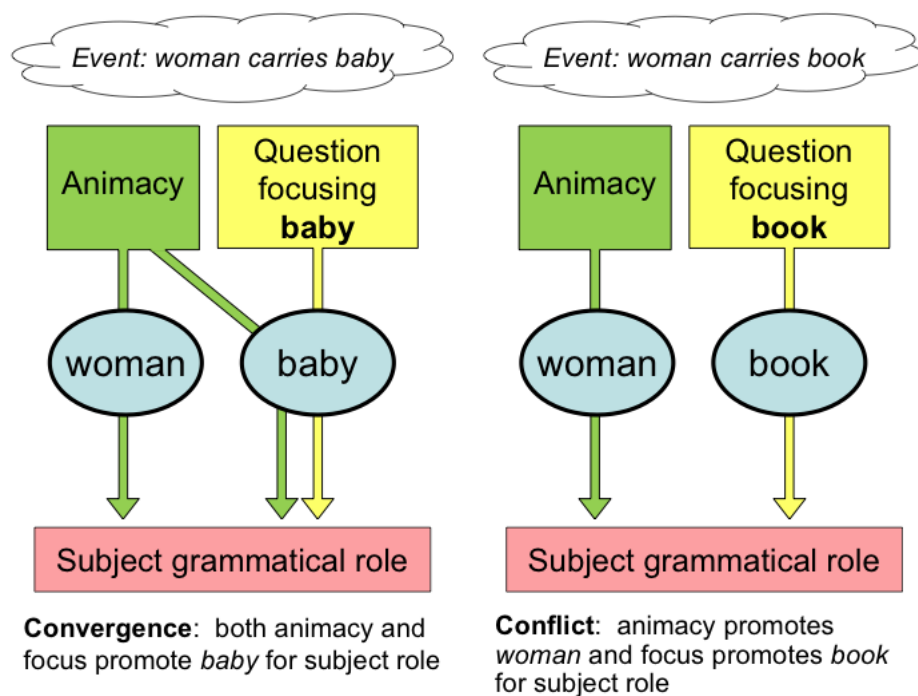


Figure 1. Illustration of converging and conflicting cues to grammatical role assignment during picture description. On the left, animacy of both *woman* and *baby* promote their assignment of the subject grammatical role, but *baby* is also focused by the task question. With *baby* receiving the subject grammatical role, a passive relative clause ensues. On the right, animacy of *woman* supports subject grammatical role assignment while focus to *book* supports subject assignment to this entity, leading to conflict and variability in passive relative vs. active object relative structure choice.

Given a question such as “what is red?” causing participants to search a scene in order to formulate a response, some pictured entities will be found more rapidly than others. For example, Dobel, Gunnior, Bölte and Zwitserlood (2007) found that in picture description tasks, the animate pictured entities are identified extremely rapidly. This effect likely reflects some combination of their inherent visual salience in a picture (perhaps owing to size, location in the picture, amount of other non-target “clutter” in the scene, and other visual features) and also the attentional focus naturally devoted to searching for animate elements in a scene, especially given a task of describing an action, for which animate entities are likely to play a large role. Thus visual salience itself is complex and likely to be a combination of picture features, the degree to

which the linguistic context (e.g. *what is red?*) directs visual search efficiently in a particular picture, and other task demands influencing visual search.

These considerations concerning the multi-dimensionality of visual salience and its interaction with linguistic context guided our decisions on how to investigate effects of these factors on utterance form. A traditional factorial design would manipulate the salience of the items at high and low levels, but the generality of any such manipulation is questionable, given the myriad factors that contribute to salience. Recent developments in the use of mixed-effects models have increased the viability of non-factorial designs in which factors such as visual salience can vary continuously (Baayen, Davidson & Bates, 2008; Jaeger, 2008; Quene & van den Burgh, 2008). We therefore treated visual salience as a continuous and multi-dimensional factor in our study. Specifically, we made no special efforts to manipulate salience of elements in the scenes in our picture description task but instead collected three different measures of how visually salient the critical elements were in each visual scene. We then used these salience measures in multi-level analyses to assess how salience variation affected utterance form

Method

Participants

One hundred twenty-two undergraduates at the University of Wisconsin-Madison participated in exchange for pay or for extra credit in an introductory psychology course. Of these, 68 participated in the production experiment and 54 participated in one of three visual salience rating tasks. All were native speakers of American English.

Materials

Twenty verbs that can each take both an animate and inanimate grammatical object were selected. A color cartoon picture was created for each verb or adapted from pictures used by

Gennari et al. (2012). Each picture contained two depictions of events named by the verb, one acting upon an animate grammatical object and once acting upon an inanimate grammatical object. For example, the pictures for the verbs *throw* and *hug* are shown in Figure 2. Each picture shows an animate entity—a man—as the object of the action, and also an inanimate direct object—a ball in the case of *throw* and a toy for the *hug* picture. The animate and inanimate objects of the action were the target items in the experiment. Each picture also contained other elements, always including one or more additional inanimate and animate elements matching the target items. Thus the *throw* picture in Figure 2 includes a second ball and several other men in addition to the ball/man being thrown, and the *hug* picture contains another man and another toy in addition to the ball/toy being hugged. These extra elements increased the specificity of speakers' descriptions of the target elements in order to distinguish them from other similar elements in the pictures.

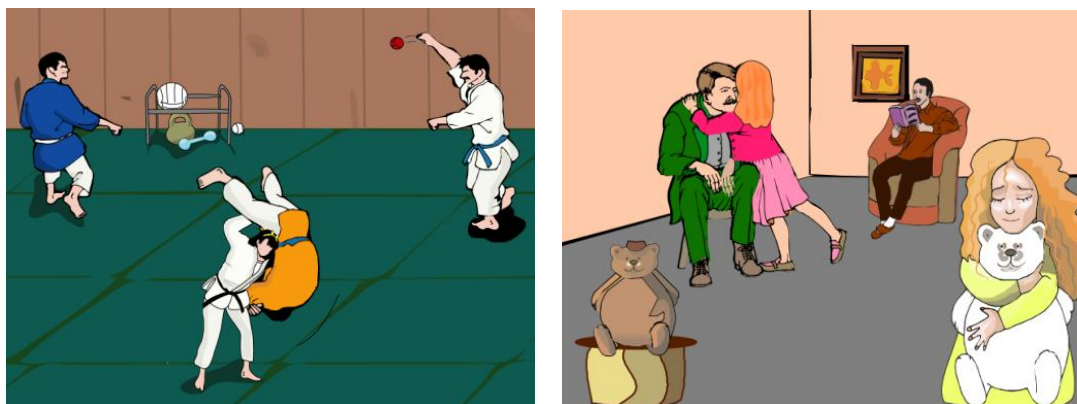


Figure 2. Test pictures for the verbs “throw” (left) and “hug” (right).

To elicit speech, spoken questions were recorded for each picture, and the participants' task was to answer the question presented with the picture. Questions for experimental trials asked participants to describe a particular target person or object in the picture. For example, questions

corresponding to Figure 2 would be “Who is wearing orange?” to elicit a description of the animate ‘man’ target wearing an orange jacket and “What is red?” for the inanimate ‘ball’ target being thrown by a man. There are multiple men and balls in the picture, so participants had to further describe the target item in order to identify it.

Forty-three filler pictures were included to reduce strategic effects and structural priming (the repetition of utterance sentence structure from one trial to the next; Bock, 1986). For filler trials, participants were asked to describe what a particular person was doing or identify a particular object; these items were designed to elicit simple sentences without relative clauses.

Production Experiment Procedure

Participants in the production experiment first completed a pre-exposure task in order to familiarize participants with the drawing style of the pictures, to encourage uniform verb usage (e.g. to use *carry* rather than *hold* for the picture showing carrying) and to normalize lexical retrieval times across verbs. In the pre-exposure, participants viewed a small portion of a picture, depicting a single action (for example, the portion showing the man throwing the ball in the *throw* picture of Figure 2). These smaller pictures contained only the target animate or inanimate entity and the agent acting upon that entity. After two seconds, a verb describing the action appeared underneath the picture, in the case of experimental picture segments, or a noun appeared for filler picture segments. Participants were instructed to read aloud the word underneath the picture. Participants viewed, in random order, two picture segments for experimental pictures (one segment showing action on an animate entity and one acting on inanimate object) and one picture segment for filler pictures. Fillers were included so that all pictures in the main experiment would have had some pre-exposure.

After the pre-exposure phase, participants performed the main experiment, using a variant of the task developed by Gennari et al. (2012). Participants were told that they would view pictures and answer questions about them. They were provided with a cover story in the instructions that promoted the use of action descriptions with relative clauses in their responses. Participants were told that their picture descriptions (their responses to the questions) would be shown to a later group of participants who would try to guess which picture elements their responses described. They were told that superficial changes would be made in the pictures when they were shown to the new participants, and so to be clear in their descriptions, participants should describe the actions in which the pictured people and objects were taking part. The combination of encouraging action descriptions in the instructions and the presence of multiple entities in the picture (encouraging modification of the target noun) elicited a high rate of relative clause responses without any explicit instruction to produce them.

At the start of each trial, a picture appeared on the screen and remained onscreen throughout a trial, until the participant pressed a key to go on to the next trial. Three seconds after the picture appeared, participants heard a recorded question asking about a target person or object in the scene, such as “What is red?” Participants answered by speaking into a microphone; initiation latencies and all responses were digitally recorded for later analysis. These methodological choices formed the primary differences from those in Gennari et al., (2012), in which no initiation latencies were collected and most studies presented written rather than auditory questions and collected written productions. Using a methodology that allows for the collection of initiation latencies should allow for additional investigation of production processes and sources of production difficulty.

Animate and inanimate questions for experimental items were counterbalanced across participants so that each participant saw each picture only once and received 10 trials with a question about an animate patient (e.g., the man being thrown in Figure 2) and 10 trials with an inanimate theme question (e.g., the ball being thrown in Figure 2). Test and filler trials were pseudo-randomized such that there were always at least two fillers between any two test trials.

Visual Salience Procedure

Because visual salience is a complex notion and not simply the effect of a single factor such as size, we collected three separate measures of the visual salience of target entities. For example in Figure 2, a number of features could contribute to greater salience of the bear being hugged than the ball being thrown. These include the relative size of these entities (the bear is bigger than the ball), their location in the picture (the bear is in the foreground of its picture, the ball in the background), the salience of the agent acting on the object (the hugging girl is in the foreground and larger than the man throwing the ball), the color, and other features. Our salience measures were aimed at capturing variation of this sort.

The first salience measure was a visual salience rating task of the target items, in which 17 participants who did not take part in the main experiment explicitly rated the visual salience of the target entities (e.g., the ball). In this task, participants first passively viewed all 20 pictures one at a time, pacing themselves through the entire set, in order to become familiar with the drawing style and events depicted in the pictures. This pre-exposure was followed by the rating task. On each trial, participants saw one of the 20 experimental pictures. They read a description of a target item, (e.g., *The ball that is red*) and indicated how visually salient or “easy to locate” the named element was in the picture, using a 1-7 scale, with lower numbers indicating greater visual salience.

In the second salience task, a different group of 17 participants rated the visual salience of the animate agents acting on the inanimate target items (e.g., the man throwing the ball). We reasoned that especially for inanimate objects, identification of the agent of the action could be crucial to identifying the target entity itself. For example, identifying the man and his throwing action may help identify the item near his hand as a ball. The procedure for the agent salience task was identical to the first rating task, with the only difference being that the participants received a statement referring to an agent (e.g., the man wearing red) and rated on a 1-7 scale how easy that entity was to locate in the scene.

The third task was designed to be an implicit measure of visual salience of the target items. An additional 20 participants who did not participate in either the other rating tasks or main task viewed each of the 20 experimental pictures once, and either the inanimate target entity was probed with a spoken question, such as "What is red?" The participants were instructed to locate the inanimate target item¹ as quickly as possible and name it as soon as they located it, always using the frame *the noun* (e.g., *the ball*), with no other words. The dependent measure was thus not an explicit rating but instead the latency to name the target entity. While these latencies were likely affected by lexical retrieval times of the target object nouns in addition to their visual salience, we were mindful of prior research suggesting that visual salience is influenced by task demands (Kuchinsky et al., 2012). We therefore sought to include a salience measure that had similar task demands to the picture descriptions in the main experimental task.

Ratings and initiation latencies from the three rating tasks were then z-scored by subject. The target salience rating task (Task 1) correlated with both explicit agent salience ratings (Task 2,

¹ We do not report latencies to locate and name animate entities as we found it prohibitively difficult to get participants to produce only a noun phrase (e.g., *the man*) when there were multiple men in the picture. Participants almost always produced an additional description of the animate noun. This tendency to provide an additional description rarely occurred with inanimate nouns.

$r(15)=0.44, p<0.06$), and with object naming times (Task 3, $r(15)=0.65, p<0.01$), such that objects given a high salience rating tended to be acted on by agents with a high salience rating and tended to be named more quickly in the object naming task. The correlation between agent salience ratings and object naming times was in the same direction but was not reliable ($r(15)=0.28, p<0.3$). Given that the object salience ratings correlated with the other two measures, and given the view that salience is composed of many subcomponents, we summed these three z-scored measures into a single composite measure of visual salience.

Results

Production data. Before analysis of relative clause choice and production difficulty measures, several types of irrelevant trials were removed, including utterances that were not relative clauses (e.g., *the ball*, or *the ball on the right*), affecting 17.6% of animate trials and 25.8% of inanimate trials. We suspect the higher exclusion rate among inanimate trials is due to the fact that participants occasionally failed to locate some inanimate competitors in the pictures and subsequently produced a simple noun phrase (e.g., *the ball*) that did not distinguish the target from similar elements in the scene. Participants almost never failed to notice an animate competitor, with the result that animates were more often modified. Relative clauses in which the participant produced a different verb than the one provided in pre-training were also excluded from analysis, affecting 8.8% of animate and 12.3% of inanimate trials. Inclusion of these different-verb trials in the analyses reported below did not change any of the results; we took the more conservative path of excluding these trials so that animate and inanimate trials would not vary in their rate of conformity to experiment instructions. As most responses for the verb *spray* contained a different verb, all trials for this verb were removed.

One participant was excluded for producing almost no action descriptions and three were excluded for having mean initiation latencies more than two standard deviations from the mean of all participants. Utterances with disfluencies or initiation latencies longer than six seconds were removed ($n=25$). A total 834 relative clause utterances from 64 participants were analyzed (65% of total utterances). This rate is similar to that in Gennari et al. (2012) and not unexpected given the inherent difficulty in depicting actions with high name agreement and the fact that participants were not explicitly instructed to produce relative clauses.

Participants' responses were coded either as active or passive relative clauses. The rates of these utterances are shown in Figure 3. As expected, relative clauses with animate target head nouns were overwhelmingly passive (98.7% passives, SD 4.1) while inanimate targets were nearly evenly split between active and passive relative clauses, with 47.3% (SD 38.6) passives. This result replicates previous experimental and corpus results (Gennari et al., 2012; Gennari & MacDonald, 2009; Roland et al., 2007). Interestingly, there were substantial individual differences in the proportions of active vs. passive utterances for inanimate targets. About a third of participants produced almost exclusively active object relatives, about one third produced almost exclusively passive relatives and the remaining third produced nearly equal numbers of passives and actives. This study was not designed to examine individual differences, and the small number of observations on which these patterns are based (10 inanimate trials per participant) make it difficult to draw any conclusions from these results. However, future research on individual differences should further investigate individual differences in structure choice.

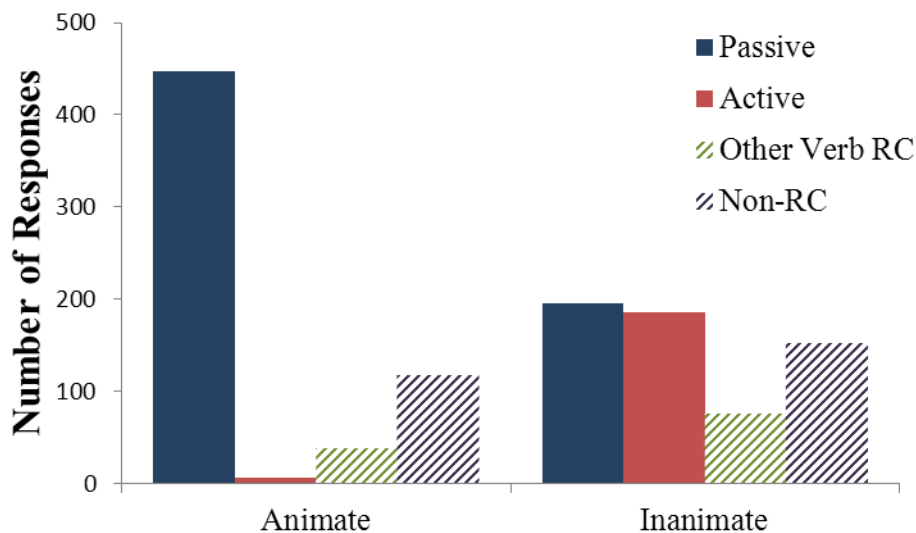
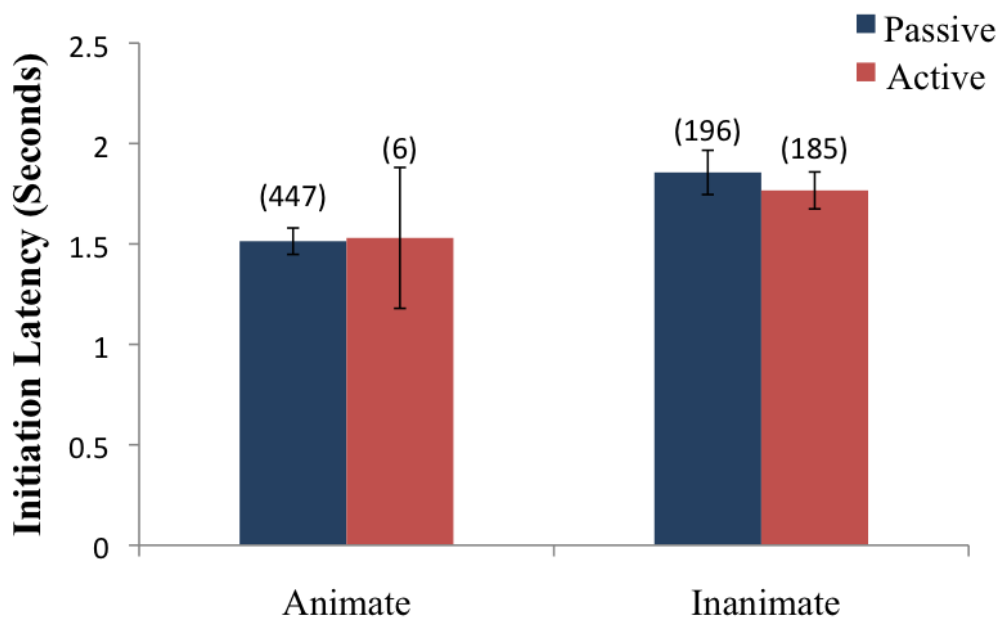


Figure 3. Number of passive, active (object relative), relative clauses using a different verb, and non-relative clause (“other”) responses. These counts exclude the verb *spray*, which was removed from all analyses.

Two features of the utterances were coded to assess production difficulty across conditions: initiation latencies and relative pronoun use. These measures of production difficulty are known to correlate with difficulty (e.g., length) of upcoming phrases (*initiation latency*: F. Ferreira, 1991; V. Ferreira, 1996; *relative pronoun use*: V. Ferreira & Firato, 2002; Jaeger, 2005; Race & MacDonald, 2003). Speech initiation latencies, defined as the time from the offset of the spoken question to the onset of the response, were measured from the digitized recording of the utterance. Initiation latencies are contained in Figure 4. Relative pronoun use was defined as the presence or absence of an optional relative pronoun (*that, who, whom*). We investigated the effect of these measures of production difficulty on the animacy of the target (head) noun, the response structure and the number of words in the head of the relative clause (e.g. *the ball*, ranging from 1-8 words) and the number of words in the relative clause itself (range=2-18 words), excluding any relative pronoun.

Figure 4. Mean initiation latency (by subject) as a function of target animacy and utterance structure. Numbers in parentheses refer to the number of observations contained in each bar.



We conducted several analyses on these initiation latencies to investigate whether this complex picture description task yielded similar effects to those previously reported with other generally simpler pictures and tasks. First, a linear mixed effects regression (lmer) analysis (Baayen, Davidson & Bates, 2008) using the lme4 package in R (Bates, Maechler & Bolker, 2011) was conducted, with both participants and items (pictures) as random effects and animacy (animate or inanimate target) included as a fixed effect. In all models, random slopes were included only if they significantly improved model fit (Baayen, Davidson & Bates, 2008). We found a significant effect of animacy on initiation latencies, such that latencies to animate entities tended to be shorter than those to inanimate entities targets (Table 2). Model fit did not improve when response type (active or passive) was included in the model, suggesting that the animacy of the target, not the utterance type, predicted initiation latencies.

Table 2

Results of mixed-effects model predicting initiation latency from head-noun animacy. The model contained intercepts and by-subjects (s) and by-items (i) slopes.

| Effect of animacy on initiation latency | | | | |
|---|-------------|------|--------|--------------|
| | Coefficient | SE | t | Random Slope |
| Intercept | 1.69 | 0.09 | 18.54* | |
| Animacy | -0.33 | 0.13 | -2.58* | s, i |

*A coefficient is considered a significant predictor if $|t| > 2$ (Baayen, 2008).

Consistent with previous findings (V. Ferreira & Firato, 2002; Jaeger, 2005; Race & MacDonald, 2003), number of words in the relative clause was a significant predictor of relative pronoun use (the optional words *that*, *who* or *which* at the start of the relative clause), as shown in Table 3. Longer relative clauses were more likely to be preceded by relative pronouns, and there was a relative clause length by response type interaction. Active utterances more often contained relative pronouns, but only with longer relative clauses (approximately greater than five words). It is unclear why this length effect would be particularly strong in the active utterances. Perhaps the overall rarity of the active object relative clauses contributed to increased planning difficulty. Previous research has also suggested that the length of the head noun (e.g., *the ball*) influences relative pronoun use (Jaeger, 2005), but as the head nouns in this experiment were almost all two words long, it was impossible to examine effects head noun length in this study.

Table 3

Results of mixed-effects logistic model (Jaeger, 2008) predicting relative pronoun usage from number of upcoming words in the relative clause and response structure (active or passive).

| Relative Pronoun Usage | | | | | |
|------------------------|-------------|------|--------|---------|--------------|
| | Coefficient | SE | z | p | Random Slope |
| Intercept | -4.85 | 0.94 | -5.17* | p<0.001 | |
| Words in RC | 0.95 | 0.18 | 5.39* | p<0.001 | |
| Response | -1.03 | 1.85 | -0.56 | p=0.54 | s |
| Words in RC x Response | 0.94 | 0.35 | 2.67* | p<0.01 | |

Visual Salience. Given this evidence that the picture description task yields familiar, interpretable data for utterance choices, initiation latencies, and relative pronoun use, we next examined the relationship between visual salience and production measures for inanimate trials (recall that animates had essentially no variation in structure choice and were all highly accessible and salient, similar to results in other studies, e.g. Dobel et al., 2007). First, as shown in Table 4, visual salience (the composite of the three visual salience measures) was a reliable predictor of time to begin speaking in inanimate target trials, such that responses to more visually salient inanimate entities tended to have shorter initiation latencies than for less salient inanimates. This result is what would be expected if participants did in fact take more time to locate the less-salient objects in the pictures.

Table 4

Results of linear mixed-effects model predicting initiation latency of inanimate target trials from visual salience of the target item. The analysis included only inanimate trials because all animate target entities were highly visually salient human entities.

| | Initiation Latency | | | Random Slope |
|-----------|--------------------|------|--------|--------------|
| | Coefficient | SE | t | |
| Intercept | 1.93 | 0.12 | 16.48* | |
| Salience | 0.8 | 0.09 | 4.43* | s, i |

More interestingly, visual salience also affected structure of the utterance produced in inanimate trials; analyses are shown in Table 5. The direction of the effect, shown in Figure 5, was that the more visually salient inanimate targets were more likely to be described with active object relative constructions such as *The toy that the girl is hugging* than the less visually salient inanimate items, which tended to yield more passive relative clauses such as *the ball that's being thrown by the man*. This finding is notable because animate entities, which are overall highly salient, were almost exclusively described with passive relatives, and thus highly salient animate beings and low-salient inanimate objects patterned together in their tendency to be described

with passive relative clauses, while an intermediate case, salient inanimate entities, tended to be described with active object relative clauses. This is an unexpected finding if visual salience alone is driving speakers' structure choices. Minimally, these results suggest that in a task in which people describe pictured events, visual salience appears to have different effects on animate entities, who are viable potential agents of actions and inanimate entities, who are not likely to be event agents. We consider these visual salience effects further in the discussion.

Table 5

Results of mixed-effects logistic model predicting active (versus passive) produced sentence structure on inanimate target trials from visual salience of the target item.

| | Sentence Structure | | | | Random Slope |
|-----------|--------------------|------|--------|----------|--------------|
| | Coefficient | SE | z | p | |
| Intercept | -0.41 | 0.67 | -0.062 | p=0.95 | |
| Salience | 1.77 | 0.79 | 2.23 | p=0.026* | s, i |

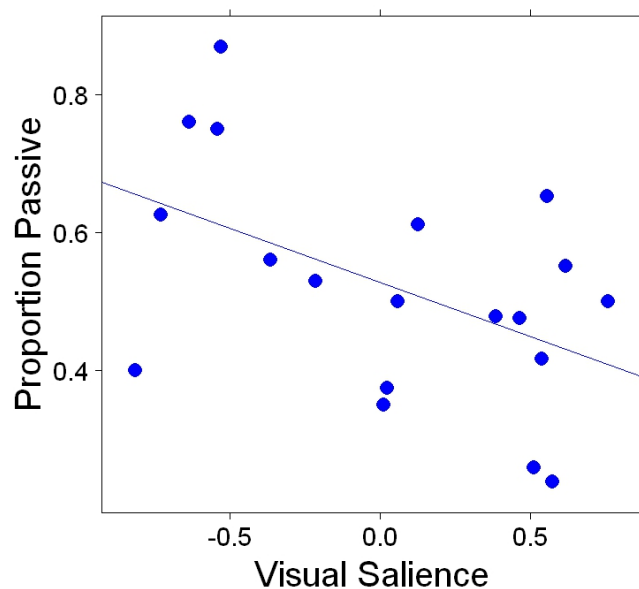


Figure 5. Proportion of relative clauses describing inanimate entities produced as passive structures as a function of visual salience of the entity described. ($r=0.49$)

We suspect that a better understanding of the complex visual salience effects requires attention to the task demands that are inherent in situations in which speakers are jointly guided by both visual and linguistic context. First, in our task speakers described actions in their replies to questions, and so it makes sense that animates (potential agents of actions) yielded different production behavior than inanimate entities, which are typically not the source of actions. A more subtle second issue is the fact that task or communicative demands can change over the course of a trial. That is, search times varied with visual salience, and the longer a participant searched the scene for the target object that was necessary to answer the question, the more the participant will have inspected non-target aspects of the scene during the visual search. We hypothesize that variation in amount of visual search actually changes the task and communicative goals for the speaker: The longer search times to locate the less-visually salient entities make the participants more likely to notice other items in the scene, including the competitor objects in the picture (e.g., the non-target ball). Consistent with this view, error trials for inanimate items were numerically more likely to contain an error related to failing to distinguish the target item from competitors (e.g., saying only *the ball* in the presence of a competitor ball) when the target entity was more visually salient ($r=.39$, $p=.1$), though this pattern failed to reach significance due to the small number of errors of this type (77 across all inanimate trials) and the lack of statistical power stemming from having only 19 items. Nonetheless, this suggests that participants really were less likely to notice or focus on competitors when the target inanimate item was highly visually salient.

These results suggest that speakers' additional focus on competitor objects, in conjunction with the linguistic context asking a question about a particular entity, encourages the speaker to be more explicitly contrastive—to distinguish the target item from the other similar item in the

picture, rather than to just describe one of many items in a scene. This goal is best achieved by using a passive relative, in which the speaker focuses on the target entity and that entity becomes the subject of the relative clause. In particular, a passive relative allows the agent of the action to be dropped (e.g., *The ball being thrown* as opposed to *The ball being thrown by the man*), allowing the speaker to focus on the target entity and avoid explicit mention of any other pictured entity. We investigated this hypothesis by contrasting the rate of agentless passives in participants' utterances. Previous work on agent-dropping has linked it to semantic interference; Gennari et al., (2012) found higher rates of agentless passives when the agent and patient were more semantically similar. This is consistent with our data, where we found a higher rate of agent dropping for animate targets (Animate: 54.6% of passives were agentless, Inanimate: 35.7% of passives were agentless, $t(18)=4.08, p<.001$). However, a closer look at agent-dropping within the inanimate targets suggests that semantic similarity cannot be the whole story, because there was a correlation between agent-dropping and visual salience, such that agentless passives were produced often for less salient inanimate targets ($r=0.48, p<0.05$). Thus once again the low-salience inanimate entities patterned with the highly salient animate targets. These data suggest that a number of factors may affect agent omission, but within the inanimate entities, the higher rate of agent omission for low salience entities is consistent with the suggestion that agent dropping is one element of the passive, in addition to making the target the sentence subject, that speakers can use to focus the target element.

This hypothesis suggests that subtle changes in properties of the visual scene can affect structure choice through changing the intended message of the utterance. Describing an item in a scene is a subtly different task than describing that item with the goal of distinguishing it from a competitor. If the increased search time to less salient objects makes participants more likely to

notice competitor objects and thus give responses with a more explicitly contrastive element, this would be an additional example of an interaction between visual and linguistic contexts, which in this situation could be driving our visual salience effect.

An alternative hypothesis, suggested by a reviewer, is that the salience effects observed here are not being driven by the salience of the target per se but by the salience of the agent acting on the target. Indeed, these two factors (both assessed in our salience measures) are positively correlated, as reported above. As a result, the present study cannot tease apart the effects of agent-salience and target-salience. In our visual salience ratings, the salience of the agent acting on the inanimate targets was correlated with the salience of the target itself, so we treated the salience of the agent acting on the inanimate target entity as contributing to the salience of that target, as a more salient agent should make the segment of the picture depicting the action more salient overall. It is possible pictures designed to contrast salience in this way could better distinguish these factors. Because we observed almost no object relative utterances describing animate target entities, which have visually salient agents acting upon them, we do not anticipate large independent effects of agent salience (that is, beyond the fact that salient agents may speed the identification of the target and identification of the action being done on the target). This suggestion awaits further testing.

Discussion

This study investigated the nature of visual salience and its potential interactions with linguistic context to influence speakers' utterance choices during language production. Although more work remains to be done to elucidate these effects, this study made progress in several domains. First, we established that visual salience in a complex scene can be assessed with a composite of several different measures, and that this composite can reliably assess visual search

and utterance formulation processes, as indexed by speech initiation latencies. Second, we confirmed that animacy of the entity to be described, which is strongly tied to visual and conceptual salience, has a robust effect on speakers' utterance forms, with animate entities routinely described with passive relatives, while inanimates were described with a mix of passive relatives and active object relatives. Third, we showed that the link between visual salience and utterance form is not straightforward, and it likely interacts with linguistic context in complex ways.

The important visual salience result in this study was that visual salience alone cannot predict structure choice in language production; While the (always salient) animate entities yielded passive relatives, inanimate entities were more likely to yield passive descriptions when they were less salient in the visual scene. These results stand in contrast to ones obtained in other tasks that have manipulated visual salience (Gleitman, et al., 2007; Tomlin, 1997), which generally have found a much simpler relationship between salience and structure, in that increases in visual salience yielded increases in making the target the sentence subject. These tasks did not contain animacy manipulations, a linguistic context, visual competitors, or, crucially, a contrastive element, unlike our question-answering task and more complex scenes, and these added features reveal interactions among factors that can ensue when both linguistic and visual context are present.

This complex relationship between task, linguistic context and visual salience is consistent with the findings of Kuchinsky et al., (2011), who found that task is a better predictor of gaze patterns than visual scene properties, suggesting that a speaker's communicative goals can drive both the pattern of scanning a scene and the speaker's utterance plan, and other work that describes a more task-dependent relationship between visual properties of scenes and behavior

(Brown-Schmidt, Byron & Tanenhaus, 2005; Kaiser, Runner, Sussman & Tanenhaus, 2009).

The effect of visual salience is moderated by the goals of the speaker, so we expect the role of visual salience to differ based on the context of the utterance. Thus, we expect that visual salience may not play the same role in a task in which speakers describe a simple scene containing a salient element (Gleitman, et al., 2007; Tomlin, 1997), vs. when the visual salience of scene elements stay constant as the task changes (Kuchinsky, et al., 2011), vs. when items that vary in visual salience must be contrasted with competitors (the present study). These data are not necessarily in conflict with each other, but rather reflect the task-dependence of visual salience effects. There is also no evidence that any of these tasks are more or less natural than the others—“natural” language production spans many linguistic and visual environments, and all of these tasks share elements of language production as it happens outside the laboratory. It is thus not surprising that the effect of visual salience could interact with task, because production itself occurs in varied situations and speaker goals, only some of which include referring to elements in the visual environment.

A potentially related interpretation of our results is that they are an example of audience design (Brennan & Clark, 1996), in which speakers tailor their utterances to respond to perceived listener needs. For example, when a speaker has spent a relatively long time finding and identifying a low-salience inanimate pictured entity, he/she senses that a listener will have similar difficulty when viewing the scene. To ameliorate this inferred difficulty, the speaker could assign the low-salience entity to the prominent subject grammatical role and thereby describe the entity with a passive, topicalizing it and focusing it for the listener, thereby presumably aiding identification in the visual scene. This view ascribes very direct attention to listener needs on the part of the speaker (Brennan & Clark, 1996), in that the speaker’s own

difficulty in visual search leads to inferences about the listener's state and needs, which in turn shape the speaker's choice of utterance form. One concern about this interpretation is that there is increasing evidence that speakers may not in fact be formulating sophisticated assessments of listener needs during sentence production (Gann & Barr, in press; Keysar, Barr & Lin, 2003; Wardlow Lane & V. Ferreira, 2008), nor with work suggesting that production behavior that could be interpreted as audience design actually has a speaker-internal origin (e.g., Bard et al., 2000; Horton & Keysar, 1996). These concerns lead us to prefer the first alternative, which requires fewer inferences on the part of the speaker about the state of the listener. On that view, long search times lead to a complex visual scene representation for the speaker, which then influences the speaker's pragmatic interpretation of the question, such as "What is red?" We suggest that a felicitous answer to that question varies as a function of scene complexity, so that speakers are more explicitly contrastive (using a passive construction) on those occasions when they have become most aware of competitor objects in the scene. This contrastive focus of non-salient objects is necessarily for the audience (the speaker is answering a question, after all), but it does not assume complex inferencing about the listener's cognitive state. This view is therefore more consistent with approaches in which speakers use their own cognitive state to guide utterance choices instead of generating inferences about the listener (Horton & Keysar, 1996).

These two perspectives are not mutually exclusive, in that adjustments to utterance form can have both a speaker-internal and a more inference-based audience design origin (MacDonald, in press). Additional work is required to distinguish these two accounts and identify potential interaction between these influences. These approaches share an important feature that also merits more research, namely the claim that the act of visual search itself (its duration and its

outcome) can change task demands in a way that can shape utterance form. This view and the current results are valuable in promoting the joint study of linguistic and visual context and suggest that considering the linguistic context of the utterance in conjunction with visual salience of entities in a scene can provide a more coherent account of structure choices in language production than when either these two factors are considered individually.

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Chapter 2: Animacy and interference in production of head-first and head-final relative clauses.

When producing a sentence, producers map a non-linguistic message to an utterance form, but how exactly this mapping occurs is not well understood. One factor that does seem to guide this message to utterance mapping is the ease of planning. Speakers appear to plan their utterances to allow more “accessible” or salient nouns to be placed earlier in the utterance. This arrangement allows words that are more fully planned to be uttered earlier, leaving more planning time for longer or more difficult to plan nouns later in the sentence (V. Ferreira, 1996; F. Ferreira & Swets, 2002; Smith & Wheeldon, 1999; Wagner, Jescheniak, & Schriefers, 2010). Frequent nouns (Griffin & Bock, 1998; Jescheniak & Levelt, 1994), shorter nouns (Hawkins, 1994) primed nouns (Bock, 1986a; 1987) given versus new nouns (Bock & Irwin, 1980; V. Ferreira & Yoshita, 2003; Prat-Sala & Branigan, 2000) and animate nouns (Bock & Warren, 1985; F. Ferreira, 1994; McDonald, Bock & Kelly, 1993) all tend to be placed earlier in utterances, so speakers tend to make sentence choices that allow those nouns to be placed earlier in the sentence. Thus, the difficulty with which a word is retrieved or articulated has a number of consequences on language choices.

This does not create a situation in which message factors and ease-of-production factors are in conflict as a speaker is producing a sentence, but rather accessibility factors, or factors that otherwise make words or phrases easy to produce, are not independent of message factors. For example, when someone asks “Where is my book?” that context establishes not only the aspect of the message that will be conveyed in reply--that the message will be about this book--but it also affects the mapping from message to form, because the book is salient and established in the discourse, which has the effect of becoming more accessible, like any other salient, given or

otherwise easy to retrieve word or phrase. Aspects of the message itself will impact what words and phrases are easy or hard to produce.

Thus, many factors affect the easy with which elements of an utterance can be planned and produced. Some factors derive from the immediate context, as words that are highly salient (Gleitman, January, Nappa & Trueswell, 2007) or given (Bock & Irwin, 1980; V. Ferreira & Yoshita, 2003; Prat-Sala & Branigan, 2000) or recently uttered words (Arnold, Wasow, Ginstrom & Losongco, 2000; Brennan & Clark, 1996; Garrod & Anderson, 1987; Garrod & Doherty, 1994) and sentence structures (Bock, 1986b; Branigan, Pickering & Cleland, 2000; Hartsuiker & Westenberg, 2000; Levelt & Kelter, 1982; Potter & Lombardi, 1998; Pickering & Branigan, 1999) are all easy to plan and produce. Alternately, some aspects of production difficulty derive from long-term learning: planning and articulation become easier if you have done it many times in the past. Thus, words and phrases that a speaker has planned and articulated frequently will be easier to produce (Griffin & Bock, 1998; Jescheniak & Levelt, 1994).

This frequency-based easy of production can not only be investigated in a single language, but can be investigated across languages, as different constructions occur with different frequencies across languages. Consequently, these patterns ought to be informative of subsequent productions. Obviously the structures permitted by individual languages will affect the choices available to speakers and thus their utterances (e.g., Gennari, Mirkovic & MacDonald, 2012; Myachykov & Tomlin, 2008; Yamashita & Chang, 2001) but even when similar options are available to speakers, productions are driven both by the intended message and by often idiosyncratic patterns in individual languages. For example, Bock, Irwin, Davidson & Levelt (2003) examined speakers' varying preferences for producing absolute reports of time

(e.g., *It's ten fifteen*) vs. relative reports (*It's a quarter after ten*) both as a function of the environment—whether the speakers were looking at a digital or analog clock—and as a function of whether the participants spoke Dutch or English, two languages that permit both kinds of telling-time expressions but differ in the relative frequency with which they are used, and speaker choices reflected these relative frequencies. Within a single language, Bresnan and Ford (2010) characterized both central tendencies and variability in speakers' preferences for double object vs. prepositional dative constructions (*give Harry the book* vs. *give the book to Harry*, respectively). They found that overall, choice of construction can be well-characterized by about ten different features of the message and utterance, including the animacy, definiteness, and length of the noun phrases expressing the recipient (*Harry*) and theme (*the book*), but they also found individual differences in these preferences: Phrase length had a greater effect on structure choice for Australian English speakers than for American English speakers, and there were also differences among individuals within a dialect. While properties of the message clearly affected production choices, these message factors were mediated by patterns in the individual languages that speakers learn and subsequently reproduce when they speak.

These idiosyncratic patterns may not be predictable given basic typological features of the language. For example, there is not necessarily a reason why phrase length ought to have a stronger effect on structure choice in Australian English than in American English. That said, these idiosyncratic patterns may have measurable effects on other areas of the language. These arbitrary patterns may have consequences or neighborhood effects on different, but similar constructions. There are many examples of these “frequency by regularity interactions” at the syntactic level. For example, comprehension cost associated with a lower frequency noun is dampened when used in a high-frequency construction (Juliano & Tanenhaus, 1994), suggesting

that comprehenders learn about what element is likely to come next in a sentence, and apply this knowledge to subsequent comprehension episodes. These frequency by regularity interactions are akin to structural priming in comprehension, much like implicit learning has been implicated as a mechanism of structural priming in production (Bock & Griffin, 2000). In structural priming in comprehension, a sentence structure that has recently been comprehended becomes easier of comprehend in a subsequent exposure (Arai, van Gompel & Scheepers, 2007; Branigan, Pickering & McLean, 2005, c.f. Tooley & Traxler, 2010). This suggests that exposure to a particular structure, either in many instances over time or in an immediate context, aid comprehension in an entirely different context, such as one with different lexical items (Thothathiri & Snedeker, 2008; Traxler, 2008). Similarly, in structural priming in production, speakers are more likely to produce a sentence structure they have recently produced or comprehended (Bock, 1986, c.f. Pickering & Ferreira, 2008), again, even in the absence of lexical overlap (Cleland & Pickering, 2003). What is learned across these exposures is to some extent context-independent—it is not the case that the exact same lexical items need to be used in subsequent exposures to observe the comprehension or production advantage, so language users are generalizing some pattern across multiple instances of a similar structure.

A question that still remains is how context independent this learning may be, and to what extent language users generalize information across multiple instances of the same structure, or even across different but related structures. MacDonald and Christiansen (2002) suggest that one component of the ease of comprehension of subject-extracted relative clauses over object-extracted relative clauses may be that the subject relative clauses share a word order with main clause utterances (in English). Thus, comprehenders may generalize the event structure of main clauses while comprehending relative clauses, which would suggest that comprehenders do

generalize knowledge across different structure types. The extent to which language users generalize knowledge of patterns across structures, and the extent to which this generalization across structures may affect production choices, is still unclear. The current study aims to answer some of these questions with a main clause and relative clause production task in three languages: English, Japanese and Korean. By investigating structure choice across the three languages, we can see what choices derive from universal effects of production difficulty, and what choices derive from language-specific factors, including generalization across main and relative clause structures across a language.

The present study, we first investigated passive usage in the three languages in a simple picture description task in which the discourse environment made passives a viable structure choice. This allowed us to investigate the extent to which passives are used across these three languages: English, an SVO language and Japanese and Korean, which are both SOV. In addition to the typological variation across languages, previous work suggests that passives are overall very rare in Korean (Song & Choe, 2007). This task allowed us to examine the extent to which Korean speakers really do avoid the passive, in addition to gauging the viability across the three languages. This allowed us to investigate the extent to which the viability of the passive in main clause utterances may influence the viability of passives in relative clause utterances in the relative clause production task.

The relative clause production task utilized in the present study is similar to those employed in Gennari, Mirkovic & MacDonald (2012) and Montag & MacDonald (in press). Participants viewed pictured and answered questions about an animate or inanimate target entity. The cover task encouraged participants to give responses that contained verbs, so this task allowed us to elicit sentence that contained active object relative and passive relative clauses

with either animate or inanimate head nouns (1a, b, c). In addition to English, we investigate Japanese and Korean, which are uniquely suited to investigate both production difficulty and language-specific factors that contribute to structure choices. First, though these two languages are head-final (the head of the relative clause comes after the relative clause, not before, as in English) and these languages still have the same active object and passive relative alternation as does English. Second, while Japanese and Korean are both quite grammatically dissimilar from English, they are quite similar to each other. In fact, Japanese active object and passive relative clauses are identical to their Korean counterparts (1b, c; 2b, c).

1a. Active (English) The ball (that) the boy is kicking.

1b. Active (Japanese): 男の子が蹴っているボール

boy-NOM kick-Pres-Prog ball

“The ball the boy is kicking”

1c. Active (Korean): 소년이 차는 공

boy-NOM kick-Pres-Prog ball

“The ball the boy is kicking”

2a. Passive (English) The ball (that is) being kicked by the boy.

2b. Passive (Japanese): 男の子に蹴られているボール

boy-BY kick-Pass-Pres-Prog ball

“The ball being kicked by the boy”

2c. Passive (Korean): 소년에게 차이는 공

boy-BY kick-Pass-Pres-Prog ball

“The ball being kicked by the boy”

The contrast between these three languages allows us to investigate a number of factors. If speakers of different languages make similar production choices, it is possible that understanding these particular choices will be a means toward understanding structure choice and language production more generally, independent of language-specific idiosyncrasies and understand the universal cognitive demands that influence speakers regardless of the language they are speaking.

Conversely, systematic differences between languages could reflect a number of factors. Differences in production choices across languages could be a consequence of language typology. The fact that Japanese and Korean are SOV languages, or that they are head-final languages may introduce entirely different sets of production demands on the speakers as elements of a sentence unfold in entirely different orders in these languages. In fact, previous work suggests that differences in word order between English and Japanese do bring about differences in locus of planning difficulty, which has implications for production choices (Chang, 2009). Thus, we may expect difference in production choice between the SVO, head-initial English and the SOV, head-final Japanese and Korean based on typological and word order difference between these languages. Another possible explanation for differences across languages is language specific patterns that are idiosyncratic in that they do not necessarily reflect language typology. Much like there is no a priori reason that relative frequencies of dative and double-object structures ought to vary in American and Australian English, there may be patterns of language use across

our three languages that affect production choices but whose distal cause is not immediately evident.

In Experiment 1, we investigate structure choice in a picture description task designed to elicit main clause productions. This task investigates the relative frequencies of active and passive sentences in main clause utterances in which the animate patient or inanimate theme is topicalized or becomes the focal element in the response. This is analogous to the context of the relative clause production task, in which participants describe the target entities in responses to questions probing descriptions of those targets. We can then determine if speaker's choices in main clauses may help predict choices in relative clauses. In Experiment 2, we investigate structure choice in English, Japanese and Korean in a picture description, relative clause production task. We examine not just structure choice but also other markers of production difficulty, such as agent dropping (Gennari, Mirkovic & MacDonald, 2012). We find that the choice of an active object or passive relative clause in each language is related to the choice of main clause active or passive sentences, suggesting that relative clause productions are not made independent of other sentence types in the language, but rather frequencies of active versus passive sentences in main clauses may influence production choices in relative clauses.

This design allows us to have, in addition to English, two different languages that offer identical choices to their speakers, in both main and relative clause utterances, but relative frequencies of the available choices that may vary substantially between the two languages. We can thus investigate the effects of animacy and structure frequency on structure choice both within and between sentence word order and typology. This will allow us a greater understanding of the factors that contribute to structure choice, including idiosyncratic

differences in structure frequency that speakers may learn and generalize across, and that ultimately affect the viability of structure choices during production.

Experiment 1: Main Clause Production

In order to investigate rate of passive productions in main clause sentences as a potential factor that may influence passive choice in relative clauses, we investigated the choice of active and passive sentences in a main clause the three languages. Active and passive sentences may exist across languages, but they may not necessarily be used in identical contexts or with similar frequencies. We wanted to investigate the frequency of passive main clause sentences in a context similar to that of our relative clause task. Typological differences between English, Japanese, and Korean, which incidentally share many typological properties, may contribute to structure choice. For example, the fact that Japanese and Korean allows subject dropping or a scrambled word order so passives may be a less-common choice in these languages that afford speakers alternate production options. In addition to typological factors, idiosyncratic differences in relative frequencies of passive sentences across the three languages, may contribute to different relative frequencies of active and passive main clause sentences in these two languages. For example, despite the fact that Japanese and Korean share many typological properties, previous work suggests that passives are overall rare in Korean (Song & Choe, 2007), so in our task as well Korean speakers may produce fewer passives than the English and Japanese speakers. An investigation of these three languages allow us to investigate the differential contributions of language typology and structure frequency on production choices of active and passive main clause utterances, and better understand the relationship between structure choice in main clause and relative clause utterances.

Methods

Participants Twelve native English speaking undergraduates at the University of Wisconsin, Madison participated in this experiment in exchange for course credit in an introductory psychology course. In addition, twelve native Japanese speaking and twelve native Korean speaking UW-Madison students and community members participated for course credit or pay.

Materials Segments of the relative clause illustrations used in previous studies (Gennari, Mirkovic & MacDonald, 2012; Montag & MacDonald, in press) as well as Experiment 2 in the present study we used. These picture segments illustrated only a patient or theme with an agent acting on it. For example, items might be a picture of a boy kicking a ball (inanimate) or a boy kicking a girl (animate).

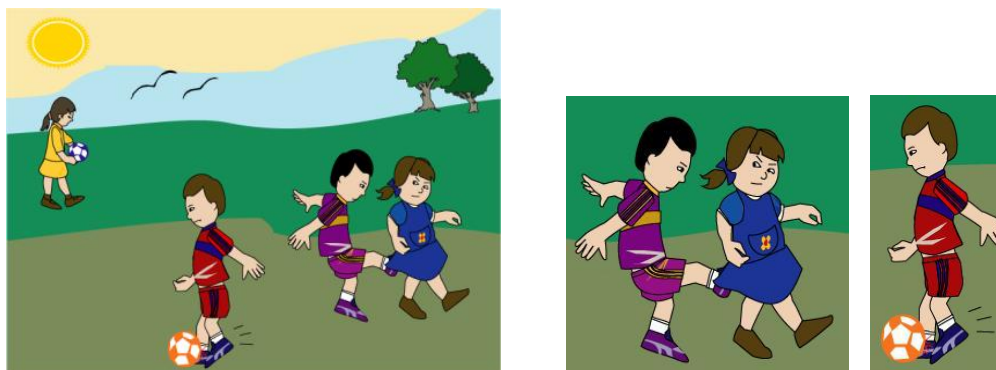


Figure 1: Left: Picture for the verb “kick” used in Gennari, Mirkovic and MacDonald (2012) and Experiment 2 to elicit relative clauses. Right: Segments of the relative clause test picture used to elicit main clause descriptions of animate and inanimate entities for the verb “kick.”

Procedure Participants typed responses to a written question about the patient or theme of the picture (e.g., *Tell me about the ball*; *Tell me about the girl*) designed to elicit active or passive main clause utterances. All written items, including written questions and task instructions were translated into Japanese and Korean and presented in the participants’ native language. In

addition to 20 test pictures (10 animate, 10 inanimate) each participant received 22 filler trials. Responses were coded as either active (e.g. *The boy is kicking the ball*) or passive (*The ball is being kicked by the boy*). All test sessions were conducted in the participants' native language.

Results Trials were excluded in which participants did not produce a sentence with an action verb (e.g., *It is an orange soccer ball*). This accounted for 32.5% of animate and 33.3% of inanimate trials (English), 30% of animate and 32.5% of inanimate (Japanese) and 30% of animate and 32.5% of inanimate (Korean).

In English, on the trials in which participants produced a sentence with a verb, 96.5% (SD = 6.4) of animate and 97.3% (SD = 4.9) of inanimate trials were passive. Rates of passive productions to animate and inanimate targets did not differ ($t(11) < 1, p > 0.7$). This suggests that in cases in which the patient or theme of an utterance is topicalized, English speakers overwhelmingly prefer to produce a passive to describe that patient or theme, regardless of animacy.

In Japanese, on the trials in which participants produced a sentence with a verb, animate trials were 3.6% active (SD = 6.5) 83.8% passive (SD = 14.8) and 12.6% causative (SD = 12.8). The causative is a sentence type permitted in Japanese that generally translates as a passive in English. For example, an English translation of a causative would be approximately *the boy is caused to be wiped by the woman*. In this sentence boy and woman are both marked with the same subject and object markers as they would be in a passive sentence, but the inflection on the verb is different than it would be in a passive sentence. Because of this similarity in structure between the causative and passive utterances, we grouped them together in subsequent analyses. Inanimate trials were 74.8% passive (SD = 29.1). Causatives cannot be used to describe an inanimate entity so none were produced. Participants produced significantly more passive or

causative sentences to animate than inanimate targets ($t(11) = 2.80, p < 0.05$). Thus, we see structure choices in English and Japanese are different, with English speakers exhibiting a ceiling effect in which they almost always choose to utter a passive when the patient or theme of the action is topicalized, and an effect of animacy in Japanese, such that speakers almost always prefer a passive (or causative) when an animate patient is topicalized, but occasionally produce an active when describing an action with a topicalized inanimate theme.

In Korean, on the trials in which participants produced a sentence with a verb, 74.8% (SD = 32.2%) of animate and 71.3% (SD = 33.3%) of inanimate trials were passive. Participants produced equal numbers of passive sentence to animate and inanimate targets ($t(11) < 1, p > 0.5$). The tendency to produce a passive to describe a topicalized patient or theme is not as strong in Korean as it is in English or Japanese, despite the similar typology of Korean and Japanese as overall, Korean speakers used significantly fewer passives than English and Japanese speakers. (Using mixed effects logistical regression (Jaeger, 2008) with only random intercepts, $z = 1.98, p < 0.05$).

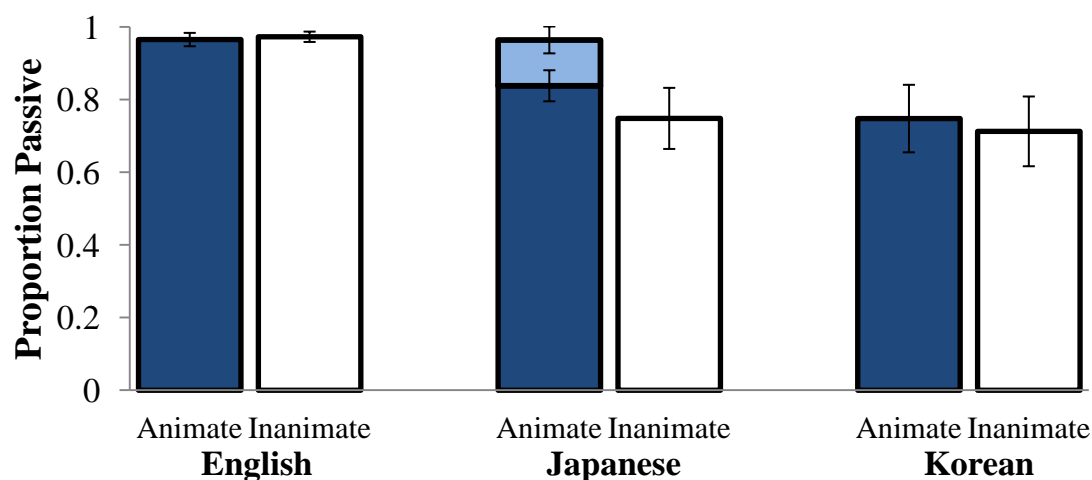


Figure 2: Production choices in main clauses in English, Japanese and Korean. Light blue bar refers to causative utterances.

Discussion These results show that language typology is not necessarily a good predictor of the relative frequencies of active and passive main clause utterances. Despite their typological similarity, Korean speakers produced significantly fewer passive utterances than Japanese speakers. That's not to say that typology had no effect on structure choice; Japanese speakers who are afforded the additional causative form occasionally produced that sentence type. Given that typology was not the motivating factor in structure choice, other idiosyncratic patterns within a language might be more reliable predictors. This task gives an indication of what speakers of these three languages might produce in contexts in which a theme or patient is topicalized in a main clause utterance, so these patterns may be good indicators of what speakers will do in a relative clause production task. We may be able to use these patterns to inform patterns of active object and passive relative clauses in a relative clause production task. One possible outcome is that relative frequencies of active and passives in main clauses in the more frequent main clauses affect the frequencies in relative clauses. Another option is that the word order of the relative clause utterances are dissimilar from their main clause counterparts in all three languages, so these patterns in main clause utterances may not have any effect on relative clause utterances. Investigating production choices in relative clause utterances can help us understand the extent to which patterns in main clause utterances might affect patterns in relative clause utterances, and the extent to which overlap-- of word order, morphology or typology-- might be necessary to observe pattern generalization from one area of language to another.

Experiment 2: Relative Clause Production

The goal of this study was to examine production choices in utterances containing relative clauses. We aimed to investigate the effects of various factors on these production choices. First, as in Experiment 1, we manipulated the animacy of the entities being describes in

order to investigate the effect of animacy on structure choice. In addition, we wanted to understand the relationship between the main clause utterances in Experiment 1 on relative clause utterances, along with effects of language and language typology on utterance choice. As in Experiment 1, there are aspects of the three languages we investigated that make the comparison between English, Japanese and Korean particularly interesting. Unlike English, Japanese and Korean are head-final languages, meaning that the head noun (the entity being described) is produced after the relative clause. It is possible that this re-ordering of the head noun may cause production choices in Japanese and Korean to be quite different than production choices in English. Alternately, patterns of active and passive utterances in main clauses might be a better predictor of structure choice in relative clauses. Both Song and Choe (2007) and Experiment 1 show that passives tend to be relatively rare in Korean, so it is possible that despite the almost identical typology between Korean and Japanese in these utterance types, Korean speakers will make different production choices than Japanese speakers, who may make choices more similar to the English speakers. Thus, we can investigate the contributions of word order, typology and relative frequencies of main clause structure alternatives on production choices in relative clauses.

We were also able to investigate rates of agent dropping (not specifying the agent of an action) across languages. Gennari, Mirkovic & MacDonald (2012) found that in English, Spanish and Serbian, agent dropping was more frequent when describing animate targets, and this was due to the increased semantic interference between the more similar animate agents and patients. The present study allows us to replicate this pattern in English, and investigate the agent dropping phenomena in Japanese and Korean, which unlike English, permit agent dropping in both active and passive utterances, and because they are head-final languages, the agent is the

first noun of the utterance, and thus the production demands that lead to agent dropping in other languages may not exist in Japanese and Korean.

It is possible that because of the different word orders of the English versus the Japanese and Korean sentence alternatives, we will see very different production choices and patterns of agent dropping in English versus the other two languages. In Japanese and Korean, the word order between active and passive relatives are identical, so speakers are not offered the opportunity to plan the sentence constituents in a different order by selecting one alternative or the other, as they are in English. This may lead to an entirely different pattern of production choices in English versus Japanese and Korean. Further, it may lead to entirely different consequences of semantic interference, which in English leads to agent-dropping. Perhaps speaker will either alleviate this production difficulty in another way, or perhaps semantic interference will not be a concern for speakers of a head-final language.

Alternately, our observed patterns of active and passive main clause use in Experiment 1 may better predict production choices. Well-rehearsed patterns of active versus passive use in main clauses may generalize to relative clauses. If re-using a message plan is easier than creating a new plan, then speakers may mimic patterns in main clause use in their relative clause productions.

To elicit relative clauses, we used a relative clause elicitation method that was similar to the one developed by Gennari, Mirkovic & MacDonald (2012) and identical to that of Montag & MacDonald (in press). An effect of animacy comparable to that of previous relative clause production studies would be realized as more passive being produced with animate than with inanimate head nouns.

Methods

Participants Sixty-eight native English speaking undergraduates at the University of Wisconsin-Madison participated in this experiment in exchange for course credit in an introductory psychology course. A portion of these participants' data was reported in Montag and MacDonald (in press).

In addition, 58 native Japanese speakers, 19 from the University of Wisconsin-Madison and other American universities and 39 from Hiroshima University participated in exchange for pay. Two participants were removed due to equipment failure and two participants were removed for producing almost no relative clause responses with verbs, for a total of 54 participants included in analyses.

Finally, 39 native Korean speaking UW-Madison students and community members participated for course credit or pay. One participant was excluded for producing almost no relative clauses with verbs.

Materials Twenty verbs that can each take both an animate or inanimate grammatical object were selected. Color pictures were created that illustrated each of these twenty verbs. In each picture, there were two instances of that particular verb, once acting upon an animate grammatical object and once acting upon an inanimate grammatical object. These animate and inanimate entities were the target items in the experiment. In addition to the twenty test pictures, there were 43 filler pictures for a total of 63 trials.

To elicit relative clauses, participants heard spoken questions asking them to describe either an animate or inanimate target. For example, questions corresponding to Figure 1 would be “Who is wearing orange” for the animate ‘man’ target and “What is red” for the inanimate ‘ball’ target. There is more than one man in the picture and more than one ball, so to act in

accordance with the demands outlined in the cover task, the participants needed to produce relative clauses with verbs to sufficiently differentiate the target from the other items in the picture. For the target item ‘man’ in this picture, a good response would be “the man being thrown by the woman” or “the man that the woman is throwing” because these responses distinguish the target man from the second man in the picture. For filler trials, participants were asked to describe what a particular person was doing or identify a particular object. Filler pictures and questions were created so that participants had no reason to use a relative clause in their responses.

All written and spoken materials were translated into Japanese and Korean so all task materials were entirely in the participant’s native language. All spoken materials were recorded in a quiet room by a native speaker of the language being recorded (English, Japanese or Korean).

Procedure All test sessions were conducted in the participant’s native language. Participants first completed a pre-training task designed to encourage them to use the specified verb associated with each picture (for example, to use “carry” as opposed to “hold” for a picture with carrying events) when describing the pictures in the later task. Different verbs tend to occur in active and passive sentences with different frequencies so the verb pre-training was designed to limit the effects of these verb-specific tendencies. In pre-training, participants viewed only the segments of each test picture that illustrated the verb. All participants saw both the animate and inanimate uses for each verb so they would not be able to anticipate their target when viewing the complete picture in the main task. After two seconds of exposure, a verb describing the action appeared underneath the picture. Participants were instructed to simply read aloud the word underneath the picture. For filler pictures, participants viewed a segment of picture

containing a person or object and a corresponding noun. The order of presentation was randomized.

After completing the pre-training task, participants performed the main task of the experiment. Detailed instructions with a cover task were utilized to prompt relative clause productions. Participants were told that the experiment was about interpreting pictures, and that their responses would be shown to a later group of participants who would try to guess which pictures their responses described. They were told that because colors or clothing might be changed, or items in the picture might be rearranged, describing the actions in which the people and objects were taking part would be the best strategy to employ in order to complete the task. In each trial, a color picture appeared on the screen. After three seconds, participants heard a question asking about the target person or object in the picture. Participants were instructed to answer the question by speaking into a microphone. Each participant saw ten pictures with a question about an animate patient (e.g., the girl being kicked in Figure 1) and ten pictures with questions about inanimate themes (e.g., the ball being kicked in Figure 1). A different set of participants saw the other half of the animate-inanimate target pairs, so that participants saw each picture only once. Test and filler trials were pseudo-randomized such that there were always at least two filler trials between any two test trials.

Results Before analysis of relative clause choice and production difficulty measures, several types of irrelevant trials were removed

In English, as most responses for the verb *spray* contained a different verb, all trials for this verb were removed. We also removed one participant who produced almost no relative clauses with verbs. Though the present study does not employ any initiation latency analyses we eliminated the same 3 participants as in Montag and MacDonald (in press) and 25 trials for

having excessively long initiation latencies. The inclusion of these trials and participants did not change the pattern of results. In Japanese, we also excluded all responses to the verb *spray* as participants never used the trained verb to describe the animate targets. Likewise, in Korean, responses to the verbs *spray* and *splash* were removed as participants produced very few utterances with the verb trained during pre-training. In addition, all responses to the verb *throw* were removed because participants never produced the pre-trained verb to describe animate targets.

Next, we excluded individual utterances that were not relative clauses (e.g., *the ball*, or *the ball on the right*), affecting 17.6% of animate trials and 25.8% of inanimate trials (English), 4.9% of animate trials and 22.8% of inanimate trials (Japanese) and 27.9% of animate and 25.5% of inanimate trials (Korean). We suspect the higher exclusion rate among inanimate trials in English and Japanese is due to the fact that participants occasionally failed to locate some inanimate competitors in the pictures and subsequently produced a simple noun phrase (e.g., *the ball*) that did not distinguish the target from similar elements in the scene. Participants almost never failed to notice an animate competitor, with the result that animates were more often modified. It is unclear why Korean speakers did not exhibit this pattern, or why overall rates of errors might be different among speakers of different languages. The different populations or different experimenters that are necessarily a component of cross-linguistic research may have contributed to this group differences, but error rates are all well within the normal range for sentence production experiments so we do not believe these small differences in error rates hurt the interpretability of our data.

Next, relative clauses in which the participant produced a different verb than the one provided in pre-training were also excluded from analysis, affecting an additional 8.8% of

animate and 12.3% of inanimate trials (English), 16.4% of animate and 13.1% of inanimate trials (Japanese) and 21.8% of animate and 13.9% of inanimate trials (Korean). Inclusion of these different-verb trials in the analyses reported below did not change any of the results, so we took the more conservative path of excluding these trials so that for each item, speakers of each language all produced the same verb.

After all these exclusions, in English, a total 834 relative clause utterances from 64 participants were analyzed (65% of total utterances) were analyzed. In Japanese, 723 trials from 54 participants were analyzed (67%) and in Korean, 421 responses from 38 participants were analyzed (55%). This slightly smaller number of analyzable responses is likely because we removed responses from three verbs in Korean because speakers rarely produced the trained verb. This reflects the poorer mapping between the pictures and the verb in Korean. We could have altered the pictures for each language to make sure each picture was an ideal illustration of the verb, but then we would not have been able to use identical materials across all languages. Previous work with this task has shown that even subtle visual properties can have significant effects on production choices (Montag & MacDonald, in press) so we opted to use identical materials across all languages to control for potential effects of visual properties on production choices.

Participants' responses were coded either as active or passive relative clauses (or causative, if permitted by that language). Relative clauses with animate target head nouns were overwhelmingly passive (98.7% passives, SD 4.1) while inanimate targets were nearly evenly split between active and passive relative clauses, with 47.3% (SD 38.6) passives. This analysis was reported in Montag & MacDonald (in press) and is consistent with previous studies of relative clause frequencies (Gennari et al., 2012; Gennari & MacDonald, 2009; Roland et al.,

2007). In Japanese, when the target noun was animate, speakers produced relative clause that were overwhelmingly passive (90.0%, $SD = 11.5$). An additional 7.3% ($SD = 9.8$) productions were causative (e.g. The boy that is caused to be wiped by the woman). With inanimate target nouns, relative clauses were 38.9% ($SD = 37.3$) passive and no responses were causative. Finally, in Korean, when the target noun was animate, speakers produced speakers produced 50.9% ($SD = 31.2$) passive relatives and when the target noun was inanimate, 6.6% ($SD = 15.3$) passive relatives. Figure 3 illustrated the proportion of passive utterances across all three languages.

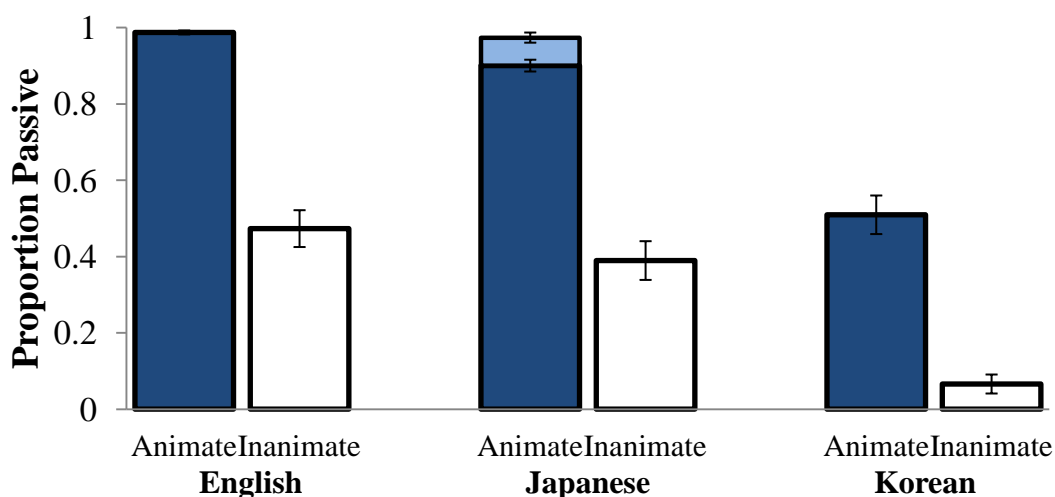


Figure 3: Production choices in relative clauses in English, Japanese and Korean. Again, the light blue bar refers to causative utterances.

All three languages showed a robust effect of animacy such that passive structures were more common in productions to inanimate targets across languages. Using mixed-effects logistic regression with random slopes and intercepts for participants and verbs, $z = 10.45$, $p < 0.001$. These results confirm that the animacy of the target noun, which would become the head

of the produced relative clause, did in fact influence the structure of the production. In addition, the data showed an effect of language, such that Korean speakers produced significantly fewer passive relatives than English and Japanese speakers ($z = 5.68, p < 0.001$). Even though the exact nature of the animacy effect varied by language, in all languages animacy affected production choices. This pattern of results is consistent with previous findings (Gennari, Mirkovic & MacDonald, 2012), who found that despite differences in absolute passive frequencies in English, Spanish and Serbian, speakers of all languages produced more passive utterances when describing animate targets.

This pattern of results is interesting for a number of reasons. First, an effect of animacy was found even when not just noun order (English) but all the word order between the active and passive forms was constant (Japanese and Korean). This finding suggests that speakers' structure choices cannot be accounted for simply by accessibility-driven noun ordering, but accessibility seems to drive productions in other ways, such as grammatical role assignment. This adds additional support to the idea that it is not noun ordering alone, but assignment of nouns to grammatical roles that plays a significant role in structure choice (c.f., Tanaka, Branigan, McLean, & Pickering, 2011).

Second, despite the typological differences between English and Japanese, and the typological similarities between Japanese and Korean, English and Japanese speakers produced remarkable similar proportions of active and passive utterances while Korean speakers produced significantly fewer passives. This suggests that language typology may not itself affect structure choices. The similar rates of passive relative clause utterances in English and Japanese are consistent with the pattern of passive utterances in the main clause productions of Experiment 1, as is the finding that Korean speakers produced significantly fewer passives. This suggests that

relative frequencies of main clause passive utterances in a language may be a better prediction of structure choice in this relative clause task than language typology.

When comparing production choices on the relative clause and main clause tasks, the relative frequencies of the structures of quite similar with a few notable differences. First, in the main clause task, we only observe a main effect of animacy in Japanese, and there only if causative sentences are grouped with passive, which in the relative clause production task, all three languages show a robust animacy effect. Animacy effects do exist in main clause sentences (e.g., F. Ferreira, 1994) so it is unclear what element of this task precluded these effect. It is possible that the explicit topicalizing the animate patient or inanimate theme in the main clause production over-rode any choice that a speaker might have made based on animacy. Despite this difference, we see a number of similarities. Importantly, the patterns across rates of passivization in main clause and relative utterances are strikingly similar. Korean speakers produced fewer passive main clause and relative clause utterances relative to English and Japanese speakers. This gives some evidence for neighborhood effects in structure choices. Production choices in relative clauses seem to track choices in main clause utterances, rather than act independently. Something arbitrary, like the relative frequencies of active and passive utterances in main clause sentences has consequences in other areas of the language. A high frequency of passive sentences in main clauses creates a neighborhood such that passive sentences become more accessible and thus more frequent in other corners of the language.

Agent Dropping Results

Further analyses show that we replicate the animacy effect in agent dropping initially reported in Gennari, Mirkovic & MacDonald (2012). In both English and Japanese, Participants

produced fewer agents to animate targets than inanimate targets. In English, 54.6% of passives were agentless and 35.7% of inanimate targets were agentless. Using mixed-effects logistic regression with random slopes and intercepts for participants and verbs, animacy significantly predicted agent dropping ($z = 3.77, p < 0.001$), such that participants more often dropped agents when describing animate entities. In Japanese, in responses to animate targets, 8.6% (SD = 28.2) of causative utterances did not specify an agent and 7.3% (SD = 15.1) of passive utterances did not specify an agent. All active utterances contained an agent, which is not surprising given the small number of active response to animate targets. In response to inanimate targets, 1.6% (SD = 6.5) of active utterances and 1.8% (SD = 8.7) of passive utterances did not specify an agent. Again, speakers more often dropped agents when describing animate targets ($t(53) = 3.00, p < 0.001$; mixed effects logistic regression is not possibly due to the large number of zero-values and small amount of variance). In Korean, it is difficult to conclude anything about the tendency to drop agents in Korean because these agent-dropped utterances were overall very rare in actives (only one agent-dropped active utterance in the entire data set), which constitute about half of utterances describing animate targets and almost all of the utterances describing inanimate targets. Though the rate of agent-dropping appears numerically higher in passive relatives with inanimate heads (25.0%, SD = 46.3) than passive relatives with animate heads (14.1%, SD = 27.1), so few participants ever produced passive utterances to inanimate targets that these differences are not statistically reliable. Figure 4 shows the rates of agent-dropping across the three languages.

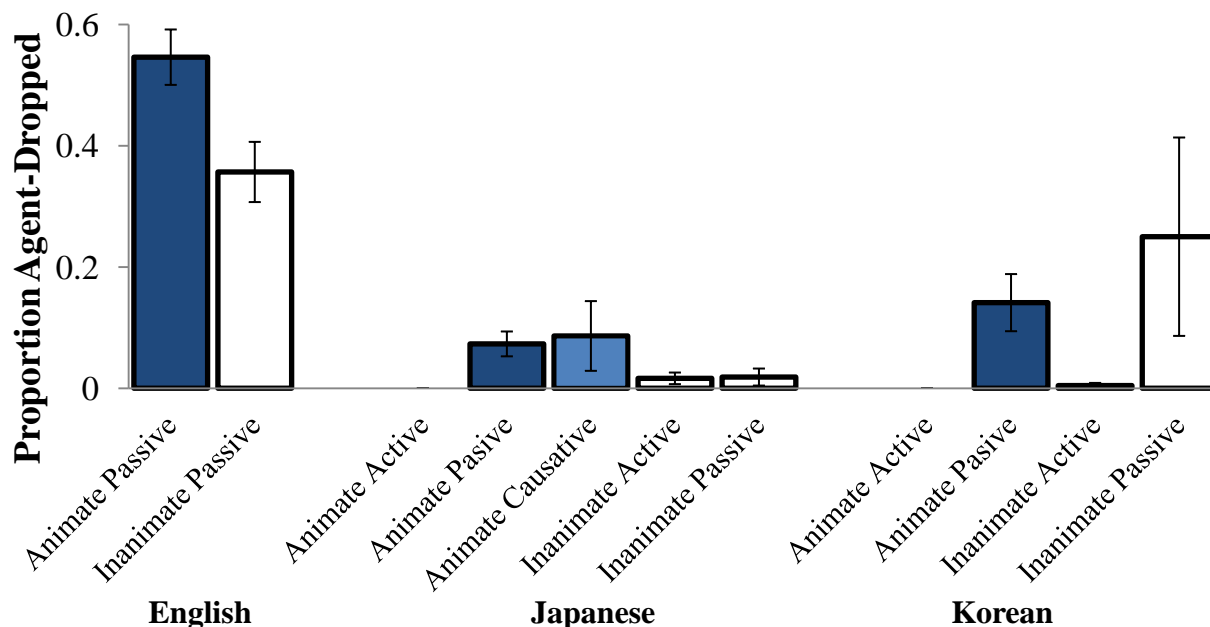


Figure 4: Rates of agent dropping in each structure that permits agent-dropping.

The patterns that emerge across languages in agent-dropping are consistent with the patterns reported in Gennari, Mirkovic and MacDonald (2012). Though English speakers are far more likely to drop agents overall, in both English and Japanese, speakers are more likely to drop agents when describing animate entities. This difference in absolute frequency of agent dropping may reflect typological differences across these languages, as speakers of the typologically similar Japanese and Korean dropped agents less often than English speakers. The animacy effect in agent dropping in English and Japanese is consistent with previous findings, which suggest that agent dropping more often occurs when there is interference between two similar nouns, either because they are both animate or otherwise semantically similar (Gennari, Mirkovic & MacDonald, 2012). This suggests that interference during lexical selection is a factor that all speakers share, regardless of the language they are speaking. Though it may not be the only factor predicting agent-dropping, the animacy effect across languages suggests that

speakers of all languages make choices to alleviate difficulty associated with noun interference during production planning.

We failed to see an effect of animacy in Korean due to the very low rate of agent dropping in active sentences and the very low number of participants who produced any passive relatives with inanimate heads. Perhaps given a much larger sample, or a task that promoted more passive utterances we might have detected this animacy effect in Korean. Or perhaps the production difficulty associated with interferences between semantically similar nouns is alleviated differently in Korean. Additional manipulations would be necessary to understand this pattern of data.

Discussion There are a number of similarities and differences in structure choice in relative clauses across these English, Japanese and Korean. Despite typological differences between English and Japanese and Korean, in all three languages, speakers tended to use more passive productions when describing animate rather than inanimate targets. Though this effect of animacy was robust in all three languages, the absolute number of active and passive utterances varied across languages. Notably, these differences did not take place along typology lines; despite almost identical typology in these sentences in Japanese and Korean, Japanese speakers produced almost identical proportions of active and passive utterances as English speakers, while Korean speakers produced significantly fewer passives. Structure choice in main clause utterances (Experiment 1) predicted production choices in Experiment 2, not language typology. This is surprising, given past work that suggests that typological differences across languages can have significant effects on production choices (Chang, 2009; Christianson & Ferreira, 2005). This suggests multiple factors affect production choices: difference choices afforded speakers of

different languages based on typology, and some idiosyncratic patterns with a language that cannot be attributed to language typology.

When investigating rates of agent dropping, speakers in English and Japanese were more likely to drop agents when describing animate entities. This suggests that there is a non-linguistic (semantic) factor that contributes to the data—semantic interference seemed to matter across languages, but that language specific typological or linguistic patterns must also contribute to the observed pattern of data as overall rates of agent-dropping varied across languages.

General Discussion

In a main clause and a relative clause production task, we investigated production choices in English, Japanese and Korean. In the main clause production task, we found that language specific patterns, not necessarily typological properties, seem to motivate production choices (Korean speakers produce fewer passives than speakers of the other two languages) and in one language (Japanese) animacy seems to affect production choices. In the relative clause production task, animacy affected production choices in all three languages, and the absolute number of passive production tracked production choices in the main clause production task. We also found in the two languages in which this analysis was possible (English and Japanese) speakers more often dropped agents when describing animate rather than inanimate entities. These findings have a number of implications.

First, the effect of animacy in both relative clause production choices and agent-dropping suggests a common role of animacy across all three languages. Interestingly, we find an effect of animacy in structure choices despite the fact that word order of active object and passive

relatives are the same in Japanese and Korean. This is consistent with work that suggests that animacy may affect structure choice through grammatical role assignment (Tanaka, Branigan, McLean & Pickering, 2011). Speakers decide which element of their message is the topic, and this assignment of topic is often emergent from the linguistic context or discourse in which the planning sentence is to be uttered. Speakers then phrase their utterance with respect to how that particular language codes the topic or an entity that should be focused. Generally, this places the more accessible topic entity into a more prominent sentence position, which is likely done to alleviate production difficulty on the speaker, as these prominent positions are often early in the sentence, allowing speakers to place more fully planned words earlier in an utterance, or conform to well-rehearsed patterns in a language. Animacy or topic status seem to affect grammatical role assignment in all languages, but the effect of these constraints act with along with linguistic patterns and structure preferences within a particular language as speakers conform to well-rehearsed linguistic patterns.

Second, the effect of animacy in English and Japanese agent-dropping suggests a common source of production difficulty across languages. Semantically similar nouns are difficult to select simultaneously, so semantic overlap predicts agent-dropping, where the speaker only needs to plan and produce a single noun (Gennari, Mirkovic & MacDonald, 2012). Semantic interference seems to be a factor that affects production choices not because of how any single language is structured, but because of cognitive limitations on the speed or efficiency with which lexical selection can occur. This provides further evidence that some production choices are made to alleviate production difficulty on the part of the speaker, and suggests an additional source of the production difficulty.

Finally, the observed pattern of main clause and relative clause data suggests that patterns of main clause productions may predict patterns of relative clause productions. Some patterns in language may be idiosyncratic, but they have predictable consequences elsewhere in the language. This provides some evidence for generalization across similar, but nonetheless different sentence types. Rather than viewing different sentence structures as discrete entities, different structures may have different degrees of similarity with each other, based on various features (word order, case marking, morphology, etc) and patterns governing the use of one structure may influence the use of another structure with fractural overlap. This is consistent with previously identified frequency by regularity interactions found at the syntactic level. Despite the comparative rarity of relative clause sentences, and the rarity of passive relative clauses compared to object relative clauses, the viability of a passive relative is boosted when then viability of passive main clauses increased.

There are a number of potential explanations for why we see this generalization across main clause and relative clause sentence. It is possible that the high frequency of one structure causes the planning of that structure to be highly accessible, so it is easy to produce whenever some feature of that structure may be used. This would mean that in languages in which passives are frequent in main clauses, the passive is a highly accessible structure so speakers can easily co-opt a portion of that well-rehearsed plan when producing relative clause utterances. An alternative is that a frequent structure will be associated with a greater diversity of desired messages, so a neighbor of that frequent structure will also more likely be associated with a wide range of possible messages. This would suggest that passives are more frequent in some languages because there are more types of messages that are appropriately coded with a passive. The passive is then less “marked” so it can be used to express a more messages types in relative

clause contexts as well. The present data cannot distinguish between these two possibilities, but existing data about the value of re-using a production plan (MacDonald, 2013) suggests that implicit learning (priming) in sentence production may plausibly arise through production constraints that cause re-using a well planned sentence plan to be easier than planning a new one. Much like how, at the word level, a large orthographic neighborhood (Jared, McRae & Seidenberg, 1990) or a high-frequency homophone (Jescheniak & Levelt, 1994) predicts shorter naming latencies, a structure (passive relative clause) with a high-frequency neighbor (passive main clause) may receive a similar boost in ease of planning and production. In this sense, investigating the cognitive demands on the speaker, and how repeating a well-rehearsed plan is yet another tool at the speaker's disposal to decrease those production demands may help explain why speakers make the production choices they do.

An important point is that the finding that patterns of main clause sentence choice predict relative clause sentence choices is incompatible with a generative account of language production (e.g. Jackendoff, 2002; Pinker, 1984). If sentences are spontaneously generated with rules, then there is no reason that production patterns of one sentence type should influence patterns of another similar, but different sentence type. A better understanding of how knowledge and patterns governing the use of one structure affects the use of a similar, but different structure will help us understand both the knowledge that underlies sentence production abilities, as well as the cognitive processes that speakers employ as they produce language.

Further, understanding how production demands shift as a function of the word order of the sentence being produced, or the language being produced (Chang, 2009; Christianson & Ferreira, 2005) in tandem with pattern generalization across sentence types within a single language will help us better understand the planning process. If we can understand what makes

production hard, we can better understand the processes that a speaker is doing as they produce a sentence. For example, planning two similar nouns at the same time is inherently hard, as is planning a passive if your language rarely uses passives. Understanding how these sources of difficulty can derive from fixed typological factors (SOV vs. SVO; head-initial vs. head-final), language use factors (relative frequencies of active and passive sentences) or organization of sensory, semantic or motor knowledge in the brain can help us understand sentence production. In the future, cross-linguistic studies will likely play a major role in helping us tease apart and understand the contributions of these various sources of production difficulty.

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Chapter 3: Emerging literacy and production: Text exposure affects spoken production of complex sentences in eight and twelve year old children and adults.

The field of language development has typically focused on questions of whether or not a child can perform a particular behavior, or at what age that behavior emerges. These are certainly very important questions, and answering these questions has given us much insight into the developmental trajectory of language acquisition, and the skills and learning that contribute to emerging linguistic abilities in children. Less well studied is how language abilities change over time, and how adult-like behavior often emerges long after a child initially exhibits that particular behavior. Studies that do address changes in behavior across childhood indeed find that adult-like behavior often emerges years after the behavior is initially exhibited (Ameel, Malt & Storms, 2008; Hudson Kam & Edwards, 2008; Maratsos, Fox, Becker & Chalkley, 1985; Saji et al., 2011). One reason that these change-over-time studies may be less common than emergence-of-behavior studies is that traditional notions of performance and competence suggest that the change of a behavior over time reflect language performance, which is less interesting than competence, the true knowledge of language. If changes in behavior related to ongoing learning are just noise, then investigating this variability is not addressing the truth of what language is. However, more recent theories suggest that experience plays a more central role in language abilities (Seidenberg & MacDonald, 1999; MacWhinney & Bates, 1989). If experience with one's linguistic environment is what allows individual to learn and use language, then investigating this ongoing learning process is in fact investigating the processes and knowledge that underlie that language behavior. If the role of experience is more central to language abilities than previously thought, then understanding the role of experience, not only in the

emergence of a behavior but the developmental trajectory, is an important component of the language acquisition story.

There is little debate that experience plays a significant role in language comprehension abilities. There is a large body of work showing that patterns of comprehension behavior in adults are indeed predicted by patterns in the linguistic environment. These studies suggest that statistical learning of one's linguistic environment is the driving factor of comprehension abilities, as distributions in the linguistic environment predict comprehension difficulty. The frequency in which structures appear in corpora affect comprehension difficulty (Garnsey, Pearlmutter, Meyers & Lotocky, 1997; Gennari & MacDonald, 2009; Reali & Christiansen, 2007; Roland, Elman & Ferreira, 2007; Taraban & McClelland, 1988), as does structure frequency in participant-generated sentence completions (Gennari & MacDonald, 2008; Levy, Fedorenko, Breen & Gibson, 2012; Trueswell, Tanenhaus & Kello, 1993), in all cases much better than traditional measures of syntactic complexity. These experience-driven accounts of comprehension suggest that the sorts of statistics and patterns that might be driving comprehension abilities, but relatively little attention has been paid to the sorts of patterns that might drive production abilities. If production patterns, along with comprehension patterns are better explained by experience rather than syntactic complexity, that would provide compelling evidence that experience alone may account for language abilities.

To investigate the roles of syntactic complexity and experience, we employed a relative clause production task (Gennari, Mirkovic & MacDonald, 2012; Montag & MacDonald, in press) to elicit object and passive relative clauses from eight and twelve year old children and adults. Since Miller & Chomsky (1963) introduced relative clauses as an example of the potentially infinite language knowledge (competence) being limited by constraints on human

memory, relative clauses have become an iconic example of certain sentences that are inherently harder to comprehend (or produce) than others are. Hundreds of journal articles have been published trying to determine why certain relative clause sentences such as sentences containing object relative clauses (1a), where the head noun, *the reporter*, is the object of the verb (the one who was attacked) are harder to comprehend than sentences containing subject relative clauses (1b) where the head noun, *the reporter*, is the subject of the verb (the one who attacked).

Differences in comprehension behavior were historically attributed to memory demands thought to be inherent in sentences of different types. The object relative clauses in (1a) require the comprehender to hold the head noun, *reporter*, in memory until the word “admitted,” where the comprehender learns what action the reporter took part in, while in the subject relative case, the duration with which the head noun must be maintained in memory is much shorter.

- 1a. Object Relative: The reporter that the senator attacked admitted the error.
- 1b. Subject Relative: The reporter that attacked the senator admitted the error
- 1c. Passive Relative: The reporter that was attacked by the senator admitted the error.

The additional memory demand has been implicated for the increased processing time for object over subject relative clauses (Bartek, Lewis, Vasishth & Simth, 2011; Gibson, 1998; Grodner & Gibson, 2005; Just & Carpenter, 1992; King & Just, 1990). Other work has shown that the relative frequency of these structures predicts comprehension difficulty (Gennari & MacDonald, 2009; MacDonald & Christiansen, 2002; Reali & Christiansen, 2007), and increasing the amount of experience (training) a person has with the less-common object relative clauses improves comprehension ability (Roth, 1984; Wells, Christiansen, Race, Acheson & MacDonald, 2009).

Through the example of subject and object relative clauses, we can see that what makes some sentence types harder than others does not seem to be aspects of syntactic complexity associated with those structures, but experience with the statistical regularities that underlie those structures. The present study compares production choices of object relative clauses (1a) to passive relative clauses (1c) which conveys a similar message as the object relative clause but like 1b, are less syntactically complex. A syntactic complexity view would suggest that children should more often produce the less complex passive relatives, while an experience based view would suggest that children's production choices should be driven by the frequencies of these sentence types in the individual's linguistic input.

This is by no means the first study to use relative clauses as a window into the language development trajectory. Relative clauses have been extensively studied in children, with a similar theoretical trajectory as the adult work, with early studies approaching relative clauses as a indicative of innate processing differences between different structure types and more recent work focusing on experience-based accounts of comprehension and production differences across different structures. Early work with children's comprehension of relative clauses sought to investigate which structures were harder or easier for children to comprehend, but this work largely ignored the learning component and often assumed that any observed comprehension patterns must be due to inherent differences in difficulty between different structure types. To investigate comprehension abilities in children, these studies tended to employ an object manipulation task. Children were presented with an array of toy animals and were asked to act out a sentence with those toys. The sentences children were asked to act out contained relative clauses, such as "The pig kissed the horse that jumped over the sheep." These tasks were typically quite difficult for children, with accuracies around 30%-80% for 5 year olds, depending

on the type of relative clause tested, and accuracies less than 10% in some conditions for 4 year olds (de Villiers, Flushberg, Hakuta & Cohen, 1979; Goodluck & Tavakolian, 1982; Sheldon, 1974; 1977). Subject relative clauses were generally easier than object relative clauses (de Villiers, Flushberg, Hakuta & Cohen, 1979; Fluck, 1978; Goodluck & Tavakolian, 1982; Roth, 1984), like patterns found with adults, and consistent with a syntactic complexity approach. However, there was some variability in that finding (Sheldon, 1974; 1977). Subsequent work has shown that the structures used in these studies (specifically, object relative clauses with animate head nouns and full noun phrase embedded nouns) are typically quite rare in the linguistic environment (Reali & Christiansen, 2007; Roland, Dick & Elman, 2007), so it is not surprising that children exhibited the difficulty they did on these tasks, as they would have had very little experience with types of sentences used as experimental items.

More recent work has focused on the relationship between child-directed speech and child productions (as assessed by the CHILDES corpus) and children's relative clause production and comprehension abilities. Analyzing language behavior in the context of language experience allows for behavioral patterns to be interpreted in light of the type and amount of experience that children might have received. Diessel and Tomasello (2000) extensively investigated productions by children in CHILDES. An investigation of the productions of five children, from the age of about two to about five showed that children's relative clause productions tend to contain a high proportion of object relative clauses, the classically more syntactically complex relative clause. However, this and subsequent work (Diessel & Tomasello, 2005; Kidd, Brandt, Lieven & Tomasello, 2007) suggests that like adults, children seem to be sensitive to the types of nouns that tend to be used in these relative clauses in typical speech. Children tend to produce relative clauses with the noun types (inanimate head nouns and embedded pronouns, such as *the*

book that I read) that tend to appear in adult speech. This is consistent with the findings in the adult comprehension literature that relative clauses with inanimate head nouns or embedded pronoun subjects are quite easy to comprehend (Mak, Vonk & Schreifers, 2002; 2006; Traxler, Morris & Seely, 2002; Reali & Christiansen, 2007) and are indeed frequent in adult speech and the linguistic environment (Reali & Christiansen, 2007; Roland, Dick & Elman, 2007). The existing work on adult and child productions of relative clauses suggest that, at a very general level, children and adults seem to exhibit similar production patterns of relative clauses. This suggests that early relative clause behavior is not driven by innate linguistic knowledge, but closely tracks experience that children have with these relative clause types. The question that remains is how similar are adult and child production behaviors at a finer grain size? Adults have significantly more experience with relative clauses by the simple fact that they are older, so does this additional experience have a systematic effect on production behavior?

In production, children continue to learn the statistics that govern the use of words and constructions long after they first begin to utter those phrases. When children begin to use a particular word or construction, they are not necessarily using it in an adult-like manner. They often over- or under-extend it, by either using it to refer to referents or situations it does not apply, or failing to use the word in appropriate situations (Bowerman, 1978; Clark, 1978; Kay & Anglin, 1982; Rescorla, 1980). Even when children use the same nouns and verbs as adults, they may not make the same word-to-context assignments as adults, but over time, these mappings gradually comes to mimic those of adults (Ameel, Malt & Storms, 2008; Saji et al., 2011). If children's noun and verb usage does not initially resemble that of an adult, but comes to resemble adult use over time, then over time children's structure choice may become more similar to adult structure choice, as children learn finer grained details of the statistics that

govern structure choice. If we see systematic differences between adult and child structure choices, we can attribute some of these differences to different amount and types of experience that adults and children are bringing to the task. Investigating child behavior in a production task and comparing it to adult behavior will ultimately help us understand how child and adult language production differ and what learning takes place to bring about adult performance.

Another potential source of variance between child and adult relative clause productions is that not only do adults and children differ in the amount of experience they have with language statistics, but the nature of those statistics may be qualitatively different for adults and children because children have much less experience with statistics of written language. There has been substantial work investigating distributional differences in vocabulary choice across written and spoken domains, as well as written materials intended for children. Vocabulary in spoken and written language tends to be different, with a greater representation of rarer words in written over spoken texts (for a review, see Akinnaso, 1982 and Chafe & Tannen, 1987; DeVito, 1966) regardless of the age of the participants in the spoken conversation (Hayes, 1988; Hayes & Ahrens, 1988). However, relatively little work has explicitly investigated structural differences between written and spoken language, especially written and spoken language intended for children. Comparisons of adult-directed written and spoken corpora (Biber, 1988; Roland, Dick & Elman, 2007) indeed find significant differences in the distributions and of different relative clause types. If the distribution of these structures were also different in child-directed written and spoken materials, learning to read would indeed be an event that qualitatively changed the patterns of sentence structures that an individual encounters.

The finding that literacy has a significant effect on spoken language abilities would have significant implications for language acquisition. The emergency of literacy is generally not

investigated as a possible source of experience that contributes to language development, but if the types of sentence structures used in written and spoken language vary, this could be a source of qualitatively different statistics for the newly literate child. It would also provide further evidence that language abilities are shaped by experience with one's linguistic environment, not innate constraints on the timetable of linguistic development or structural difficulty. It would also allow us to account for more variability in behavior as we can better approximate the linguistic environment to which an individual is exposed by considering the contribution of both written and spoken materials.

In the corpus analyses of Experiment 1, we will investigate the experience with object and passive relative clauses that children have received. We investigate these relative clause types because they convey a similar message, so they are the production alternatives afforded speakers in Experiment 2. First, we would like to quantify the distributions of these complementary structures in children's literature (Experiment 1a) and child-directed speech (Experiment 1b) and how the distributions of these relative clauses might differ in written and spoken language. With this knowledge in hand, we can understand why children make the choices they do in the production task, and make predictions for the sorts of changes that ought to happen as an individual gains more experience with language, especially experience with written language.

The production studies of Experiment 2 consist of a variant of a picture-description task successfully used with adults (Gennari, Mirkovic & MacDonald, 2012; Montag & MacDonald, in press) that has been slightly modified for use with children. In previous studies, we have extensive data on the sorts of choices that adults make, including structure choice of an active object (e.g. *The ball that the man is throwing*) or passive relative (e.g. *The ball that is being*

thrown by the man), use of relative pronouns such as *that* or *who* preceding relative clauses, and whether or not an agent is specified in passive utterances (e.g. *The ball being thrown* vs. *The ball being thrown by the man*) (Gennari, Mirkovic & MacDonald, 2012; Montag & MacDonald, in press). We will compare the production choices of adults, and eight and twelve year old children on this task, and investigate the extent to which production choices across the developmental trajectory might be predicted by the emergence of literacy, and individual differences in production choices might be predicted by individual differences in reading ability or text exposure.

Experiment 1a: Corpus analysis of Children's literature

An analysis of the types of relative clauses in literature intended for children may be able to predict children's productions in the relative clause production task of Experiment 2. An analysis of complex structures in children's literature has never before been attempted, so this analysis will also investigate how the distribution of complex structures might be different from literature intended for adult audiences.

Corpus The corpus used for this analysis was the juvenile literature² accessible in the COCA (Corpus of Contemporary American English) corpus (Davies, 2008-). This corpus consists of 2.40 million words of literature intended for children aged 3-16 years. It consists of fiction and non-fiction magazine articles as well as excerpts from fiction novels. It contains a total of 1708 documents (articles, excerpts, etc) from 97 different sources (magazine and book titles).

Method

Target age of document coding: The 97 different sources contained in the corpus were each coded for the intended age of the child audience. The recommended ages for book titles were

² In the version of COCA used in these analyses (updated June 6, 2012) about a quarter of the documents categorized as juvenile literature were not in fact juvenile literature. All reported data removes these irrelevant documents so only the literature intended for children is included in all analyses.

retrieved from the Barnes and Noble website (www.bn.com). Recommended ages for magazines were retrieved from the websites of the magazines themselves. When the target age of a source contained a range, the mean age was used. For example, if the recommended age was listed as “ages 8-12,” “10” was coded as the target age for that source. In cases in which recommended ages were given as grade levels, these grade levels were converted to ages such that first grade = 6 years, second grade = 7 years, and so forth.

Relative Clause Coding: The COCA corpus is tagged, but not parsed, so part of speech tags were used to extract possible relative clauses. Appendix A contains the search terms used to extract possible relative clauses. All object relative and passive relative clauses were then selected by hand from these candidate sentences. It is not possible to directly search for relative clauses with only part of speech tags, so we opted to cast a wide net, then eliminate irrelevant sentences by hand. One type of relative clause that we knew were unable to extract were those with embedded nouns modified by an adjective (e.g. *The book that the tall woman read*). We do not believe that our results are significantly affected by this omission. These relative clauses were then coded for a number of factors: Animacy of the head noun, whether or not the relative clause was preceded by a relative pronoun (e.g. *The book that I read* vs. *The book I read*), and in the case of object relative, animacy of the embedded noun and type of embedded noun (pronoun or full noun phrase). Passive relatives were coded for whether an agent was specified (e.g. *The ball that was caught* vs. *The ball that was caught by the man*.) This coding allows us to make predictions about the production choices that speakers might make in Experiment 2 if they were affected by statistics of written language.

Results A total of 3300 object relative and 1242 passive relative clauses were present in this corpus. Table 1 and 2 break down the total number of object and passive relative clauses by various coding criteria.

| | With Relative Pronoun | | Total | No Relative Pronoun | | Total | Grand Total |
|------------------|-----------------------|---------------------|-------|---------------------|---------------------|-------|-------------|
| | Animate Head Noun | Inanimate Head Noun | | Animate Head Noun | Inanimate Head Noun | | |
| Embedded Full NP | 4 | 75 | 79 | 13 | 154 | 167 | 246 |
| Animate | 4 | 60 | 64 | 11 | 131 | 142 | 206 |
| Inanimate | 0 | 15 | 15 | 2 | 23 | 25 | 40 |
| Embedded Pronoun | 34 | 313 | 347 | 447 | 2260 | 2707 | 3054 |
| Animate | 32 | 311 | 343 | 445 | 2237 | 2682 | 3025 |
| Inanimate | 2 | 2 | 4 | 2 | 23 | 25 | 29 |
| Grand Total | 38 | 388 | 426 | 460 | 2414 | 2874 | 3300 |

Table 1: Summary of object relative clauses in COCA juvenile literature.

| | With Relative Pronoun | | Total | No Relative Pronoun | | Total | Grand Total |
|-----------------|-----------------------|---------------------|-------|---------------------|---------------------|-------|-------------|
| | Animate Head Noun | Inanimate Head Noun | | Animate Head Noun | Inanimate Head Noun | | |
| Agent Specified | 3 | 14 | 17 | 17 | 148 | 165 | 182 |
| No Agent | 33 | 95 | 128 | 161 | 771 | 932 | 1060 |
| Grand Total | 36 | 109 | 145 | 178 | 919 | 1097 | 1242 |

Table 2: Summary of passive relative clauses in COCA juvenile literature

The data presented in these tables is consistent with previous work on the distributions of relative clauses in written texts, but also makes a number of novel contributions. First, we find that the ratio of passive to object relative clauses is quite different than previous estimates of written corpora. We find that object relatives are more frequent than passive relatives, with 2.7 object relatives for each passive relative. Roland, Dick and Elman (2007) report more *passive* than object relatives in their written corpora, though more *object* than passive relatives in their spoken corpora. This suggests that one way in which child and adult literature differ is in the

frequency of passive relative clauses. Table 3 shows a summary of the ratio of object to passive relatives in this and the 5 corpora reported in Roland, Dick and Elman (2007)

Next, we find that rate of reducing (not using a relative pronoun) in object relative and passive relative clauses is mostly consistent with previous work. As summarized in table 3, we report slightly higher rates of reduced object relatives clauses than Roland, Dick and Elman (2007), but almost identical rates of reduced passive relatives. It is possible that we report a higher rate of reduced object relatives because we also report a higher rate of embedded pronoun in our object relative clause sentences, which we find are more likely to be reduced. We find that 92.5% of object relative clauses contain embedded pronouns, while Reali & Christiansen (2007) report only 23.0% and Roland, Dick and Elman (2007) report 40.8%, though both these numbers count only object relative clauses with relative pronouns, which are less likely to contain embedded pronouns in previous studies (Roland, Dick & Elman, 2007; Temperley, 2003), and in our data (81.5% of our object relatives with relative pronouns contain embedded pronouns versus 94.2% without relative pronouns). The small number of passive relatives (14.7%) that specify agents in our data is also consistent with previous work (Biber, 1988; Roland, Dick & Elman, 2007).

To our knowledge this is the first corpus analysis to explicitly investigate reading material intended for children, and the relative frequencies of relative clause types are consistent with previous work. This data is presented in Table 4, and will be discussed in conjunction with the CHILDES corpus data of Experiment 1b.

Juvenile literature across age groups

The juvenile literature in COCA contains documents intended for a wide range of audiences. Previous work has not quantified differences in syntactic structure across literature

intended for children of different ages but this corpus permits us that opportunity. Sources that did not contain at least 5,000 total words were eliminated as those very small corpora may not contain an accurate estimate of the number of relative clauses in a document of that sort. Thirty-two sources were included in this analysis. Figure 1 shows the frequency of object relative clauses for each 1000 words, by the age of the intended audience of that written source. The unfilled dot represents a magazine called “Know Your World” which is intended for high school students with low reading skills. When this data point is included in the analysis, the correlation between frequency of relative clauses and intended age is not significant ($r(30) = 0.26, p = 0.15$) and when it is eliminated, the correlation is significant ($r(29) = 0.39, p < 0.05$). It seems honest to remove this point because if the text was intentionally written to be accessible to less skilled readers, it’s possible that the authors intentional used fewer complex sentences and thus the lack of relative clauses was either a conscious choice or a consequence of other conscious choices made by the authors of that magazine.

No similar correlation was between frequency and target age of the written source was found for the passive relatives. This could reflect a lack of power as there were fewer passive relatives overall and fewer sources contained any passive relatives. Or it is possible that that a smaller number of passive relatives is in fact a defining feature of children’s literature and we would have to include a larger range of written materials, particularly those aimed at young adults and adults, to find an age-related correlation.

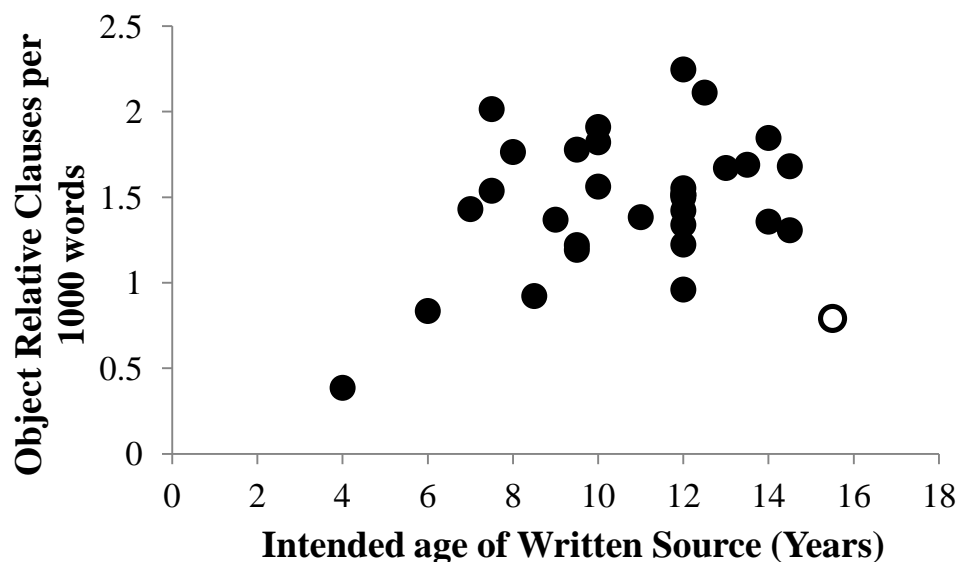


Figure 1: The frequency of object relative clauses by the intended age of the corpus document. Relative clauses tend to be more frequent in reading material intended for older audiences.

In Experiment 1b, we investigate the frequency and types of object and passive relative clauses in child-directed speech. Extensive investigations of children's relative clause productions in this corpus have been conducted (Diessel & Tomasello, 2000), but the focus of past investigations has rarely been on the child-directed portion of the corpora. We would like to quantify the differences between the language experiences children receive from spoken language, as estimated by CHILDES (Experiment 1b) and from written language, as estimated by COCA-Juvenile (Experiment 1a).

Experiment 1b: Corpus analysis of Child-Directed Speech

Given previous work comparing the frequencies of passive and object relative clauses in written and spoken material intended for adults (Roland, Dick & Elman, 2007; Biber, 1988) we wanted to investigate how these patterns might differ in speech and writing intended for children. By comparing differences in child-directed speech and text, we can make predictions about how children's language experience changes as they become literate, which will help us make

predictions about how child and adult behavior on the sentence production task in Experiment 2 may differ.

Corpus We used a subset of the parsed CHILDES (MacWhinney, 2000) corpus, which contained a total of 1.12 million words³.

Method To extract relative clauses, the CLAN program was used to extract all complement modifications, which contains all relative clauses. All object and passive relative sentences were then extracted from these sentences containing complement modifications by hand. Then, all object and passive relatives were coded for the same criteria as they were in Experiment 1a.

Results

We identified 383 object relative clauses and only 4 passive relatives in this corpus. The object relative clauses broken down by the coding features are given in Tables 3. All 4 passive relative clauses modified inanimate head nouns and did not specify agents. Two contained relative pronouns.

| | With Relative Pronoun | | Total | No Relative Pronoun | | Total | Grand Total |
|------------------|-----------------------|---------------------|-------|---------------------|---------------------|-------|-------------|
| | Animate Head Noun | Inanimate Head Noun | | Animate Head Noun | Inanimate Head Noun | | |
| Embedded Full NP | 0 | 3 | 3 | | 6 | 6 | 9 |
| Animate | 0 | 2 | 2 | 0 | 4 | 4 | 6 |
| Inanimate | 0 | 1 | 1 | 0 | 2 | 2 | 3 |
| Embedded Pronoun | 3 | 73 | 76 | 21 | 277 | 298 | 374 |
| Animate | 3 | 72 | 75 | 21 | 275 | 296 | 371 |
| Inanimate | 0 | 1 | 1 | 0 | 2 | 2 | 3 |
| Grand Total | 3 | 76 | 79 | 21 | 283 | 304 | 383 |

Table 3: Summary of object relative clauses in CHILDES child-directed speech.

³ The CHILDES corpora used were Bates, Bernstein, Bliss, Bloom (1970), Bloom (1973), Bohannon, Brent and Brown.

Object relative clauses overwhelmingly contained embedded pronouns and did not contain a relative pronoun. Table 4 provides a summary of various characteristics of the written and spoken child-directed corpora of Experiment 1a and 1b, as well as the three written and two spoken corpora described in Roland, Dick and Elman (2007). One finding is that various properties of the relative clauses found in the juvenile literature corpus tend to differ from the other written corpora along the same dimensions that spoken language differs from written languages. In many ways, children's literature is a cross between spoken language and written language. Children's literature seems to have a ratio of passive to object relative clauses intermediate between those of adult speech and adult text and the number of object relative clauses with embedded pronouns is more similar to that of speech than text. This observation is potentially important for theories of language development because object relative clauses with embedded full noun phrases are those used in most relative clause comprehension studies, so if children do not encounter these sentence types until they read, or even until they begin to read more challenging texts, it is not surprising that children struggle with these sentence types. Additionally, object relative clauses with embedded full noun phrases and animate head nouns are virtually non-existent in these corpora. These distributional properties of relative clauses in corpora not only pertain to language development, but also to adults. Adults who are not ardent readers may struggle with the sorts of object relative clauses used in typical psycholinguistic experiments, which is consistent with training studies that investigate the effect of experience on object relative clause comprehension (Wells, Christiansen, Race, Acheson & MacDonald, 2009).

The use of relative pronouns in the children's written and spoken corpora are consistent with patterns of relative pronoun use in the adult corpora. Across all corpora (except object relative clause of BNC-spoken) relative pronouns are more frequent in spoken language,

consistent with the idea that relatives pronouns can be used by the speaker strategically to allow for more planning time, which is not a concern during writing (Ferreira & Dell, 2000; Race & MacDonald, 2003; Montag & MacDonald, in press).

| | Ratio of Passive Relatives to Object relatives | Percentage of reduced object relatives | Percentage of reduced passive relatives | Percentage of ORCs with embedded pronouns (in RCs with relative pronouns) |
|---------------------|--|--|---|---|
| COCA-Juvenile | 2.7 | 87.1% | 88.3% | 81.5% (92.5% all ORCs) |
| CHILDES | 95.8 | 79.4% | 50.0% | 96.2% (97.7% all ORCs) |
| BNC | 0.6 | 65.0% | 77.5% | |
| BNC-Spoken | 4 | 78.9% | 62.5% | |
| Brown | 0.5 | 70.6% | 78.9% | 40.8% |
| Switchboard | 10.10 | 48.6% | 72.1% | 90.4% |
| Wall Street Journal | 0.4 | 65.3% | 91.3% | |

Table 4: Summary of frequencies of relative clause types across 7 corpora. Highlighted rows represent spoken corpora. The top two corpora summarize data from Experiments 1a and 1b. The bottom five corpora summarize data reported in Roland, Dick and Elman (2007).

Table 5 shows the frequency of different relative clause types per million noun phrases. Here it becomes obvious how infrequent complex sentences, of any type, are in child-directed speech. Though the *relative* frequencies of different relative clause types may be approximately equal across adult and child corpora, the *absolute* frequencies are substantially lower in child-directed speech. While children's written corpora may resemble a midpoint between adult written corpora and adult speech, child-directed speech is substantially simpler. This has a number of consequences. First, this is strong evidence for syntactic accommodation in child-directed speech (Cross, 1977; Hayes & Ahrens, 1988; Newport, Gleitman & Gleitman, 1977). Second, this is evidence that children are receiving very little experience with object relative clauses and even less experience with passive relative clauses until they begin to read (or are read to by a caregiver). These corpus analyses show how different child and adult experience with relative clauses may be, especially before a child learns how to read.

| | Object Relative | | Passive Relative | |
|---------------------|-----------------|---------|------------------|---------|
| | Full | Reduced | Full | Reduced |
| COCA-Juvenile | 1,152 | 7,773 | 392 | 2,966 |
| CHILDES | 397 | 1,492 | 10 | 10 |
| BNC | 2,943 | 5,455 | 3,118 | 10,730 |
| BNC-Spoken | 3,863 | 14,423 | 1,729 | 4,746 |
| Brown | 1,976 | 4,746 | 2,867 | 10,733 |
| Switchboard | 5,616 | 5,314 | 302 | 779 |
| Wall Street Journal | 1,802 | 3,385 | 1,224 | 12,788 |

Table 5: Relative clause types per million NPs. Highlighted rows represent spoken corpora. The top two corpora summarize data from Experiments 1a and 1b. The bottom five corpora summarize data reported in Roland, Dick and Elman (2007).

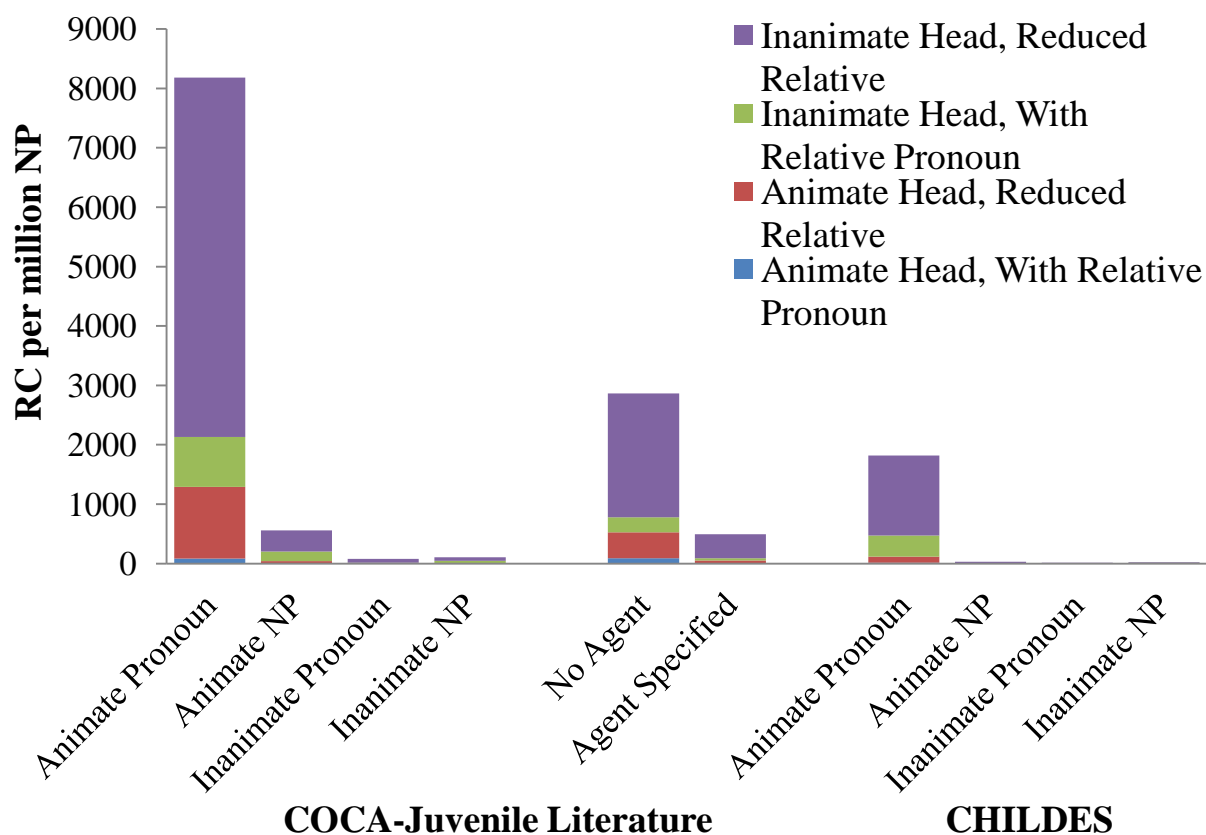


Figure 2: Distribution of various relative clauses in COCA-Juvenile literature (Experiment 1a) and CHILDES (Experiment 1b). The type of embedded noun is plotted on the x-axis, or in the case of passive relatives, whether or not an agent was specified. Passive relatives were virtually non-existent in CHILDES so they are not plotted. Raw data is in Appendix B.

Discussion The absolute frequencies of object and passive relatives, as well as the absolute frequencies of various sub-types of relative clauses, presented in Tables 1, 2 and 3 and plotted in Figure 2, allow for predictions of exactly how child and adult productions might differ in the relative clause production task of Experiment 2. The corpus analyses of Experiment 1a and 1b investigate object and passive relatives, which convey a similar message and thus are the choice of structure that speakers in Experiment 2 will make. One prediction is that children should produce fewer passive relatives than adults. Passive relatives are extremely rare in child-directed speech so children may only encounter these structures when they are either being read to or reading for themselves. This suggests that their experience with these structure types should dramatically increase as they accumulate more reading experience, and their productions of these structures should increase as they accumulate more experience with these structures. A second prediction is that children should use more relative pronouns in their utterances. Spoken language tends to contain more relative pronouns than written language, so children will have encountered a greater proportion of relative clauses with relative pronouns before they start reading.

Experiment 2 investigates production choices of adults and eight and twelve year old children on a relative clause production task. If children are making choices that reflect the experience with these sentence types they have accumulated in their lifetime, their productions should adhere to the predictions made by comparing child and adult written and spoken corpora.

Experiment 2: Production of complex sentences

In this study, we investigate production choices in a picture description task, similar to that of Gennari, Mirkovic and MacDonald (2012) and Montag and MacDonald (in press). Given the findings of the corpus analysis of Experiment 1, we can predict what children's production

choices might be if they were to systematically differ from adults in ways that might be predicted by differences between spoken and written language.

Participants Thirty undergraduates at the University of Wisconsin-Madison participated in exchange for course credit in an introductory psychology course. All were native speakers of American English. Thirty eight-year old children (15 female; mean age 8,3; SD 7.4 months; range 6,11-9,1) and 30 twelve year old children (9 female; mean age 12,2; SD 4.8 months; range 11,3-12,11) in the Madison, Wisconsin area will participated in exchange for a \$10 gift card. All were native speakers of American English.

Materials Eighteen verbs that can each take both an animate or inanimate grammatical object were selected. Color pictures were created that illustrated each of these twenty verbs. In each picture, there were two instances of that particular verb, once acting upon an animate grammatical object and once acting upon an inanimate grammatical object. These grammatical objects were the target items in the experiment. For example, the picture for the verb ‘throw’ (Figure 3) incorporated both a man being thrown and a ball being thrown, and the animacy of these target items was an independent variable of the experiment.

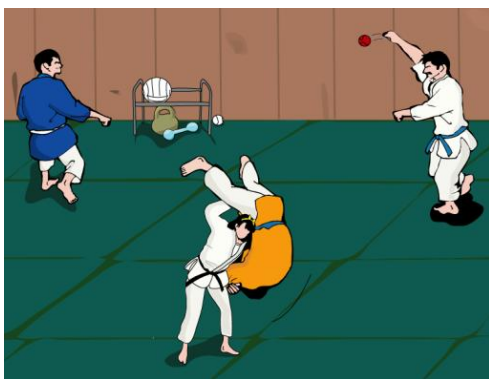


Figure 3: Test picture for verb “throw”

In addition to the 18 test pictures, there were 26 filler pictures for a total of 44 trials. These items differ from the items used in Montag & MacDonald (in press) in two ways. First,

there are two fewer test trials because two test pictures were deemed too violent for use with young children. Second, we reduced the number of filler trials to reduce the amount of time the task required as younger children have difficulty concentrating on this task for extended periods of time.

To elicit relative clauses, spoken questions were recorded that asked participants to describe a particular target person or object in the picture. For example, questions corresponding to Figure 3 would be “Who is wearing orange” for the animate ‘man’ target and “What is red” for the inanimate ‘ball’ target. There is more than one man in the picture and more than one ball, so the participants needed to produce relative clauses to sufficiently differentiate the target from the other items in the picture. For the target item ‘man’ in this picture, a good response would be “the man (who is) being thrown by the woman” or “the man (that) the woman is throwing” because these responses distinguish the target man from the second man in the picture. For filler trials, participants were asked to describe what a particular person was doing or identify a particular object. While the test pictures and questions were created such that participants needed to produce a relative clause with a verb as their response to completely answer the question, filler pictures and questions were created so that participants had no reason to use a relative clause in their responses. All spoken materials were recorded in a quiet room by a native English speaker.

Additional materials were used to gauge literacy or text exposure in children and adults. For adults we used the author recognition task and reading habits questionnaire developed by Acheson, Wells and MacDonald (2008). For children, we created a title recognition task appropriate for eight and twelve year old children. It was a modified version of the title recognition task of Cunningham & Stanovich (1990), updated to reflect the books that children

read now, and taking care to eliminate any books that have been made into popular movies (Appendix A). In addition, we administered a parent survey that, along with standard demographic and language development questions, asked parents to rate their child's mastery and enjoyment of mathematic and language arts, and the number of hours per week their child spend on a variety of activities, including reading, watching television, using a computer and outside play.

Procedure Detailed instructions with a cover task were created to prompt relative clause productions. All three age groups were presented with the same instructions, but the experimenter read the instructions aloud to the 8-year olds while the text was presented on the screen. Participants were told that the experiment was about interpreting pictures, and that their responses would be shown to a later group of participants who would try to guess which pictures their responses described. They were told that because colors or clothing might be changed, or items in the picture might be rearranged, describing the actions in which the people and objects were taking part would be the best strategy to employ in order to complete the task.

In each trial, a color picture appeared on the screen. After three seconds, participants heard a question asking about the target person or object in the picture and answered the question by speaking into a microphone. Each participant saw nine pictures with a question about an animate patient (e.g., the man being thrown in Figure 1) and nine pictures with questions about inanimate themes (e.g., the ball in Figure 1). Different sets of participants saw each half of the animate-inanimate target pairs, so that participants saw each picture only once. Test and filler trials were pseudo-randomized such that there was always at least one filler trial between any two test trials.

After the production task, participants performed the author recognition task and reading survey (adults) or title recognition task (children). Parents filled out the parent survey while children completed the task to avoid child involvement in the survey.

Results Responses were coded as being either active or passive. Responses that did not contain a relative clause with a verb we excluded. For adults, 84 trials were excluded, affecting 18.5% of animate and 12.6% of inanimate trials. For eight year olds, 159 trials were excluded, affecting 35.6% of animate and 23.3% if inanimate trials. For twelve year olds, 83 trials were excluded, affecting 20.0% of animate and 10.7% of inanimate trials. The exclusion rate was higher for the eight year olds than either the twelve year olds or adults, which is not surprising. In previous studies with this design (Montag & MacDonald, in press) trials were excluded in which the participant failed to produce a relative clause with a verb, (e.g., *The man in the middle*) even if they successfully produced a relative clause upon being corrected by the experimenter (typically in these cases, the experimenter had to point out the non-target entity). These trials were included in this analysis as the younger children often failed to notice the non-target distracter entity so the experimenter had to draw their attention to the distracter so they could felicitously describe the target entity. We opted to include these trials for the older children and adults as well in order to keep the tasks and inclusion criteria as similar as possible.

When describing animate targets, adults produced 92.0% (SD = 14.1) passive utterances and when describing inanimate targets, produced 46.4% (SD = 35.4) passive utterances. These numbers reflect slightly fewer passive productions than Montag & MacDonald (in press), who report 98.7% and 47.3% passive productions for animate and inanimate targets, respectively in an almost-identical task. This small difference in production choices may reflect greater priming across trials due to the reduced number of fillers that were used to accommodate younger

participants. Alternately, to make the task instructions more accessible to younger children, the instructions were re-written, which may have affected how adults interpret the task and produced responses.

Children's production choices were different than adult production choices. When describing animate targets, eight year old children produced 83.0% (SD = 25.6) passive productions and when describing inanimate targets, produced 23.5% (SD = 29.7) passive productions. Twelve year old children produced 94.1% (SD = 13.7) passive utterances when describing animate entities and 22.7% (SD = 28.6) passive utterances when describing inanimate entities. Using mixed-effects logistic regression (lmer) analysis (Baayen, Davidson & Bates, 2008) using the lme4 package in R (Bates, Maechler & Bolker, 2011), all groups show a significant effect of animacy, such that speakers produced more passive utterances when describing animate entities. These production patterns allow us to test our first predicted difference between adult and child productions. Passive relative clauses are almost non-existent in child-directed speech and rare even in children's literature, so children should produce fewer passive relative clauses than adults. As predicted, we see a linear trend in passive use, with the proportion of passive utterances increasing with age. These findings are summarized in Table 6 and plotted in Figure 4. Despite the fact that linguistic measures of syntactic complexity would consider the object relatives to be the more complex structure, they were not only frequent in children's productions, but more frequent than in adults' productions. This is consistent with an experience-based account of language acquisition and use.

Table 6

Results of mixed-effects logistic model (Jaeger, 2008) structure choice (active or passive) by animacy of the target noun and linear trend of the three age groups investigated.

| | Proportion Passive | | | | Random Slope |
|-----------------|--------------------|------|--------|---------|--------------|
| | Coefficient | SE | z | p | |
| Intercept | 1.63 | 0.37 | 4.40 | < 0.001 | |
| Animacy | -7.02 | 0.61 | -11.43 | < 0.001 | s, i* |
| Trend | -1.06 | 0.39 | -2.69 | < 0.01 | i |
| Trend * Animacy | 0.07 | 0.58 | -0.124 | p < 1 | |

* random slopes were included in the model for animacy by both subjects (s) and items (i).

The animacy by trend interaction is driven by the fact that when describing animate targets, eight year olds produce significantly fewer passive relatives than twelve year olds or adults ($z = 2.01$, $p < 0.05$) and when describing inanimate targets, both eight and twelve year old children produce significantly fewer passive relatives than adults ($z = 3.15$, $p < 0.01$). The first prediction made by the corpus analyses of Experiment 1 is consistent with the observed pattern of productions in Experiment 2. Proportion of passive relative productions increases with the age of the speakers.

Speakers of different ages not only differ in the relative frequency of passive relative utterances, but in the *type* of passive utterance as well. When younger children produce passives, they tend to produce more get-passives (e.g. *The ball that is getting thrown by the man*) while adults tend to produce more be-passives (e.g. *The ball that is being thrown by the man*). This age-related shift from get-passive in the eights year olds to be-passives in the adults is illustrated in Figure 4. There is a significant linear trend, such that the proportion of passives that are be-passives increases with age ($z = 7.55$, $p < 0.001$). Eight year olds produce very few be-passives (20.3%, SD = 34.6 animate; 24.5%, SD = 39.8 inanimate), twelve year olds are more split between get-passives and be-passives (54.7%, SD = 40.6 animate; 77.2%, SD = 39.0 inanimate)

and adults produce mostly be-passives (85.2%, $SD = 23.8$ animate; 97.8%, $SD = 10.4$ inanimate). Further, twelve year olds and adults tend to exhibit an animacy effect, such that they describe inanimate entities with a higher portion of be-passives than animate entities (twelve year olds: $z = 4.73$, $p < 0.001$; adults: $z = 2.41$, $p < 0.05$) and no such effect of animacy was found in eight year olds. This finding is also consistent with the hypothesis that children's productions more closely track the distributions of spoken language. Be-passives are a feature of written language while get-passives tend to occur in the spoken register (Carter & McCarthy, 1999; Collins, 1996), so it is not surprising that as an individual's relative experience with spoken and written language shifts, so do their choice of be-passives and get-passives. It is unclear why twelve year olds and adults might show an animacy effect with their get-passive usage. It is possible that get-passives are used when the subject undergoes either an adversity or benefit because of the event (Hatcher, 1949; Chappell, 1980), and inanimate entities cannot be affected in this way, so they may be used more often with animate subjects. The fact that eight year old children did not show this animacy effect could reflect that they have not yet learned the fine-grained distribution of get and be-passives based on animacy.

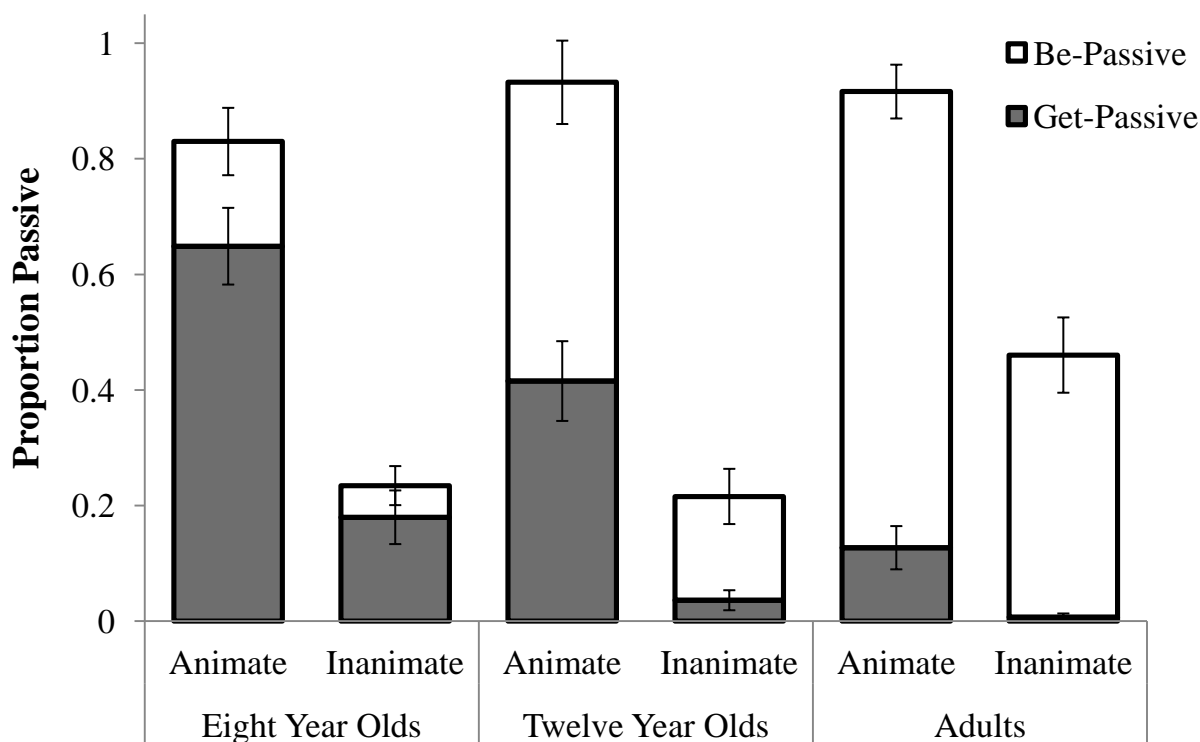


Figure 4: Proportion of passive utterances, by animacy of the target noun for eight year olds, twelve year olds and adults. Total passive utterances are broken down by be-passives or get-passives. The 4 utterances (all twelve year olds) that did not contain either a be or get passive (e.g., *The ball thrown by the man*) are not included in this graph though they are included in all analyses.

The second prediction based on the findings of Experiment 1 is that younger children's productions should be more likely to contain relative pronouns, because relative clauses in spoken language tend to contain relative pronouns more often than those in written language. Indeed, children seem to produce more relative pronouns than adults. First, structure affected relative pronoun use such that all three groups produced more relative pronouns preceding active object relative clauses. There was also a significant linear trend of age group, such that relative pronoun use decreased with age. Animacy of the target entity did not affect relative pronoun use. These results are summarized in Table 7 and plotted in Figure 5.

Table 7

Results of mixed-effects logistic model predicting relative pronoun usage by response structure (active or passive) and linear trend of the three age groups investigated.

| | Relative Pronoun Usage | | | | Random Slope |
|------------------|------------------------|------|-------|---------|--------------|
| | Coefficient | SE | z | p | |
| Intercept | 0.64 | 0.33 | 1.95 | < 0.06 | |
| Response | 3.59 | 0.51 | 7.03 | < 0.001 | s, i |
| Trend | -1.77 | 0.40 | -4.40 | < 0.001 | i |
| Response * Trend | 1.10 | 0.66 | 1.67 | < 0.1 | |

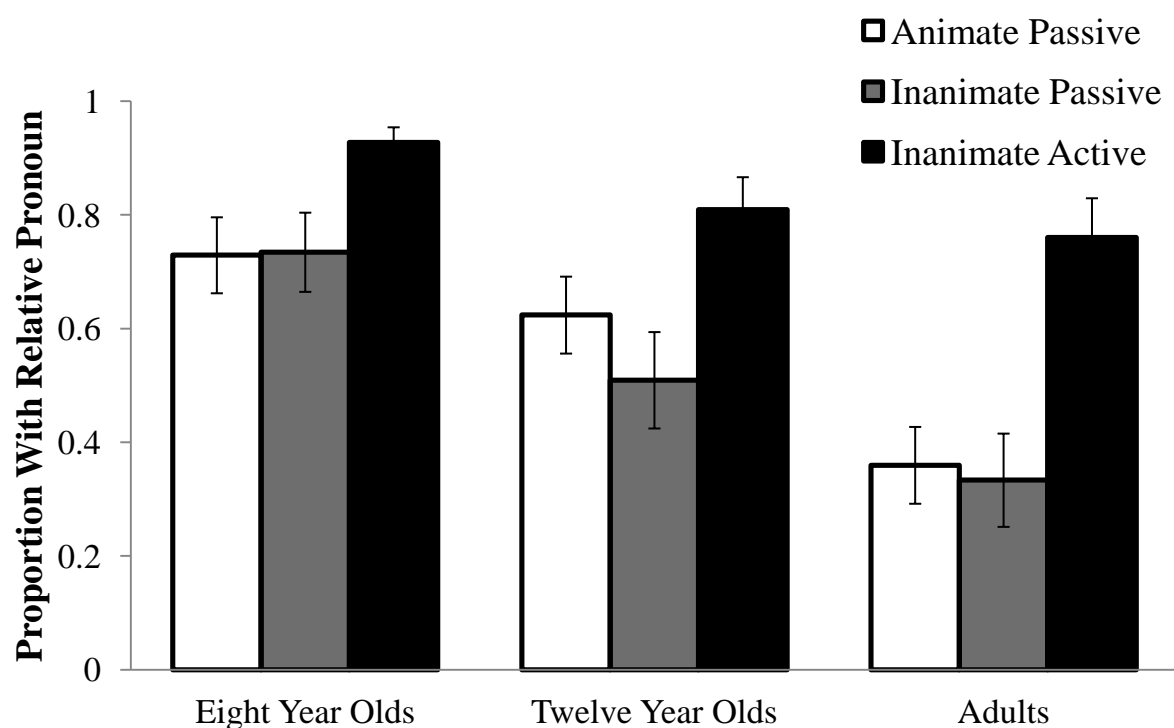


Figure 5: Relative pronoun use by age group, target animacy and structure produced.

There are two potential explanations for why children produce more relative pronouns than adults. The first is that children have more experience with statistics of spoken than written language, and spoken language contains more relative pronouns, so children are merely

reproducing this higher rate of relative pronouns. The second is that relative pronouns can be used strategically to provide speakers with more planning time (Ferreira & Dell, 2000; Race & MacDonald, 2003; Montag & MacDonald, in press), so perhaps children are using relative pronouns strategically and need that extra planning time more because they have less practice with sentence production. The present study cannot distinguish between these two alternatives, but subsequent work that investigated whether young children can use relative pronouns strategically to reduce planning difficulty would begin to answer this question and allow us to interpret this result. One weak indication we have that the youngest children may not be using relative pronouns strategically comes from production patterns of agent-dropping in passive utterances. Eight year olds do not seem to use agent-dropping in passive utterances strategically like adults and twelve year olds do so they may not be using relative pronouns strategically either.

Previous studies using this relative clause production paradigm have found that when producing passive relatives, speakers tend to drop agents more often (e.g., *The ball that was thrown* vs. *The ball that was thrown by the man*) when the entity being described is animate rather than inanimate (Gennari, Mirkovic & MacDonald, 2012; Montag & MacDonald, in press). Further, the reason this pattern of agent-dropping reflects the difficulty associated with planning two similar nouns, because speaker more often drop agents when the head noun is semantically similar to the agent (Gennari, Mirkovic & MacDonald, 2012). Agent dropping may then reflect a choice that speakers make online to make the production process easier. The flexibility of production choices that speakers can strategically use to ease the burden of production planning may not be something that younger children can take advantage of. Perhaps they do not know that specifying agents in passive relative clauses can be dropped strategically to aid in production, or perhaps they are not yet skilled enough producers to take advantage of this flexibility. Indeed,

in a mixed-effects logistic regression, with random slopes and intercepts for both subjects and items, eight year olds do not tend to drop more agents when describing animate targets ($z = -1.15$, $p > 0.2$) though both twelve year olds ($z = 3.68$, $p < 0.001$) and adults ($z = 1.92$, $p = 0.055$) do tend to more often drop agents when describing animate targets (Figure 6). This may reflect the idea that younger children have not yet learned to take advantage of the flexibility of their language to make the production process easier.

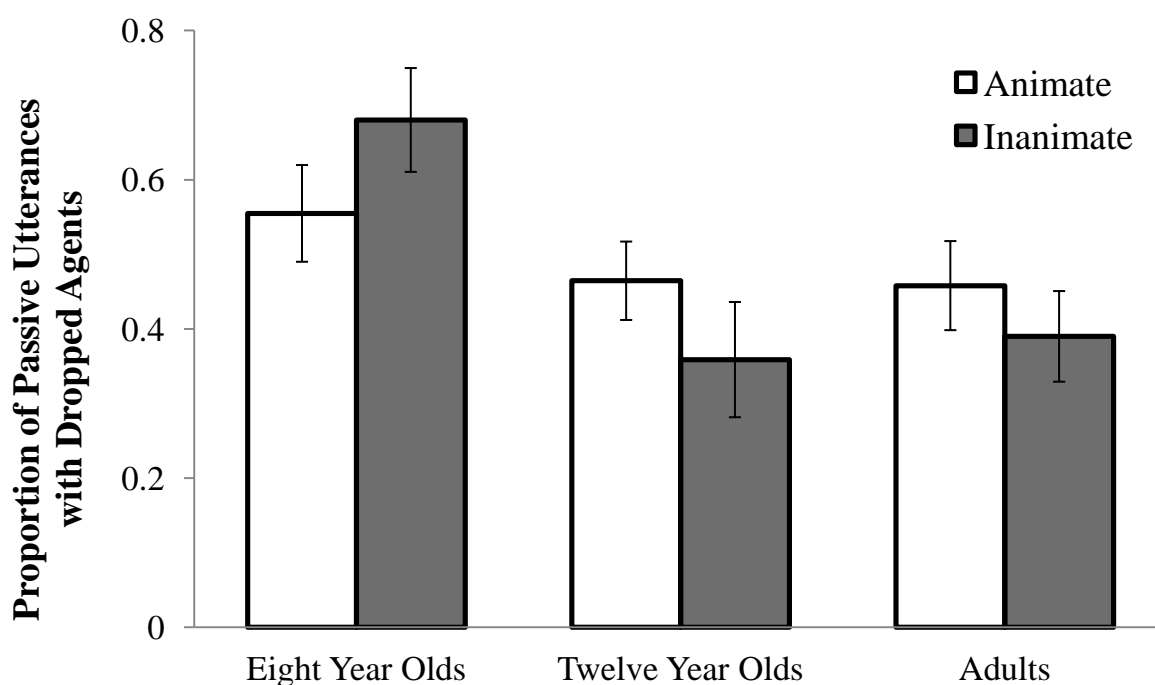


Figure 6: Proportion of passive relative clauses with dropped agents across the three age groups investigated.

Group differences between eight year olds, twelve year olds and adults suggest a number of difference across the developmental trajectory that suggest that increased experience with written language may be driving changes in language behavior across development. Specifically, structure choice and the relative frequencies of get-passives and be-passives are consistent with

increased experience with written language across development. The decrease in relative pronoun use across development may reflect a greater familiarity with patterns of written language, or it, along with rates of agent-dropping in passive utterances may reflect that twelve year olds and adults, but not eight year olds, are able to strategically use language flexibility to ease the cognitive burden of sentence planning. If the emergence of literacy predicts production choices, then in addition to group differences, we would expect that individual who are better readers or have more text exposure should show different patterns of production behavior than poorer readers. These individual differences would provide additional evidence that text exposure may predict production behavior on this task.

Literacy Results

If behavior in this production task is in part predicted by literacy and text exposure, then individual differences in literacy should predict production behavior. While the observed group differences are consistent with the prediction that literacy predicts to speaking behavior, individual differences within a single group would provide particularly convincing experience that literacy or text exposure contributes to production choices in this task.

Both the eight year old and twelve year old children completed identical literacy measures, so all child participants' data was analyzed together. We failed to find any measures that predicted structure choice, though we did find significant predictors of the use of get-passives versus be-passives. Age as well as the parental report of the number of hours the child spends reading each week were both significant predictors of get-passive usage when describing both animate and inanimate targets, and there was an age by reading interaction. This pattern of data is consistent with the hypothesis that as children accumulate more experience with written language, they produce fewer get-passives, which is a feature of spoken language. Older children

produced fewer get-passive than older children (Animate: $t(56) = -3.99, p < 0.001$; Inanimate: $t(31) = -4.55, p < 0.001$) and children who read more hours per week produced fewer get-passives than children who read fewer hours per week (Animate: $t(56) = -2.21, p < 0.05$; Inanimate: $t(31) = -2.26, p < 0.05$), but the nature of the interaction was this was that time spent reading only predicted get-passive usage in the younger group of children (Animate: $t(56) = 2.15, p < 0.05$; Inanimate: $t(31) = 2.04, p = 0.051$). This may reflect the fact that there was less variance in get versus be-passive usage in the twelve-year old children, or it may reflect that parental reports of time spent reading were more reliable in the younger children who have only recently begun reading, so parents have a more accurate measure of their children's reading habits. We unfortunately did not find the score on the title recognition task to be predictive of production choices in children, though we found a significant correlation between age and title recognition score ($r(58) = 0.74, p < 0.001$) which suggests title recognition task may be a slightly less valid measure of text exposure in our sample than simply participant age.

Adults' scores on the author recognition task did significantly predict many production choices. First, adults with higher scores on the author recognition task produced more passive relative utterances when describing inanimate entities ($t(28) = 2.96, p < 0.01$). This is consistent with the finding that passive relatives are more common in written rather than spoken language, so adults who read more should have more experience with these structures and produce them more often. Adults with higher author recognition scores also tended to produce fewer relative pronouns in their passive utterances describing both animate and inanimate targets (Animate: $t(28) = -2.44, p < 0.05$; Inanimate: $t(21) = -2.93, p = 0.001$). This may reflect the fact that adults with greater text exposure have more experience with the relative clauses in written language that are less likely to be preceded by relative pronouns, or it could reflect that adults who read

more will be better sentence producers and are less likely to need relative pronouns to give themselves extra planning time in this online task.

These individual differences are consistent with the group differences data, as individuals with more reading experience tend to exhibit production choices more like the patterns found in spoken language, than do individuals with less reading experience. This suggests that literacy may be a contributing factor to adult-like language production, and to our knowledge is the first study to explicitly investigate the effect of literacy on spoken production choices. Additional studies are necessary to confirm that literacy is the causal variable that accounts for the group and individual differences in production choices. It is possible that the more literate children also have more literate parents, so their greater proportion of passive relative clauses does not stem from their text exposure, but the greater proportion of passive relative clauses in their parents' speech. There are many other differences in experience that might be comorbid with text exposure, so future studies are necessary to identify exactly which difference between individuals with more and individuals with less text exposure actually affect production choices.

Discussion We in fact see that adult and child group differences and individual differences are consistent with differences between written and spoken language. Across the developmental trajectory, older speakers and speakers with more text exposure tend to make production choices more similar to those of written language than speaker with less exposure. This is consistent with experience-based accounts of language and suggests that individuals are sensitive to even fine-grained patterns in their linguistic environments, to the extent that the subtly different patterns in written and spoken language affect speaker's productions. This is also evidence of transfer effects between the spoken and written domains. To some extent, statistics encountered in one domain are counted along with statistics in the other domain. Not only does this shed

insight into the learning mechanisms that underlie language behavior, but it provides further evidence that language abilities are driven by experience alone, as accounting for developmental and individual differences with text exposure leaves even less variability in language abilities that might be accounted for by innate constraints on language abilities.

There is also some evidence that the youngest speakers have not yet learned to take advantage of flexibility in language to make the production process easier. This is a topic that merits more research. Some language choices are made to make the production process easier while some are made to adhere to learned patterns in the language. Understanding the emergence of these two different production choices will shed light both on the production mechanisms themselves, and the type and timescale of learning that contributes to adult-like language abilities.

General Discussion

In Experiment 1, we performed corpus analyses of object and passive relative clauses in child-directed spoken and written corpora. Experiment 1a investigated the frequencies and distributions of various types of object and passive relative clauses in written materials intended for children and Experiment 1b investigated the frequencies and distributions of those same structures in child-directed speech. In Experiment 2, we investigated production choices of object or passive relative clauses in a picture description task, with eight and twelve year olds, and adults. We found that the systematic differences between written and spoken child-directed and adult-directed language predicted some of the variability in production choices made by participants of different ages. We found a linear trend such that older participants produced more passive relatives and more be-passives, both which tend to be features of written language. We also found that older participants produced fewer relative pronouns (e.g., *that*, *who*) that

younger children, which is consistent with differences between written and spoken language, but also consistent with the explanation that younger children either need to strategically use relative pronouns more often than older children and adults, or are may not be using relative pronouns strategically. The idea that younger children are not using relative pronouns strategically is consistent with the finding that twelve year olds and adults, but not eight year olds strategically drop agents when uttering passive relative clauses with animate head nouns, where there is more semantic interference between nouns than when the head noun is inanimate. These findings are consistent with the idea that the emergence of literacy affects spoken language development. We see a further evidence for a possible influence of reading experience on production choices when investigating individual difference in text exposure. Among children, age and number of hours spent read a week predict production choices and in adults, text exposure, as measured with an author recognition task, predict production choices. This suggests that not only are there transfer effects between patterns of language that an individual encounters in spoken and written language, but that sentence production abilities are measurable different in high and low literacy individuals, as measured by age differences across development and with an individual's reading habits.

This study presents a number of important findings. First, it shows that the domains of spoken and written language may not be independent systems and experience in both domains contributes to linguistic behavior. This is important for a number of reasons. First, it highlights the differences between the statistics of written and spoken language, and suggests that learning theories of language must take into account the fact that literate individual encounter two qualitatively different sets of language statistics. It is worth noting that the present corpus analysis ignores potential differences between statistics of different genres of written corpora. It

is possible that the relative frequencies and types of complex structures may vary between fiction and newspaper articles. This seems likely given the data of Roland, Dick and Elman (2007). A challenge to researchers who wish to use corpus data to predict language behavior is to use the correct corpus to predict that data, as using the wrong corpus may blur the relationship between linguistic experience and behavior.

A second reason that this finding is important is that it suggests a significant amount of knowledge transfer between the written and spoken language domains. The extent of this transfer is an interesting empirical question. Is it possible to create a task in which participants make different predictions depending on whether the task required them to listen or read language? The fact that some transfer occurs does not necessarily mean that the written or spoken context of language is completely obscured to individuals. Understanding the learning mechanisms of language, the knowledge that comprises language and how this knowledge is stored in the brain may all benefit from understanding what sort of language transfer occurs across linguistic contexts.

A final reason that the finding that both written and spoken language experience affect language behavior is important is that it may help us reconsider what language is. The present study suggests that language behavior can be closely predicted through experience an individual has likely encountered, and considering the dual contributions of written and spoken language experience leaves even less variability that could be accounted for by innate restriction of language abilities or a competence grammar. A related conclusion is the blurred line between child language acquisition and adult language use. There does not seem to be a “final adult state” that all individuals approach as they either age, or gain experience. Rather, behavior seems to reflect experience, and even among adults, more experience with written language predicts

different patterns of behavior. This is consistent with training studies of adults (Wells, Christiansen, Race, Acheson & MacDonald, 2009) that suggest that language behavior changes with experience, well into adulthood. Crucially, the evidence suggests that the changes between early and late childhood is mechanistically similar to the changes throughout adulthood. In all cases, increased text exposure predicts a pattern of production choices that more resembles patterns of written language. There is no evidence that at some age, linguistic competence is attained, but rather language behavior changes in accordance with linguist experience throughout the lifetime. This also emphasized the importance of literacy in literate societies. If effects of literacy are measurable even in spoken language, the consequences of low literacy are more vast and ubiquitous than might have been initially thought.

The present study provided evidence that production choices across the developmental trajectory can be account for by experience with spoken, and once a child learns how to read, written language. This suggests that language knowledge consists of fine-grained learning of the statistics in one's environment. There are a number of questions raised by this study that still cannot be answered. One is the role of linguistic experience that children receive though being read to by caregivers. If the distribution of relative clauses in the sorts of books that parents read to very young children are more similar to those of the sorts of books children read to themselves once they learn how to read, then the linguistic experience that young children receive by being read to could significantly affect language development, well before children learn to read themselves. Subsequent work investigating the contribution of books read to children long before literacy emerges could provide further insight into the developmental trajectory of word and sentence acquisition. Second, based on the data present in this study, we cannot draw any conclusions about how children learn to use language flexibly to alleviate production difficulty.

Presumably children must learn which features of language can be used strategically to make production easier, and the emergence of this strategic language use is not at all understood. Understanding how this production ability develops is crucial for our understanding of how children learn to produce language, and what adults must have learned to exhibit the behavior they do. Despite these unanswered questions, this study is the first step toward understanding production choices in late childhood and furthers our understanding of how linguistic experience shapes language abilities.

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Appendix A

Below is a list of book titles. Some of them are the names of real books and some are not. Please put a check mark next to the one that you know for sure are real books. There is a penalty for guessing, so you should check only the names you know for sure are real books.

- | | |
|---|--|
| <input type="checkbox"/> The Giver | <input type="checkbox"/> Number the Days |
| <input type="checkbox"/> The Last Shoe | <input type="checkbox"/> Bunnicula Strikes Again! |
| <input type="checkbox"/> The Phantom Tollbooth | <input type="checkbox"/> Wringer |
| <input type="checkbox"/> Esperanza Rising | <input type="checkbox"/> From the Mixed-Up Files of Mrs. Basil E. Frankweiler |
| <input type="checkbox"/> The Rollaway | <input type="checkbox"/> The Schoolhouse |
| <input type="checkbox"/> Walk Two Moons | <input type="checkbox"/> It's My Room |
| <input type="checkbox"/> Don't Go Away | <input type="checkbox"/> Sarah Jones and the Giant Spiders |
| <input type="checkbox"/> Hot Top | <input type="checkbox"/> Stellaluna |
| <input type="checkbox"/> The Moon Over the High Street | <input type="checkbox"/> Animal Farm |
| <input type="checkbox"/> To Kill a Mocking Bird | <input type="checkbox"/> Tales of a Fourth Grade Nothing |
| <input type="checkbox"/> The BFG | <input type="checkbox"/> The Hideaway |
| <input type="checkbox"/> He's Your Little Brother! | <input type="checkbox"/> Year of the Yellow Daisies |
| <input type="checkbox"/> Encyclopedia Brown, Boy Detective | <input type="checkbox"/> Sarah, Plain and Tall |
| <input type="checkbox"/> Hatchet | <input type="checkbox"/> Don't Let Clouds Get You Down |
| <input type="checkbox"/> Sadie Goes to Hollywood | <input type="checkbox"/> Poppleton in Winter |
| <input type="checkbox"/> Skateboard | <input type="checkbox"/> A Wrinkle in Time |
| <input type="checkbox"/> The House of the Scorpion | <input type="checkbox"/> Thank You, Mr. Falker |
| <input type="checkbox"/> Flat Stanley | <input type="checkbox"/> Sideways Stories From Wayside School |
| <input type="checkbox"/> Faith, Hope and Ivy June | <input type="checkbox"/> Curious Jim |
| <input type="checkbox"/> The Missing Letter | <input type="checkbox"/> A Year Down Yonder |
| <input type="checkbox"/> My Father's Dragon | <input type="checkbox"/> Uglies |
| <input type="checkbox"/> Wicked Witches Don't Win | <input type="checkbox"/> The Long Drought |
| <input type="checkbox"/> Frindle | <input type="checkbox"/> Roll of Thunder, Hear My Cry |
| <input type="checkbox"/> Island of the Blue Dolphins | <input type="checkbox"/> Junie B Jones Smells Something Fishy |
| <input type="checkbox"/> Joanne | <input type="checkbox"/> How I Lost My Dog |

Appendix B

Below are the search terms entered into COCA to retrieve all object and passive relative clause candidates.

[VERBLIST] refers to the following items:

[vd*]

[be] → was|is|'s|be|are|were|been|'m|'re|am|being

[have]

[100 most frequent verbs in each part of speech code not listed above]

| | | |
|-------------------|--|---|
| Passive Relatives | With Relative Pronouns | No Relative Pronouns |
| | [get] [vvn] Was [vvn] is [vvn] 's [vvn] Be [vvn] Are [vvn] Were [vvn] Been [vvn] 'm 're [vvn] am being [vvn] | [n*] [vvn] [50 most frequent prepositions] [n*] [VERBLIST] Missing Object modifying Passive Relatives [VERBLIST] [n*] [vvn] [VERBLIST] [a*] [n*] [vvn] [VERBLIST] [d*] [n*] [vvn] [VERBLIST] [p*] [vvn] |
| Object Relatives | With Relative Pronouns | |
| | [n*] that who whom which [n*] [n*] that who whom which [a*] [n*] that who whom which [p*] [n*] that who whom which [d*] | |
| | No Relative Pronouns | |
| | Embedded Full NP | With Embedded Pronouns |
| | <i>articles</i> [n*] his her my your their our its thy yer thine [n*] the [n*] [v*] [VERB LIST] [n*] a [n*] an no every <i>determiners</i> [n*] [da*] [n*] [db*] [n*] [dd] | [n*] [pn1] [n*] [pnqv] [n*] [pnx1] [n*] [pph1] [n*] [pphs1] [n*] he [n*] she [n*] he/she [n*] [pphs2] [n*] [ppis1] |

| | | |
|--|---|--|
| | <p>[n*] [dd1] [n*] [dd2] <i>nouns</i> [n*] [nn] [VERB LIST] [n*] [nn2] [VERB LIST] [n*] [np1] [VERB LIST] [n*] [nna] [n*] [nnb] [n*] [nn?2] [n*] [np2] [n*] [npd*] [n*] [npm*]</p> | <p>[n*] [ppis2] [n*] [ppy]</p> |
| | | <p>Missing object-modifying ORCs [VERBLIST] [n*] the [n*] [v*] [VERBLIST] [a*] [n*] the [n*] [v*] [VERBLIST] [d*] [n*] the [n*] [v*] [VERBLIST] [p*] the [n*] [v*]</p> |

Appendix C

Frequency, per million NPs of relative clauses in COCA juvenile literature and CHILDES.

| | | Embedded Noun | Animate Head Noun | | Inanimate Head Noun | |
|---------------|------------------|-------------------|-----------------------|------------------|-----------------------|------------------|
| | | | With Relative Pronoun | Reduced Relative | With Relative Pronoun | Reduced Relative |
| COCA-Juvenile | Object Relative | Animate Pronoun | 86.55 | 1203.54 | 841.13 | 6050.17 |
| | | Animate Full NP | 10.82 | 29.75 | 162.28 | 354.30 |
| | | Inanimate Pronoun | 5.41 | 5.41 | 5.41 | 62.21 |
| | | Inanimate Full NP | 0.00 | 5.41 | 40.57 | 62.21 |
| | Passive Relative | No Agent | 89.25 | 435.44 | 256.94 | 2085.24 |
| | | Agent Specified | 8.11 | 45.98 | 37.86 | 400.28 |
| CHILDES | Object Relative | Animate Pronoun | 14.72 | 103.04 | 353.27 | 1349.30 |
| | | Animate Full NP | 0.00 | 0.00 | 9.81 | 19.63 |
| | | Inanimate Pronoun | 0.00 | 0.00 | 4.91 | 9.81 |
| | | Inanimate Full NP | 0.00 | 0.00 | 14.72 | 9.81 |
| | Passive Relative | No Agent | 4.91 | 0.00 | 4.91 | 9.81 |
| | | Agent | 0.00 | 0.00 | 0.00 | 0.00 |

Frequency of relative clause types in children's literature and child-directed speech per million NPs

Conclusion

The three studies of this dissertation investigate factors that motivate sentence production choices. In these studies, I used a picture-description task to elicit utterances that contained either object relative or passive relative clauses. I used an almost identical task in three populations: In English, as a function of the visual environment, cross linguistically and across development, in order to better understand the factors that motivate production choices by comparing the similarities and differences across production choices in these three populations. The findings have implications for the knowledge and processes that underlie human sentence production abilities.

Chapter 1 investigated production choices in English as a function of the visual environment. I found that aspects of the intended message to be conveyed have effects on the produced sentence structure. Visual properties of the scene in which the target item appeared, in conjunction with the linguistic context of a question and answering task subtly affects the sentence structure of the produced utterance. When the goal of the speaker was to contrast the target entity from competitors, rather than simply describe it, speakers produced more passive relative utterances. This goal of contrast was more central to the message when the target entity was animate, as the very salience human entities are inherently contrasted from their salient competitors or when the target entity was a less-salient inanimate entity, as the increased visual search time brought the speaker's attention to the competitors in the scene, precipitating the more contrastive focus of the message. This suggests that subtle properties of the linguistic and visual environment can systematically affect production choices. In Chapter 2, I investigated structure choices in an identical task across three languages: English, Japanese and Korean. I found that speakers of all languages showed similar effects of animacy, in that speakers produced a greater

proportion of passive relatives when describing animate than inanimate target entities. Crucially, language typology did not predict structure choices. English and Japanese speakers produced significantly more passive relatives than Korean speakers, despite the identical typology between Japanese and Korean in the constructions investigated here. This suggests that idiosyncratic patterns within a language, that are not predictable based on language typology, affect production choices. Finally, Chapter 3 investigated structure choice across development, comparing adult production choices to those of eight and twelve year old children. In two corpus analyses, I showed that child-directed speech and literature have very different distributions of object and passive relative clauses. Production choices tracked experience with the written distributions, as both age and text exposure predict utterance choices that more closely resemble the distributions in written material. This suggests that even well into adolescence, children do not exhibit adult-like production choices, and experience with written language may be an important factor that brings about adult-like language use. These results also emphasize the importance of linguistic experience in language abilities, as variation between age groups could be accounted for with linguistic experience, especially text exposure. By comparing results across these three studies, we can better understand the motivations of production choices during sentence production.

The data of these studies suggest that there are multiple factors that contribute to production choices, and many of these choices stem from producers making choices to ease the demands of the production process. A word or phrase may be difficult because of the immediate context or it may be difficult because it's an infrequent behavior (production plan) that is thus poorly rehearsed and difficult to execute. There are many examples of both these types of production difficulty in the studies presented in this dissertation.

In Chapter 1, I find evidence of many production choices that have previously been implicated as a strategy to reduce production difficulty. Speakers exhibit longer initiation latency to produce the less-accessible inanimate nouns (F. Ferreira, 1994; McDonald, Bock & Kelly, 1993) and speakers seem to strategically use relative pronouns when the upcoming relative clause is longer (Jaeger, 2005; Race & MacDonald, 2003). These results suggest that as production gets more difficult in the moment, either because a word is particularly hard to recall from long-term memory or because a very long phrase needs to be planned and produced very quickly, speaker can make choices to alleviate these pressures and maintain fluency. Speakers can stall to give themselves more planning time, with either longer initiation latencies or with an optional word. I report another production choice that is a consequence of in-the-moment production difficulty in Chapter 2. Speakers of English and Japanese (the languages in which this analysis was possible) more often drop agents (e.g. *The man being hugged* vs. *The man being hugged by the girl*) when the head noun is animate than inanimate, which is evidence of the production difficulty associated with planning two semantically similar nouns (Gennari, Mirkovic & MacDonald, 2012). Again, this is evidence that speakers can take advantage of the flexibility afforded them in their production alternatives to ease the burden of sentence production. Finally, in Chapter 3, I showed that it takes children years to learn how to use the flexibility afforded by their language to aid in the production process. I found that only twelve year old children and adults could strategically use agent-dropping to aid in production planning. This makes sense, as it takes children a long time to learn what flexibility in language can be used strategically, and what dramatically alters the meaning of an utterance. In addition, while adult speakers seem to be able to strategically use relative pronouns or drop agents when sentence planning becomes more difficult, it is unclear if younger children are able to use

relative pronouns strategically as do adults. Younger children do tend to use more relative pronouns, but this may reflect that a larger proportion of younger children's language experience comes from statistics in the spoken domain, where relative pronouns are more frequent. Previous research suggests that children have to learn how to use disfluencies such as "um" and "uh" in an adult-like manner (Hudson Kam & Edwards, 2008) so they likely also have to learn how to use relative pronouns strategically, as adults do. Future work investigating how children learn which features of language can be used flexibly to alleviate production difficulty, and how to make those choices quickly to reap those production benefits would be a valuable contribution to the understanding of how adults can take advantage of flexibility in language to ease production difficulty. Findings that relate to the difficulty of online sentence production are crucial to viewing sentence production as a difficult endeavor, and approaching the study of sentence production with the view that alleviating this production difficulty figures prominently into the choices that speakers make (MacDonald, 2013). Beyond relative pronoun use and agent dropping in relative pronouns, future work investigating other production choices that speakers make to alleviate production difficulty, and how those abilities are learned, would be a key finding that would aid the understanding of production mechanisms.

Throughout this dissertation, I also report many instances in which the ease with which an utterance is produced derived from long-term learning across the lifetime. On the view that language production is analogous to any other motor behavior, that must be planned and executed, a production plan can be easy either because it frequent, and thus well-rehearsed by the speaker. In Chapter 1, speakers make choices based on even subtle differences in the visual environment of the scene that they are describing. This finding introduces interesting questions about the roles of both ease of production and message-related factors that contribute to

production choices. These could be competing factors, and speakers must reconcile ease of production with loyalty to a message when producing a sentence. An alternate hypothesis is that message factors contribute to ease or difficulty with which an utterance can be produced. Context and discourse factors certainly contribute to production choices, for example speakers tend to produce given nouns in more prominent sentence positions than new nouns (Bock & Irwin, 1980; V. Ferreira & Yoshita, 2003; Prat-Sala & Branigan, 2000), suggesting that in many cases, the same context that makes a noun the topic of the sentence is also the context that makes the noun more accessible and thus easy to produce. Message-related factors may also contribute to structure choice via ease of production by allowing speakers to re-use well rehearsed message plans. Once speakers decide on the focal entity of their utterance, they can conform to what they have done in the past to mark that prominent entity. Future production work that investigates how speakers converge on a message, and how that message affects, or interacts with, production difficulty will be very informative of production choices that speakers make. This question is also discussed at length in Chapters 2 and 3 of this dissertation, as it is a fundamental, and yet still unanswered question in sentence production.

In Chapter 2, I report production choices in the same relative clause production task as in Chapter 1, repeated in three languages: English, Japanese and Korean. In addition, I report utterance choice in a main clause production task, and show that production choices in main clauses predict production choices in relative clauses. This can be interpreted as another example of well-rehearsed production plans being easier to produce. If passives are common in a language, then speakers of that language are well practiced in comprehending and producing those sentences, so it may be easier to produce a passive in a subsequent utterance. Language typology is not necessarily the best predictor of relative accessibilities of structure choices, but

rather idiosyncratic patterns of structure frequency within a language. Of course, language typology affected the sentence alternatives available to the speakers, as Japanese speakers produced causative sentences that are not available to English speakers. Indeed, other work (Chang, 2009; Christianson & Ferreira, 2005) suggests that language typology is an important predictor of the availability and relative difficulty of structure choices. Cross linguistic studies provide a unique arena in which various aspects of sentence production can be dissociated, including word order, typology and structure frequency. All of these factors affect production choices, but it is not yet clear how and why, so the ability to investigate these components separately can be informative. Future investigations into features that universally make language production difficult, like simultaneously planning two semantically similar nouns, or difficult in some situations, like a passive in a language (or a context) in which the passive is infrequent, will help us understand the sources of difficulty in sentence production, and help us better understand why speakers make the choices they do.

Chapter 3 is another clear example of learning over the lifetime contributing to the ease or difficulty of particular sentence structures. I show that familiarity with the passive relative, which I show is more common in child-directed written than in spoken language, as measured with age and text exposure, predicts production choices across three age groups and within individuals in a single group. Again, this suggests that the frequency with which a structure is encountered predicted the frequency with which it is produced. Besides implications for structure frequency and ease of production, this finding has implications for the nature of language experience. Text exposure and literacy are rarely implicated in studies of language acquisition, and corpus analyses rarely distinguish between the statistics of written versus spoken corpora, despite the fact that that distributions of sentence structures can vary wildly between

written and spoken corpora. Chapter 3 suggests that speakers are indeed sensitive to the varying statistical distributions between written and spoken language, and the amount of exposure an individual has to written language predicts some production choices. It is still unclear by what mechanism these experience with patterns over the lifetime affect production choices. In some way, experience with comprehending a structure must make it easier to produce that structure, as speaker's production choices do track their experience with linguistic patterns during language comprehension. This has interesting implications for the knowledge that underlies human language abilities, and the storage and overlap of knowledge employed by language production and comprehension, and how that knowledge may or may not be independent from the procedural planning and motor processes that characterize language production.

The three studies presented here can be interpreted as suggesting that speakers make production choices to alleviate production difficulty. Speakers can employ pauses or optional words (relative pronouns, agents) to give themselves more time to plan an upcoming utterance when the planning gets difficult. Speakers also adhere to well-rehearsed production plans. Speakers will avoid rare structures as they are hard to plan. Whether passives are rare because you are a Korean speaker and passives are overall rare in your language, or because you are eight years old and have not come across many passives because they are largely a feature of written language, you will avoid passives because they are poorly rehearsed and difficult to execute. Investigations into the knowledge and processes that underlie sentence production abilities may be underrepresented in the field of psycholinguistics but they are important not only to understand what exactly an individual is doing when they produce language, but may have implications for understanding other language behaviors. Audience design (Brennan & Clark, 1996; Pickering & Garrod, 2004) or uniform information density (Jaeger, 2010) approaches to

language use suggest that understanding production choices *is not relevant* to understanding why speakers make the choices that they do. For this reason a discussion of production difficulty, both the notion of production being a difficult behavior in general, but also about individual situations, experiences or language-specific factors that make production more or less difficult in a specific context, have not featured prominently into much of the sentence production literature. The studies in this dissertation suggest that these production choices that may stem from difficulty faces by the speaker, are in fact important for understanding why speakers make the choices they do, and ultimately, why languages exhibit the patterns they do. If, in accordance with the PDC framework (MacDonald, 2013), we can understand distributional patterns of language through the understanding of production choices, then understanding sentence production is an important complement to the investigation of learning mechanisms that underlie sentence comprehension behavior.

Beyond language production, the studies in this dissertation have implications for language more generally, both what it is and how it is learned. Specifically, the studies described here make strong associationist claims about the knowledge that underlie language abilities. Production choices made by speakers in the three tasks in this dissertation suggest that speakers learn fine-grained information about linguistic patterns in their language, and apply these patterns when producing sentences. At some level this is obvious. Speakers have to learn if their language has SOV or SVO word order, and then produce sentences that adhere to the word order of their language. More remarkable is the very fine grain sizes at which speakers seem to learn patterns of word order to meaning mapping in their language. A clear example of fine-grained learning of language statistics affecting production choices comes from Chapter 1. These findings suggest that even subtle visual properties of visual scenes can affect the message

that speakers wish to convey, and have systematic effects on structure choice. This suggests very fine-grained learning on the part of the speaker. It would have been interesting to investigate the effect of these subtle visual properties on production choices in other languages or across development, would be very interesting, but a large enough sample size to test these effects was not feasible in the current studies. The extent to which these same structure-to-meaning mappings exist in other languages would help tease apart language specific or general cognitive mechanisms that might be responsible for these production choices. Further, the emergence of these fine-grained patterns in children's speech would suggest the types of patterns that children learn at various stages across the developmental trajectory.

Another interesting example of learning contributing to structure choices comes from Chapter 2, in which production patterns of main clause utterances in a language predict patterns of productions in relative clause utterances. This suggests that patterns that language users learn about the usage and distribution of one structure have consequences for the use of an entirely different, but similar, structure. This is evidence for knowledge transfer effects at the structure level, which is consistent with an experience-based approach to language production and not compatible with a generative approach to language production. Subsequent research on transfer effects, or rather, on the extent to which priming occurs and the structure types over which priming occurs at the structural level, would continue to support an experience-based approach to language use, and provide additional information about the sorts of patterns that speakers learn when they learn a language.

Finally, Chapter 3 suggests that the learning that underlies language abilities continues well into childhood and adolescence and probably throughout the lifetime, as text exposure was a predictor of structure choice not just in children but also for adults. A consequence is that there

is no clear boundary between language acquisition and adult language use, so the learning mechanisms that continue to affect adult language use well into adulthood are the same learning mechanisms that children use to learn language. This is incompatible with a critical period view of language (Lenneberg, 1967), in which the learning mechanisms of language acquisition in children are different than the learning mechanisms adults employ and instead suggests that similar learning mechanisms are responsible for both child language acquisition and experience-related changes in adult language use.

This is also the first study to implicate the emergence of literacy as a possible predictor of adult-like language behavior across language development. This might suggest that some structural processing gains observed later in childhood (Maratsos, Fox, Becker & Chalkley, 1985) may not stem from increased working memory capabilities associated with maturity, but rather a qualitative shift in linguistic experience that is a consequence of literacy. This has consequences for the role of memory in language processing and whether what manifests as verbal working memory can ever be dissociated from language experience (Acheson & MacDonald, 2009). Practically, this is further evidence of the importance of literacy within a literate society. Low-literacy individuals not only struggle with reading and writing, but may also struggle with comprehension and production of spoken language. This would suggest that the consequences of low-literacy or illiteracy in a literate society have far reaching consequences beyond the obvious reading and writing. More optimistically, quantifying differences between written and spoken language may help writing teachers give better instruction when teaching students to become skilled writers. Quantifying difference between spoken and written language would also help develop materials for individuals who are struggling with reading. If we know

what types of sentences are unique to written materials, we can provide struggling readers with additional training with those sentence types.

This dissertation contributes new knowledge to the study of sentence production. Many approaches to sentence production downplay the importance of production difficulty when investigating why speakers make the choices they do. If choices are made based on innate, linguistic rules (Jackendoff, 2002; Pinker, 1984) or to aid comprehension on the part of the listener (Brennan & Clark, 1996; Jaeger, 2010; Pickering & Garrod, 2004) then demands on the speakers are not immediately pertinent to production choices. Other theories of language use, such as the PDC (MacDonald, 2013) suggest that production difficulty, and the constraints it places on the speaker are the major driver of production choices and thus largely responsible for the observed distributions in the linguistic environment. This dissertation attempts to understand the loci of this production difficulty, and what speakers do to alleviate this difficulty. By investigating sentence production as a complex behavior that must be planned and executed, we can better understand the processes that comprise sentence production behavior, and the knowledge that speakers have accumulated over their lifetime that they use to produce language.

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