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Producing a message of comparison: Evidence of relational schemas in speech production

by

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Abstract

Four speech production experiments were conducted to examine how adults produce preverbal messages involving comparisons. It was argued that the generation of any message involving a comparison involves three decisions. First, a dimension for the comparison must be selected. Second, a contrasting object for this dimension must be selected. Third, a referent must be selected for the contrasting object. Participants were shown three objects on a computer screen and were asked to compare two objects along the dimensions of size (Experiments 1 and 2) or hue (Experiments 3 and 4). For example, a participant might be asked to compare the size of a medium-sized snake to either a small fish or a large bird. With each comparison, participants produced a noun (fish, bird) and an adjective (bigger, smaller) that could be repeated or switched from one trial to another.

Experiment 1 showed a large tendency to repeat nouns, suggesting that speakers were repeating referents. Experiment 2, however, showed a large tendency to repeat comparisons to objects of the same size, suggesting that speakers were repeating contrasting objects not referents. Experiments 3 and 4 showed that the repetition effect disappeared after one filler trial. This suggested that decisions were made in short-term working memory.

It was concluded that these three decisions are both necessary and sufficient for the generation of a preverbal message involving any comparison.

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Chapter 1. Introduction

How do we know what to say when we speak? At first the answer seems obvious: we choose those words that best express the ideas we want to communicate. But this answer is naïve because it assumes that there is a transparent mapping between thought and speech, something that Bock (1996, p. 396) has called the "mind in the mouth" assumption. In reality, a number of processes are required to compute different aspects of even the simplest of utterances (e.g., the syntactic structure, the ordering of words and phrases, the morphological properties of words, the stress patterns within and across words). Complicating this is the fact that there is often more than one syntactic frame, more than one possible word order, and more than one word that can be used to express the same message. Suppose for example, that a speaker saw a policeman giving his friend a parking ticket and he wanted to alert his friend to this fact. He might say something like, "Is that cop giving you a ticket over there?" In producing this utterance the speaker had to have decided to use: a question not an assertion, the noun "cop" and not "policeman," and that the phrase "over there" will follow "ticket" and not "cop." For each of the aforementioned choices there were acceptable alternatives, which had they been made, would have resulted in a different sentence (e.g., "A policeman over there is giving you a ticket," "Are you getting a ticket from a policeman?" "What's that guy doing over there?"). So, an important part of speaking involves choosing what structures to use. If we as researchers wish to understand how speech is produced, we must understand not

only what structures are involved in producing speech (what syntactic frames can be used, what word options exist) but also how the production system chooses one particular structure over its alternatives.

Of all the processes involved in constructing utterances, one group of processes about which very little is known is how preverbal messages are constructed. While much speculation has been made about what preverbal messages are and how they are constructed, very little empirical work has actually been conducted. Yet, the purpose of speaking is to communicate ideas. As such, understanding how preverbal messages are created brings us closer to understanding the very purpose of speaking. Thus, advancing this area of research is important. In this dissertation, I examine the structure of one kind of preverbal message and how this structure influences the description of a simple visual scene.

Before describing the experiments of this dissertation in detail, it will be important to have a clear understanding of three things: preverbal messages, repetition effects in speech production, and propositions. In Chapter 2, I will describe in a general way what preverbal messages are and the processes that go into their construction. I will explain how preverbal message relate to other stages in speech production. I will also show that there is a lot of choice involved in creating preverbal messages specifically, and speech more generally. An important function of the speech production system is, therefore, to make choices. I will be using repetition effects to study preverbal messages, so it will be important to understand what repetition is and how it has been studied in the past.

In Chapter 3, I will review some of the repetition effects that have been found in speech production. I will make a distinction between "repetition effects" and "repetition priming." I will then explain how repetition effects have been used to identify and study different structures involved in speech production. Chapter 4 will deal with two important elements of preverbal messages: referents and relations. I will explain why they are so important to the structure of preverbal messages. I will use propositions as a way of referring to these entities, so it will be important to explain what this notational system is, and how it relates to the concepts of referents and relations in preverbal messages, and how it can be used to ask interesting questions about speech production.

In Chapters 5 through 8, across four experiments, I will show several things about preverbal messages. First, I will show that speakers create abstract mental representations of relationships they have been asked to describe and that these representations guide the construction of preverbal messages. Second, I will show that speakers have a strong tendency to repeat these representations across successive utterances. I will provide evidence that this repetition effect cannot be attributed to other well-known priming effects such as lexical, semantic, or syntactic priming. Third, I will show that this repetition effect is short-lived, disappearing after one intervening trial.

In Chapter 9, I will explain what these representations are and how they are used to create messages. I will suggest some ways that these structures might be used in other situations and why. I will also explain why speakers tend to repeat these structures and why this tendency is short-lived. This chapter will end

with general comments about the significance that the present findings have for theories of speech production, some advantages and limitations of the methods that have been used in this dissertation, followed by suggestions for future research.

Chapter 2. Speech and the Production of Messages

This chapter concerns how messages are expressed through speech. It will begin with a definition of preverbal message, followed by a description of the processes that go into creating one. This review will show that there are many choices available with respect to how an intention is transformed into a preverbal message. This is true not only of preverbal messages but of other stages in speech production, suggesting that this is a general feature of production. This also means that the production system must have some way, or ways, of selecting which structures to use.

Formulating Preverbal Messages

It is commonly believed that speech production comprises at least three distinct stages (e.g., Bock, 1982, 1986; Dell, 1986; Garrett, 1975, 1988; Kempen, 1978; Kempen & Hoenkamp, 1987; Levelt, 1983, 1989; Stemberger, 1985). These stages are: conceptual formulation, linguistic encoding, and articulation. During each stage, a different type of representation of the to-be-uttered sentence is constructed. During conceptual formulation, a semantic representation of the message the speaker wishes to express is constructed. During linguistic encoding, a syntactic frame containing the words, inflections, and phonological forms of each word is constructed. Finally, during articulation, the phonetic plan created during linguistic encoding is executed by the musculature of the respiratory, laryngeal, and supralaryngeal systems.

The goal of the first stage of production is the creation of a preverbal

message. A preverbal message is a non-linguistic, semantic representation of the thoughts that the speaker wishes to express. It consists of a number of propositions containing lexical concepts that are available for linguistic encoding. In this way, a preverbal message is an important link between thought and language.

A speaker begins the production of a preverbal message by developing a communicative intent. Speakers have some reason for talking, and they want their interlocutors to understand this intent from what is said (Austin, 1979; Grice, 1979). Immediately, however, the speaker has a number of options available to him for how he might fulfill his intention. He might, for example, show his interlocutor a picture, point to an object, or make a physical gesture such as a shrug of the shoulders. If, however, he has decided to use language then he has made a commitment to performing an illocutionary act (Searle, 1979).

Many communicative intentions necessitate that the speaker divide his original goal into a number of subgoals. For example, if the intention is to give route directions the speaker must: retrieve or construct a mental map of the appropriate area, decide on a route through this area, divide the route into a number of chunks (from one landmark to the next), and decide which chunk to mention first, second, and so on. The speaker now faces a problem of having to decide how to order these sub-goals. This has been called the "linearization" problem (Levelt, LePage, & Longuet-Higgins, 1981). The problem is that while many different orders are often possible, the speaker must select one.

In some cases there is a natural order that speakers can rely on to

determine what information is mentioned first, second, and so on. This principle is illustrated in the following two sentences.

(i) I received a raise and kissed my boss.

(ii) I kissed my boss and received a raise.

Both sentences contain the same clauses but differ in the implied order of the events. In (i), receiving a raise is assumed to precede and therefore be the cause of the kiss. In (ii), however, receiving a raise follows and therefore is assumed to be the result of the kiss. In this example, the speaker is using the chronological order of events to determine order of mention (Levelt, et al., 1981).

In many situations, however, there is no natural order, and so the speaker must rely on other means to determine how to order the information he wishes to express. For example, part of a recipe for barbequed tofu could be given with either, “Marinate your tofu before putting it in the fridge,” or, “Before putting it in the fridge, marinate your tofu.” Other situations in which speakers face this problem include: giving directions, lectures, recipes, and speeches, telling stories, as well as engaging in debates and interviews.

One factor that determines how subgoals are ordered is memory. In a series of studies, Levelt and colleagues (Levelt, et al., 1981; Levelt, 1982) asked participants to describe networks of the kind shown in Figure 1. These networks consisted of different colored dots connected with lines. Participants were asked to start at the dot indicated by the arrow and to describe the network in such a way as to allow another person to draw it based on his description. They found that participants preferred descriptions that made minimal demands on memory. For

example, in Figure 1, speakers begin at the white dot and move up to the green dot. Here, they must decide whether to move to the right or to the left. Both directions have the same number of dots. However by describing the left side first, the speaker only has to remember to return to the green dot once he has reached the end of that line (i.e., the pink dot). By describing the right side first, the speaker has to remember to return to the yellow dot and then to the green dot. Thus, describing the right side first places a greater demand on the speaker's memory than does describing the left side first. Participants chose to describe the left side first, supporting the idea that they chose descriptions that placed fewer demands on memory.

A fundamental part of speaking involves talking about people, places, events, or things. To produce a preverbal message, the speaker must decide what information he will use to refer to people, places, events, and things. However, it is often possible to refer to the same object in more than one way. A bird may be, "the small bird," when located next to a larger bird, "the black bird," when next to a white bird, or, "the black one" when situated amongst a number of white objects. Intuitively, it seems that referring expressions should be chosen based on their ability to mark referents as distinct for addressees, as these examples suggest.

Experimental evidence had shown that referring expressions are not always selected based on distinctiveness. At least under some circumstances, speakers use redundant or non-discriminating attributes when referring to objects. In one study, Pechmann (as cited in Levelt, 1989) asked participants to name an

object that appeared in arrays of two or three other objects (see Figure 2). The objects in each array differed in kind, size, or color. Participants were asked to tell an imaginary listener, who could see the same slide but not the asterisk, which object was marked. In slide A of Figure 2, for example, a participant would have said, "the black bird." Here both the adjective and the noun are necessary to differentiate it from the other objects in the array (a black cup and a white bird). When the following slide was D, participants tended to say, "the white bird," rather than just "bird." Now, the adjective is not needed to identify the object that was marked. The fact that participants did produce this unnecessary attribute in their descriptions suggests that memory for how the previous object was named influenced what information was used to refer to object on current trials. Thus, memory-specific processes, which may not always be optimal, seem to play a role in determining how speakers refer to things.

Sometimes, talking demands that the speaker adopt a particular perspective with respect to the entities being mentioned. This is perhaps best illustrated with an example of describing spatial relations. Suppose a speaker wanted to describe the location of the chicken in Figure 3. To be able to describe this location, the speaker must adopt a reference frame. He could adopt a viewer-centered (deictic) reference frame by aligning locations such as, "right," "left," "above," "behind," and so on relative to his own body. An example would be saying, "The chicken is in front of the duck." From the viewer's perspective, the chicken is closer than the duck, so it is in front of the duck. He could also adopt an object-centered (intrinsic) reference frame by aligning locations relative to the

intrinsically defined sides of an object. An example would be saying, “The chicken is behind the duck.” The duck is “facing” away from the chicken so, from the duck’s perspective, the chicken is behind him. Finally, he could adopt an environment-centered (extrinsic) reference frame by aligning locations relative to salient aspects of the environment. An example would be saying, “The chicken is on the road.” While speakers have preferences for how to describe spatial layouts (e.g., speakers prefer deictic over intrinsic frames of reference and prefer “in front of” over “behind”), they do not always stick to the same frames of reference (e.g., Carlson-Radvansky & Radvansky, 1996). This suggests that speakers have some choice with respect to which perspectives they can and do adopt.

During the normal course of a conversation, speakers introduce and re-introduce referents to people, places, and things as well as predicate on these referents. In doing so, they construct mental representations of these entities, their properties, and the relations among these entities. Different accounts have been devised for these mental representations. These include: mental models (Johnson-Laird, 1983), referential models (Just & Carpenter, 1987), discourse models (van Dijk & Kintsch, 1983; Levelt, 1989), and situation models (Zwaan, 1998; Zwaan, Langston, & Graesser, 1995; Zwaan & Radvansky, 1998). I will use the term “referential model” to refer to the mental representation of those entities, their properties, and their relations that speakers rely on when they speak. I do not, however, align myself with any one theoretical model over another (e.g., Just & Carpenter’s model over Zwaan’s). What is important, however, is that there are mental representations and that speakers use them in the construction of preverbal

messages.

Referential models contain a record of what the speaker believes to be shared knowledge about the content of the discourse as it has evolved so far. This includes tokens of events, persons, and things. These tokens are entities to which reference can be made. Each reference has an "address" in the referential model. With each new speech act, the speaker is telling his interlocutor to update his referential model in a specific way. He may be telling his interlocutor to add a new address to his existing model (by mentioning a new referent), or he may be telling him to add new information to an existing address (by predicating something about that referent).

A fundamental goal of speaking seems to be the alignment of referential models between conversational participants (Pickering & Garrod, 2006, 2004). The speaker attempts to get the listener's referential representation to agree in essential points to his own. To do this, the speaker should select information that will be instrumental in changing the listener's referential model. The speaker does not need to express every detail, so long as it is still possible for the listener to be able to infer the communicative intentions from well-chosen information that is expressed. This means that the speaker must track what is common ground, what he has said already, what his partner has already said already, and what he intends to say but hasn't yet said (Levelt, 1989).

From the explanation above, it seems that the production system is faced with a number of choices with respect to how to construct a preverbal message. For example, the speaker has choices with respect to how to order information for

expression, how to refer to entities, and what perspective to adopt. In many cases, memory was shown to play an important role. For example, memory-specific processes were shown to play a role in how speakers make reference even though this may lead to a referent that includes non-discriminating information and so is less than optimal. Given the number of choices that go into formulating a preverbal message, one might ask whether this is also true of other stages of speech production. The answer is yes.

Choice and Speech Production

Before a preverbal message can be articulated, its contents must be shaped into a linguistic format. As successive fragments of a preverbal message become available, lexical concepts are activated and grammatical functions are assigned to each concept. In some cases, the speaker has some flexibility with respect to which concepts are assigned to what roles within a sentence. For example, a speaker may describe a picture of a church being hit by lightning by assigning the church to the role of sentential subject with the sentence, "The church is being hit by lightning." He could also describe the same picture by assigning the church to the role of sentential object with the sentence, "The lightning is hitting the church." In one study, Bock (1986) made one lexical concept more accessible than another (e.g., "church" over "lightning"), by priming it with a semantically related word (e.g., "worship" or "thunder"). She found that speakers were more likely to assign a lexical concept to the grammatical subject when that concept had been primed by a semantically related concept.

Another process involved in linguistic encoding is formulating syntactic

structures. Like many of the other processes referred to already, the speaker has some choice with respect to which syntactic structures he uses. For example, a picture of a pirate handing a necklace to a princess can be described with either a double-object dative, "The pirate is handing the princess a necklace," or a prepositional object dative, "The pirate is handing a necklace to the princess." There is now a large number of studies demonstrating that the selection of syntactic structures is influenced by the syntactic structures they have either produced (Bock, 1986b; 1989; Ferreira, 2003; Hartsuiker & Kolk, 1998) or heard in the past (Arai, Van Gompel, & Scheeprers, 2007; Bock, Dell, & Onishi, 2007).

In addition to selecting words and assigning them to grammatical functions, there also seems to be a process that manages the order of words within syntactic phrases. In one study, Hartsuiker and Westenberg (2000) asked participants to complete sentence fragments in Dutch, such as, "John told the detective that he nothing…" To finish these sentences, participants had to produce an auxiliary verb and a past participle such as, "...had seen." In Dutch, the order in which auxiliary verbs and past participles are mentioned is flexible, so this sentence could be completed with either word order. That is, the sentence could be completed with either, "…had seen" or "…seen had." Participants were primed to produce one word order or another by having them complete a sentence that included either the auxiliary verb or the past participle (e.g., "I could not pass through because the road was/blocked..."). Hartsuiker and Westenberg found that participants were more likely to produce a sentence with the auxiliary verb-past participle word order if the prime sentence had the same word order.

To summarize, previous studies have shown that during both conceptual formulation and linguistic encoding there are a number of alternatives that can be used to fulfill the speaker's goal, which means that the production system must select one type of linguistic structure. During conceptual encoding, the speaker decides what he wants to say. This involves deciding what speech acts to use, how to order them, and what perspectives to adopt. During linguistic encoding, the preverbal message is translated into an ordered series of word forms that are inflected. To do this, individual words must be selected, assigned grammatical functions, ordered within syntactic structures, and inflections added when necessary.

Chapter 3. Repetition and Speech

People repeat themselves in many ways and for many reasons. Sometimes repetition is conscious and deliberate. Visual artists like Frank Stella and Alfred Jensen have used repetition as a way of inducing pleasure in their viewers and exploring patterns that occur in nature (Levy, 1996). Repetition has also been used as a means of controlling public opinion, taking advantage of the fact that people are more likely to believe a statement as fact if it has been repeated (Holland, Verplanken, & van Knippenberg, 2003; Weaver, Garcia, Schwartz, & Miller, 2007). Other times, repetition is non-strategic. For example, people repeat actions such as how they reach for objects (Dixon & Glover, 2004), how they finish a melody (Hutchins & Palmer, 2008), and how they classify objects (Jones, Love, & Maddox, 2006). Sometimes repetition is a sign of impairment. For example, some individuals with senile dementia of the Alzheimer's type have shown greater lexical repetition effects that age-matched controls, suggesting their ability to selectively access meaning is impaired (Balota & Duschek, 1991). Other times, however, repetition is beneficial. Repetition leads to faster response times in classification tasks (Pashler & Baylis, 1991); repeating referents in discourse helps establish coherence (Ledoux, Gordon, Camblin, & Swaab, 2007); and repeating a conversational partner's syntactic structures in dialogue may make the process of speaking easier (Garrod & Pickering, 2004). In short, repetition is a very common form of behaviour with multiple causes and multiple effects.

Given its prevalence, it is not surprising that repetition has been the focus of a great deal of study. Studies involving repetition can be classified into one of two broadly defined groups depending on how repetition has been used. One group of studies measures the effects of repetition, while the other measures repetition more directly. I will briefly explain how these two are different and then explain how studies on speech production have made use of repetition effects.

Given that repetition is such a common phenomenon, it was natural for researchers to ask what effects repetition might have on behaviour. Studies of this sort use repetition as an independent variable and typically use reaction time and accuracy as dependent measures. Some researchers have been interested in the effects that exact repetition (i.e., responding to the same stimulus in the same way) has on performance, while others have been interested in the effects that repeating only a part of a previous stimulus (or a response) has on performance. Typically, "priming" refers to benefits found as the result of a previous encounter with a different but related stimulus, whereas "repetition priming" refers to benefits found as the result of exact repetition. For example, if a person were faster to decide that "nurse" was a word after having just seen the word "doctor," then this would be an example of (semantic) priming. If, however, a participant were faster to decide that "nurse" was a word after having just seen the same word "nurse," then this would be an example of repetition priming.

A second type of study has used repetition as a means of investigating other phenomenon. In this case, repetition is used as a dependent variable not an

independent variable. Many studies in speech production belong in this group. For example, studies on syntactic priming measure the tendency to repeat particular syntactic structures (e.g., Bock, 1986; Bock, Dell, Chang, & Onishi, 2007). I will refer to this use of repetition as a "repetition effect" because what is being measured is whether or nor speakers repeat themselves when given a choice.

Repetition Effects in Speech Production

Repetition effects have been found at all levels of production. At the conceptual formulation stage, speakers repeat descriptive schemas (Garrod & Anderson, 1987), referring expressions (Brennan & Clark, 1996; Deutsch & Pechmann, 1982), and spatial reference frames (Schober, 1993; Watson, Pickering, & Branigan, 2004). During linguistic encoding, speakers repeat grammatical structures (Bock, 1986; Bock, Loebell, & Morey, 1992; Branigan, Pickering, & Cleland, 2000), relations between noun compounds (Gagne & Spalding, 2004; Raffray, Pickering, & Branigan, 2007), particular words (Kubovy, 1977), and word orders (Hartsuiker, Kolk, & Huiskamp, 1999). During phonological encoding speakers repeat sounds (Dell, Burger, & Svec, 1997; Hillinger, 1980; Pardo, 2006). Speakers have even been shown to repeat non-words (Light, La Voie, & Kennison, 1995). In short, repetition effects are common in speech production.

One type of repetition effect that has received a great deal of attention is the tendency to repeat syntactic structures. This has been labeled a syntactic priming effect, although for consistency here I will refer to the phenomenon as a syntactic repetition effect. Since Bock's original study in 1986, syntactic

repetition effects have been replicated in many ways and in many forms. Syntactic repetition effects have been found in naturally occurring language, such as corpora (Gries, 2005), recorded conversations (Levelt & Kelter, 1982), scripted conversations (Branigan, Pickering, & Cleland, 2000), and in experimental settings (Bock, 1986b). Repetition effects have been found in a number of languages, including Chinese (Lu, Bates, Hung, Tzeng, Hsu, Tsai, & Roe, 2001), Dutch (Hartsuiker & Kolk, 1998), German (Loebell & Bock, 2003; Scheepers, 2003), as well as English (Bock, 1989). Speakers will repeat syntactic structures they themselves have produced (e.g., Bock & Loebell, 1990) as well as structures they have heard others produce (e.g., Arai, Van Gompel, & Scheepers, 2007; Pickering & Branigan, 1998). Speakers will repeat pieces of speech when talking with another human (Brennan & Clark, 1996), and even when they have been told to interact with an inanimate object – a computer (Branigan, Pickering, Pearson, McLean, & Nass, 2003).

One of the more interesting findings to come out of studies of syntactic repetition effect is that repeating content words will increase the tendency to repeat syntactic structures. In one study, Pickering and Branigan (1998) had participants complete sentence fragments such as:

(i) The racing driver showed the torn overall…

(ii) The racing driver showed the helpful mechanic…

To complete example (i), participants had to produce a prepositional phrase (e.g., "…to the mechanic"). To complete example (ii), participants had to produce a noun phrase (e.g., "…the torn overall"). Thus, in the first example,

participants were producing a sentence with a prepositional object dative, whereas in the second example they were producing a sentence with a double-object dative. Participants completed sentences such as these as syntactic primes. Subsequently, participants were given fragments that could be completed with either a prepositional object dative or a double-object dative, such as, "The patient showed…." Pickering and Branigan found the tendency to repeat syntax was much larger when the same verb was used in the prime and target sentences. They called this enhanced priming effect "lexical boost." The lexical boost has been replicated many times (Branigan Pickering, & Cleland, 2000; Cleland & Pickering, 2006; Corely & Scheepers, 2002; Schoonbaert, Hartsuiker, & Pickering, 2007). It has been demonstrated with verbs and with nouns (e.g., Cleland & Pickering, 2003), but does not seem to occur with function words (Bock, 1989; Ferreira, 2003; Fox Tree & Meijer, 1999). The lexical boost is not affected by differences in the aspect, number, or tense of verbs. The verb "show," for example, primes "shows," "showing," and "showed" as much as it does an exact repetition (Pickering & Branigan, 1998).

In some sense, this is not a surprising finding. When asked to complete a sentence, speakers are more likely to repeat what they have said when it shares a greater similarity to the sentence he has just constructed. However, there is more to this effect. Syntactic repetition effects with lexical repetition are short-lived, whereas syntactic repetition effects without lexical repetition are long-lived (Bock, Dell, Chang, & Onishi, 2007; Bock & Griffin, 2000). It seems as though the added influence of lexical repetition either replaces the syntactic repetition

effect or interacts with it in some way, causing it to quickly die off. As of yet, no compelling explanation has been offered for why lexical repetition should interact with syntactic repetition in this fashion.

To summarize, there are many cases in which humans repeat themselves. Sometimes, repetition is helpful; sometimes it is not. Psychologists have used repetition both as a dependent measure (repetition priming) and as an independent measure (repetition effect). In studies of speech production, it is not uncommon for researchers to use repetition as an independent measure (although, much of Levelt's work stands out as an important counter example). Many types of repetition effect have been studied, from the tendency to repeat sounds (e.g., Dell, et al., 1997) to the tendency to repeat conceptual roles across sentences (Hare & Goldberg, 1999). One interesting finding to emerge out of this research is that the repetition of content words and of syntax seem to interact in some important, but as of yet not well understood, way. Repetition, therefore, offers a productive means of investigating the structures involved in many aspects of speech production. It seems likely that repetition might also be used to study other less well-known aspects of speech production, in particular the structure of preverbal messages.

Chapter 4. Preverbal Messages and Propositions

In Chapter 2, I argued that speaking begins with the formulation of a preverbal message and that a number of choices about which structures to use have to be made in order to construct such a message. In Chapter 3, I further argued that speakers often repeat parts of speech and that researchers can take advantage of this tendency to study the structures and choices involved in producing speech. In this chapter, I will present a methodology that can test whether or not speakers repeat parts of a preverbal message. The goal is to use repetition effects as a means of better understanding the structures used in one type of preverbal message as well as how the production system chooses one structure over other alternatives. I will adopt a propositional notational for describing the structure of preverbal messages, so it will be important to describe what this notation is. I will then go on to explain what preverbal messages participants will be making, what they can repeat, and how this will be measured. This chapter will conclude with an overview of the four experiments of this paper.

While a number of methods have made studying other aspects of speech production easier (e.g., sentence recall, sentence completion, confederate-scripting in a dialogue, on- and off- line picture descriptions), finding ways to study the generation of preverbal messages has been difficult. On the one hand, there is a need to impose control over what speakers might say. If each speaker were free to generate any sentence he wished, there may be too much variability across individuals, a problem Bock (1996, p. 407) called, “exuberant responding.” On

the other hand, if speakers are told precisely what to say, then the processes involved in producing that message may not reflect what speakers do in more naturalistic situations. What is needed is a methodology that limits what speakers can say so that there is experimental control, and yet is not so limiting so as to provide speakers with no choice of what they can say.

The solution I proposed had two parts. First, I limited the number of preverbal messages that speakers could produce to a small set. This provided tight constraints over what messages were produced and so solved the "exuberant responding" problem. By not forcing speakers to produce any particular message, speakers were not told exactly what to say. Although such a method was more limiting than normal message preparation, it was still possible to capture critical aspects of how messages were generated. Second, other aspects of speech production were controlled so that it was possible to isolate and study the effects of structures at the message level. This was necessary to rule out other effects such as syntactic and lexical priming. The responses participants produced were designed to be as equivalent as possible along many dimensions. The responses all had the same syntactic structures, involved the same kinds of comparisons (e.g., of size), and involved comparisons to common, concrete, monosyllabic nouns (e.g., "bird," and "fish," or "cup" and "plate"). Importantly, the options of what messages participants could express were equally valid descriptions of what was shown. This ensured that participants' choices were not be influenced by differences in meaning, syntax, word length, or word frequency.

Current evidence suggests that in most cases speakers plan their speech in

units that correspond to clauses in the surface structure of speech (e.g., Ferreira & Swets, 2002; Bock, Irwin, & Davidson, 2004; Bock, Irwin, Davidson, & Levelt, 2003). This means that before speakers begin the process of linguistic encoding, they have selected the referents and predicates they are going to express in the first clause of their utterance. In the present experiments, participants were asked to produce sentences containing a single clause, and each response contained one predicate and one argument.

A propositional notation will be used to describe preverbal messages based on the notation developed by Kintsch (1974) and expanded by Britton and Black (1985). In this notation, the relation appears to the left of a set of parentheses and the arguments appear inside. Both relations and arguments are written in capitals so as to distinguish them from the corresponding words they represent. So, for example, “RAT” refers to the concept for rat, while “rat” represents an English noun. Arguments in this notation system are separated by commas. Three examples can be found in the sentences below. Sentences (1) to (3) are sample sentences and (i) to (iii) represent their corresponding propositional notation.

(1) The rat is black.

(i) BLACK (RAT)

(2) The baby was lifted from the crib.

(ii) LIFT (X, BABY, CRIB)

(3) The spy carried the letter from Edmonton to Banff.

(i) CARRY (SPY, LETTER, EDMONTON, BANFF)

Propositions were chosen as a notational system for three reasons. First, they do not capture surface features of an utterance such as the tense, aspect, or voice of verbs nor the determinacy of nouns (Graesser, Millis, & Zwaan, 1997). This makes them useful for describing elements of a preverbal message apart from the surface form of a corresponding sentence. Second, a notational system for describing them already exists. Third, there is a general consensus amongst psycholinguists that the ideas expressed by sentences can be represented as propositions. This is true both in the comprehension of sentences (e.g., Anderson, 1990; Kintsch, 1974), and in the production of sentences (e.g., Levelt, 1989). Work on discourse comprehension commonly assumes that readers generate a propositional textbase containing both the propositions extracted from the text and a small number of inferences that are needed to establish local coherence in addition to a surface code and a referential situation model (e.g., Graesser, Millis, & Zwaan, 1997; van Dijk & Kintsch, 1983). While this idea has not been developed much in the production literature, the same message structures that are used in production are presumably used in comprehension. That is, speakers create the same representation of a situation such as HIT (LIGHTNING,

CHURCH) regardless of whether it was created via the processes of production or via the processes of comprehension.

The Present Experiments

In all four of the present experiments, participants were shown pictures of three objects and were told to compare the object in the middle to the object on the right or left. In Experiments 1 and 2, participants were shown pictures of animals and compared their sizes. In Experiments 3 and 4, they were shown pictures of shapes and compared their colours. The sentences participants produced consisted of a single clause containing one subject noun, one object noun and one relational term (an adjective). In the first two experiments, this might correspond to a sentence such as, "The snake is smaller than the bird," and in the last two experiments this might correspond to a sentence such as, "The cross is lighter than the tube."

The preverbal messages corresponding to these productions all had the same general propositional structure: RELATION ($ARGUMENT_{SUBJECT}$, $ARGUMENT_{OBJECT}$). "RELATION" refers to the dimension of the comparison being made. For example, whether the comparison was in terms of size or colour. Relations surfaced in utterances as comparative adjectives such as, "bigger," and "smaller." "$ARGUMENT_{SUBJECT}$" refers to the referent that became the subject of comparison in a response, and "$ARGUMENT_{OBJECT}$" refers to the referent that became the object of comparison in a response. Both arguments surfaced in responses as monosyllabic, concrete nouns such as, "bird," "fish," "cup," and "plate." To provide a concrete example, the preverbal message underlying the

overt response, “The snake is smaller than the bird,” can be represented as: SMALLER-THAN (SNAKE, BIRD). In this example, “SMALLER-THAN” is the relation, “SNAKE” is the subject argument, and “BIRD” is the object argument.

By always showing participants three objects at the same time, it was possible to provide a choice of messages to produce. A picture of medium-sized snake, for example, could either be compared to a smaller fish to produce the message, BIGGER-THAN (SNAKE, FISH), or it could be compared to a larger bird to produce the message, SMALLER-THAN (SNAKE, BIRD). Sometimes the size or colour of the central object, the subject of comparison, did not change from one trial to the next. When this happened, participants could either repeat the same message they generated previously or switch messages. An example of this is as follows.

Trial n-1: $RELATION_1$ ($ARGUMENT_{SUBJECT}$, $ARGUMENT_1$)

Trial n: $RELATION_1$ ($ARGUMENT_{SUBJECT}$, $ARGUMENT_1$) or

$RELATION_2$ ($ARGUMENT_{SUBJECT}$, $ARGUMENT_2$)

Trial n-1: BIGGER-THAN (SNAKE, FISH)

Trial n: BIGGER-THAN (SNAKE, FISH) or

SMALLER-THAN (SNAKE, BIRD)

Importantly, both relations (here, the bigger than relation and the smaller than relation) were equally valid descriptions of the size of the snake on both trials, so participants were free to switch or repeat messages.

At other times the size or colour of the central object did change from one

trial to the next. When this happened, participants could repeat the relation they generated previously, but if they did, they would have to switch the argument. Alternatively, they could repeat the argument they generated previously, but if they did, they would have to switch the relation. An example of this is as follows.

Trial n-1: $RELATION_1$ ($ARGUMENT_{SUBJECT}$, $ARGUMENT_1$)

Trial n: $RELATION_1$ ($ARGUMENT_{SUBJECT}$, $ARGUMENT_2$) or

$RELATION_2$ ($ARGUMENT_{SUBJECT}$, $ARGUMENT_1$)

Trial n-1: BIGGER-THAN (SNAKE, FISH)

Trial n: BIGGER-THAN (SNAKE, BIRD) or

SMALLER-THAN (SNAKE, FISH)

Again, both choices were equally valid descriptions to what they saw and so were equally valid messages that could be produced.

In four experiments, I asked three questions. First, would participants repeat how they chose to describe these scenes given the chance? Second, if they had to choose between repeating the noun and repeating the adjective which would they repeat? Third, would it be possible to learn something about preverbal messages from what speakers said? In Experiments 1 and 2, the tendency to repeat all or part of a preverbal message was measured. It was hoped that participants would show a repetition effect and that this would provide some insight into whether they selected referents before relations or whether they selected relations before referents. In Experiments 3 and 4, the structure of preverbal messages was examined further by studying the time course of the repetition effect. I asked whether or not the repetition effect would survive across

intervening trials. Examining the effects of lag has proven to be a useful means of exploring the nature of other repetition effects, and I hoped that it would provide some insight into the nature of the repetition effects observed in Experiments 1 and 2.

Chapter 5. Experiment 1

The purpose of this experiment was to understand how speakers choose between two preverbal messages when both messages described a simple visual scene equally well. The preverbal messages that participants could construct contained one relation, that appeared in participants' verbalizations as an adjective, and two arguments, that appeared as nouns. The tendency to repeat either the relation or the argument was measured as a function of what was said on the preceding trial.

Participants were shown displays containing pictures of three animals: a fish, a snake, and a bird. The bird was always large and the fish was always small. The snake, however, could be smaller than both the fish and the bird (very small), larger than both (very large), or smaller than the bird and larger than the fish (medium-sized). Participants were asked to compare the size of the snake to either the bird or the fish. Thus, they could say either that the snake was smaller than another animal, or they could say that it was larger than another animal. Because all three animals were presented on every trial, both messages were equally valid. There were a total of four possible messages that the participants could express:

(i) BIGGER-THAN (SNAKE, BIRD)

(ii) BIGGER-THAN (SNAKE, FISH)

(iii) SMALLER-THAN (SNAKE, BIRD)

(iv) SMALLER-THAN (SNAKE, FISH)

To prevent participants from selecting one response and repeating that

response throughout the entire experiment, participants' responses were constrained in the following way. Whenever the snake was very large, they were told to always compare it to the next largest animal, the bird. Whenever the snake was very small, they were told to always compare it to the next smallest animal, the fish. In this way, participants were forced to produce both nouns and both adjectives. Whenever the snake was medium-sized, they were told that they could compare it to either the bird or the fish.

Across trials, it was possible for participants to repeat or to switch messages. For example, suppose a participant saw a medium-sized snake on two trials in a row. He could choose to describe the snake as being bigger than the fish on both trials (a repetition), or he could choose to describe the snake as being bigger than the fish on one trial and smaller than the bird on another trial (a switch). Because both a bigger-than and a smaller-than relationship was true on every trial, both a repetition and a switch described the size of the snake equally well.

On other trials, it was possible for participants to repeat either the adjective or the noun but not both. For example, suppose a participant saw a large snake on one trial followed by a medium-sized snake on the second trial. Further, suppose he compared the snake to the bird on the first trial. On the second trial, he could choose to describe the snake as being bigger than the fish, in which case he would be repeating the relation, BIGGER-THAN, but switching the argument from BIRD to FISH. Or, he could choose to describe the snake as being smaller than the bird, in which case he would be switching the relation from BIGGER-

THAN to SMALLER-THAN, but repeating the argument, BIRD.

Other aspects of speech that might affect the choices participants made were controlled in an attempt to isolate the repetition effects to the level of the preverbal message. Participants produced sentences containing the same syntactic structures, the same number of conceptual roles, and the same thematic relations. Furthermore, participants used the same words ("bird," "fish," "bigger," and "smaller") throughout the experiment, so variables such as word frequencies and concreteness were controlled. In this way, participants' choices could not be affected by meaning, syntax, or properties of individual words.

The responses participants could make were limited to a choice between one of two nouns and one of two adjectives. Based on a large literature showing repetition effects for words (e.g., Monsell, 1985), it was reasonable to expect that participants would repeat words in the present experiment. For example, having just said "bird" in a previous comparison might make participants more likely to say "bird" again. There are potentially many kinds of representation that might be the cause of this repetition effect (e.g., a preverbal conceptual representation, a semantic representation, a lemma, a phonological representation, or all of the above). For the purposes of the present experiment it is not important to distinguish between these representations. Having participants produce the same words many times throughout the experiment, it is expected that all such representations should become highly activated, and so neither of them should show any advantage over their alternatives. Furthermore, because participants produced both a noun and an adjective in every sentence, lexical priming by itself

does not provide a basis for a difference in the tendency to repeat nouns or adjectives.

It is my contention that the selection of a relation is more central to the construction of a response in a task such as this than is the selection of an object of comparison. Participants are asked to talk about the snake and are asked to describe is its size. If a participant decides to express the idea that the snake is relatively small, then he presumably is making a commitment to using SMALLER-THAN as the relation in his message. The prediction, therefore, is that speakers will select relations before arguments, and assuming that it will be easier for a speaker to re-use the same relation than it will be to use a different relation, they should repeat relations across trials. If this prediction is correct, this will be observed as a tendency for participants in this experiment to repeat adjectives.

To summarize, speakers were free to describe the size of one animal using one of two preverbal messages. Preverbal messages contain a relation and an argument, which can be repeated or switched across trials. It was expected that a message that involves a comparison begins with the intention to express some feature of the topic of the sentence (i.e., the snake). For example, the speaker will decide whether to express the idea that the snake is large or that it is small. This decision determines which relation will be used in the preverbal message. If the speaker has decided to express the idea that the snake is large, he will choose the BIGGER-THAN relation. If, however, the speaker has decided to express the idea that the snake is small, he will choose the SMALLER-THAN relation. Many

studies of speech production have shown that speakers choose between alternate structures (alternate reference frames, alternate syntactic structures, alternate word orders) by repeating structures that they have recently produced. So, it is likely that speakers will tend to repeat choices of relation rather than switching relations. Relations appear in the surface structure of utterances as comparative adjectives, and so the prediction is that speakers will repeat adjectives.

Method

Participants

Nineteen university students were paid for their participation in this experiment. All participants were native English speakers and had either normal or corrected-to-normal vision.

Materials and Apparatus

Stimuli consisted of pictures of three different animals: a bird, a snake, and a fish. An example of the stimuli can be seen in Figure 4. All three pictures showed the animals in profile so two versions of each picture were created, one with the animal facing left and the other facing right, by inverting the images along the vertical axis. Participants sat approximately 60 cm from the computer screen. The bird was presented in a box subtending 6.7° x 6.7° of visual angle and the fish was presented in a box subtending 2.9° x 2.9° of visual angle. The snake was presented in three sizes: very small (1.4° x 1.4° of visual angle), medium (4.8° x 4.8° of visual angle), and very large (8.1° x 8.1° of visual angle). The snake was presented in the middle of the computer screen while the other two animals were presented 8.8 degrees of visual angle to the left or right of the snake,

measured centre to centre. The stimuli were displayed on a PowerPC G4 Apple iMac computer with a 42 cm (17 in) color monitor at a resolution of 72 dpi. The experiment was created and run with the ESExpt computer program (Dixon, 2009).

Procedure

Participants were shown pictures of three animals at the same time on a computer screen and were asked to compare the size of the central animal, which was always a snake, to the size of one of the two other animals, which were always a bird and a fish. Participants were told to use one of the following four statements: "The snake is bigger than the bird," "The snake is smaller than the bird," "The snake is bigger than the fish," or "The snake is smaller than the fish." The bird was always large and the fish was always small but the snake could be either very small (smaller than both), very large (larger than both), or medium-sized (smaller than the bird but larger than the fish). When the snake was very small, participants were instructed to always compare it to the next smallest animal, the fish. When the snake was very large, participants were instructed to always compare it to the next largest animal, the bird. When it was medium-sized, participants were told that they had the choice of comparing it to either the bird or the fish. I will refer to those trials in which the snake was very small or very large as "no-choice" trials because participants' utterances were fixed, and I will refer to those trials in which the snake was medium-sized as "choice" trials because participants had a choice of two ways to describe what they saw. No-choice trials

were included to prevent participants from using only one response throughout the entire experiment.

The experimenter sat approximately 60 cm to the left of every participant during the experiment. Each display remained on the screen until the experimenter made a key press. The computer screen was angled approximately 45 degrees away from the experimenter so that he could not see the display. Participants' responses were recorded on an Apple iPod, and the experimenter's coding was later checked for accuracy. If the experimenter made an incorrect entry error during the experiment, it was changed to reflect what was recorded on the iPod.

Before the experiment began, the procedure was explained to participants, and then they were given fifteen practice trials. During the practice trials, the experimenter monitored what participants were saying and corrected them if necessary.

Design

The experiment consisted of two blocks of 192 trials each. Participants were given the opportunity to rest after the first block of trials. The sizes of the animals was randomly sampled by the computer on each trial. On approximately one third of the trials the snake was very small, on another third it was medium sized, and on the remaining third it was very large. Both the sizes of the snake and the profiles of the three animals were randomly ordered within each block. Each participant saw all combinations of animal sizes and profiles making this entirely a within-subjects design. The response made on trial *n* was analyzed as a function

of the choice of noun and adjective from the previous, *n-1* trial. After the experiment was finished, each participant was given a brief questionnaire in order to identify whether or not she or he was a native speaker of English.

Data Analysis

The data from choice trials were analyzed using generalized linear mixed effects modeling with the R program lmer, using the logistic function as the "link" function (Bates & Sakar, 2006; R Development Core Team, 2006). This is similar to using logistic regression, in which the log odds of a given response (in this case, saying, "The snake is smaller than the bird") is predicted as a linear function of the predictor variables. Here, the predictor variables were the choice of noun and adjective from trial *n-1*. Depending on the nature of the previous trial and the participant's reponse, the previous response could share either the noun, adjective, both, or neither with the target response, "The snake is smaller than the bird." If the previous trial was a choice trial and the participant elected to say "The snake is smaller than the bird," the target response would entail repeating both the noun and the adjective. If the previous trial as a no-choice trial and the bird was very small, participants were required to say "The snake is smaller than the fish." Consequently, the target response would repeat the adjective but not the noun. If the previous trial was a no-choice trial and the bird was very small, participants were required to say "The snake is bigger than the bird." In this case, the target response would repeat the noun but not the adjective. Finally, if the previous trial was a no-choice trial and the participant elected to say "The snake is bigger than the fish," the target response would involve repeating neither the noun nor the the

adjective. Thus, across different types of trials and participants' responses, the choice of utterance could be predicted as a function of the factorial combination of noun and adjective repetition.

Unlike traditional logistic regression, generalized linear mixed effects modeling allows one to use participants as a random effect (Dixon, 2008). Exploratory analyses were used to identify the random effects structure that provided the best model fits. Allowing both the repetition effect for noun and adjective to vary independently over participants provided the best model fits, and this is what is reported in our analyses for all four experiments.

In order to assess the strength of evidence provided by the results, several models of interest were fit to the data, and their relative adequacy was assessed using likelihood ratios. The likelihood ratio is the likelihood of the data given the best fit of one model divided by the likelihood of the data given the best fit of the other and provides a readily interpretable index of how well the two models match the results. If the likelihood ratio is very large (or very small), it implies that one model provides a superior account of the results. Following the approach outlined by Glover and Dixon (2004), the likelihood ratios were adjusted for the difference in the models' degrees of freedom based on the Akaike Information Criterion (Akaike, 1973). I will use the symbol λ_{ADJ} to refer to this adjusted likelihood ratio.

Errors were classified into one of three categories: (1) speech errors, (2) judgment errors, and (3) anchoring errors. Speech errors were defined as any response that was not a clear and immediate verbalization. These included false

starts, hesitations, and stammering, even if the utterance that was ultimately produced was correct. Speech errors also included utterances in which participants used nouns or adjectives other than what they were instructed to use (e.g. saying "larger" instead of "bigger"). Judgment errors included those times when participants incorrectly judged the size of the snake. An example of such an error would be saying, "The snake is bigger than the fish," when in fact it was smaller. An example of an anchoring error would be comparing the snake to the largest animal instead of the next smallest animal when it was very small. Although these responses were technically correct, they were not consistent with the instructions. Producing a large number of anchoring errors would be an indication that a participant was not attending to the instructions.

Results

On average, 8.4% (*SD* = 5.3) of all responses were classified as errors and excluded from the final analysis along with the trial following an error. Participants made an average of 4.1% (*SD* = 3.1) speech errors, 2.7% (*SD* = 1.9) judgment errors, and 1.6% anchoring errors (*SD* = 1.3), with the largest percentage of anchoring errors for any one participant being 4.1%.

A logistic function was used to estimate the likelihood of giving one response ("The snake is smaller than the bird") as a function of whether the preceding nouns and adjectives were the same ("bird," "smaller") or different ("fish," "bigger"). The log odds of participants saying, "The snake is smaller than the bird," on choice trials as a function of the noun and adjective produced on a preceding trial can be seen in Figure 5. This graph shows a clear tendency to

repeat both the noun and the adjective, but a much stronger tendency to repeat the noun. To assess the evidence for these effects, four models were constructed and their relative fits to the data were compared. The first was a null model that included only an intercept. The second model included a main effect of repeating the noun. A comparison of these two models yielded a strong advantage for the second model, as indicated by a large adjusted likelihood ratio ($\lambda_{ADJ} > 1{,}000$). A third model included a main effect of adjective as well, and, when compared to the second model, the results strongly favoured the third model ($\lambda_{ADJ} = 127.5$). A fourth model included an interaction between noun and adjective as well as the two main effects. The results of comparing this model to the model with two main effects were hardly greater than one ($\lambda_{ADJ} = 1.6$); thus, there was little evidence for an interaction.

To assess whether participants in our study were biased toward choosing animals on the basis of side, the noun and adjective repetition effects were broken down by whether the animal used in responses appeared on the left or right. Previous speech production studies in which participants named objects aligned in a row have shown a bias toward beginning utterances with objects that appeared on the left (Hartsuiker, Kolk, & Huiskamp, 1999); thus, it was important to determine if the repetition effects observed in this study interacted with spatial location. As shown in Table 1, there was little difference between the tendencies to use the animal on the two sides. To test this, a model that included the main effect of animal side was compared to a model that only included the main effects of noun and adjective. The resulting likelihood ratio was less than one ($\lambda_{ADJ} =$

0.8); thus, there was no evidence that animal side mattered.

In this experiment, the snake was always presented in profile, which meant that it was always facing one of the other animals. Some studies have shown that a centrally presented face that appears to be "looking" to the right or left can induce an automatic shift of attention in the that direction (Friesen & Kingstone, 1998). It is possible, therefore, that participants' attention may have shifted toward the animal the snake was facing, biasing them to use that animal in their response. This possibility was tested with a final model. The noun and adjective repetition effects were broken down by whether the snake was facing the selected animal. The pattern of means shown in Table 2 suggests no difference in responses based on the direction the snake was facing. However, for the sake of completeness, this was tested by comparing a model that included main effects noun, adjective, and snake's gaze to a model that included only the two main effects of noun and adjective. The adjusted likelihood ratio for this was 0.6, indicating that there was no evidence that the snake's profile made a difference in how participants chose to respond. Effects of both position and orientation were tested in subsequent experiments. No evidence for either kind of effect was found and so these variables will not be discussed again.

Discussion

Although in principle it was possible for speakers to randomly alternate between repeating words and changing words, they tended to repeat both nouns and adjectives. The tendency to repeat nouns was much larger than the tendency to repeat adjectives. It was initially argued that messages involving comparisons

begin with the intention to express some feature of the topic of comparison, such as the snake being large or the snake being small. It was further argued that this intention determined which relation would be used in a preverbal message. If a speaker decided to express the idea that the snake was large, he would select the BIGGER-THAN relation in his preverbal message. This would be observed as a tendency to repeat adjectives. However, the tendency to repeat nouns was much larger than the tendency to repeat adjectives, suggesting that speakers were doing something else.

One possibility is that the construction of a message involving a comparison began, not with the intention to express some feature of the topic of comparison, but with the selection of a foil that would be used in the comparison. A foil can be thought of as the value against which an object is being compared. If a speaker says that a snake is big, the foil is small. If he says that something is expensive, the foil is cheap. If he says that something is old, the foil is new. In the present context, this would mean that participants began by deciding whether to compare the snake to something small or to something large. The present results would make sense if this choice was generally made by repeating the choice made on the previous trial. Because the sizes of the bird and the fish were fixed in this experiment, repeating a comparison to something small meant repeating the choice of FISH in a preverbal message. Similarly, repeating a comparison to something large meant repeating the choice of BIRD in a preverbal message. The result of such a repetition would have been a tendency to repeat nouns.

A critical aspect of this analysis is the distinction between the foil and the referent. A foil in the present usage refers to an abstract characterization of one end of the comparison dimension. In other words, for the size dimension used here, the foil would be “small things” or “large things” in the general. In contrast, the referent is a specific entity in the domain of the message that can be used as an

exemplar of the foil (i.e., the bird or the fish). I argue that speakers must first select the foil (an abstract class) and only subsequently select the referent (a concrete realization of the foil). As I will discuss in more detail later, selecting a foil and then a referent for that foil is part of a "relational schema" that is used for messages of this sort.

The alternative to the relational schema explanation is that both the noun and the adjective repetition effects were lexical repetition effects. In this view, the production of a word activates its lexical representation(s), and these representations may remain active for a brief period of time. This residual activation may have made it easier or faster to reactivate the same representation(s) on a following trial, making it more likely for speakers to produce the same words. Repetition effects were found for both nouns and adjectives because lexical representations for both had been activated. Many models of word production assume that a speaker constructs (or activates) three different mental representations of a word in the process of producing it (Bock & Levelt, 1994; Dell & O'Seaghdha, 1992; Levelt, Roelofs, & Meyer, 1999; Roelofs, 1992): the lexical concept, the syntactic representation, and the phonological representation. Producing the same word a second time presumably involves activation of all three representations again. This means that there are three mental representations that may be responsible for the observed repetition effect. For now, I will not speculate as to the role that each representation might have played in the observed repetition effects, and I will simply refer to the repetition of any aspect of a word as lexical repetition. However, as was stated in the introduction, lexical repetition cannot explain why a much larger repetition effect was found for nouns.

Chapter 6. Experiment 2

In this experiment, I tested whether the large repetition effect observed in Experiment 1 was the result of a tendency to repeat relational schemas or whether it could be better explained as the result of a tendency to repeat specific words. Participants were shown the same pictures of three animals, made the same size comparisons, and were asked to use the same four responses as in the first experiment. Unlike the first experiment where only the size of the snake varied, though, all three animals were free to vary in this experiment. On one third of all trials, the snake was very small; on another third, it was medium-sized; and on the remaining third, it was very large. Orthogonal to this manipulation, the bird was large and the fish small on half of the trials, and the bird was small and the fish large on the other half of the trials. This meant that on approximately half of the trials, the bird and fish would remain the same size from trial $n\text{-}1$ to trial n. This sequence replicates the conditions used in Experiment 1, and I expected to find similar results. On the other half of trials, the bird and fish would change size from one trial to the next, unlike the sequences used in Experiment 1.

The relational-schema account makes a distinctive prediction for sequences on which the bird and fish change size. If participants selected the big end or the small end of the size dimension before they chose nouns, then they should anchor their responses to the same end of the dimension regardless of whether this was the same noun from the preceding response or not. So, when the pictures of the bird and fish remain the same size, they should be more likely to

repeat nouns from previous trials. On these trials, the exact same pattern of results should be seen as in Experiment 1: There should be a very large tendency to repeat nouns accompanied by a smaller tendency to repeat adjectives. The critical prediction, however, is that when the sizes of these pictures change, participants should show a tendency to switch nouns, not to repeat them. This tendency should occur because the identity of the "larger" and "smaller" objects will have switched from the preceding trial.

The present design is a strong test of whether participants will repeat relational schemas or whether they will repeat the words they have recently produced. In particular, the prediction is that rather than repeat exactly what they have said before, participants will be more likely to switch what they say. However, this prediction only applies to those trials on which the pictures of the same size and the identities of these pictures switch. It does not apply to those trials on which they stay the same. If, however, the effects in Experiments 1 were the result of repeating particular lexical items (e.g., repeating "bird"), then participants should be more likely to repeat nouns irrespective of whether the previous size of the bird and fish were the same or different.

Method

Participants

Twenty-five first-year university students received course credit for their participation in this experiment. Five participants were excluded because they were non-native speakers and one additional participant was excluded because of

an unusually high error rate (overall errors = 26.7% with 15.2% anchoring errors). This left nineteen participants in the final analysis.

Materials and Apparatus

Stimuli consisted of the same three pictures of a bird, a snake, and a fish used in Experiment 1. Properties of the stimuli and how they were presented were the same as in Experiment 1 with the exception that the size of the bird and the fish was not fixed. Both animals were sometimes large and sometimes small. Voice onset times were recorded using the capacities built into the ESExpt program based on the Mac OS X speech recognition software.

Procedure

Participants were given the same instructions, made the same responses, and followed the same procedure as in Experiment 1. Participants' responses were recorded on an Apple iPod, and the experimenter's coding was later verified using this recording, as was described in Experiment 1.

Design

The experiment contained two blocks of 192 trials each. Size of the bird and fish, size of the snake, location of the bird and fish, as well as the profiles of each animal were randomly selected on each trial for each participant. The probability of selecting a small bird on each trial was 0.5. The bird and the fish were never the same size on a given trial. The three snake sizes were equiprobable.

Data Analysis

The data were analyzed in the same way as in the previous experiment. Because response latencies were collected it was possible to use this data as a means of identifying outliers (in addition to speech errors). When the time to begin speaking was greater (or less than) three standard deviations from the mean for a given participant for a give response, it was classified as an outlier and excluded from the analysis. These data and the trials following the errors were excluded from the analysis of the responses participants made as well as from the analysis of their response latencies.

Results

On average, 5.0% (*SD* = 2.3) of all responses were classified as errors and excluded from the final analysis. Participants made an average of 2.9 % (*SD* = 1.5) speech errors, 1.1 % judgment errors (*SD* = 0.7), and 1.0 % (*SD* = 0.7) anchoring errors. On average, 1.4% (*SD* = 0.5) of responses were classified as response latency outliers and were excluded from the analysis. The analysis of what participants said ("oral responses") will be presented first, followed by the analysis of the time it took them to begin speaking ("response latencies").

Oral responses

The log odds of participants producing a response such as, "The snake is smaller than the bird," on choice trials as a function of the choice of previous noun, adjective, and whether the comparison animals were the same size of not can be seen in Figure 6. The data were collapsed across the actual referents used. In order to more easily understand the results, specific referents were used in

Figure 6. The figure shows an apparent interaction between previous noun, previous adjective, and whether or not the comparison animals were the same size on trials *n-1* and *n*. There was good evidence that participants were repeating nouns when the comparison animals were the same size but switching nouns when they were different sizes. In both cases, there was a tendency to repeat adjectives.

To assess these patterns of results, nexted models of the data were compared. The first model included only the effect of whether the sizes of the comparison animals were the same or different. This was compared to a model that included a main effect of noun as well. The result of this comparison was in favor of the model that included the effect of noun ($\lambda_{ADJ} = 7.9$). A third model was created that included an interaction between noun and the sizes of the comparison animals. The results were overwhelmingly in favor of this two-way interaction ($\lambda_{ADJ} > 1{,}000$). A fourth model added a main effect of adjective to the two-way interaction and provided very strong evidence for the added effect of adjective ($\lambda_{ADJ} = 135.2$). A fifth model included a three-way interaction and provided some evidence in favor of this interaction ($\lambda_{ADJ} = 3.7$), although the strength of this evidence was not very strong.

Response latencies

Response latencies in Figure 7 show a clear interaction between previous noun, previous adjective, and whether the comparison animals were the same size or not. As with the oral responses, the data were collapsed across the actual referents used and the label on the y-axis is an example of one possible response

participants made. When the comparison animals remained the same size, response latencies were fastest when participants were repeating both the noun and the adjective from a previous trial. This effect was independent of the particular nouns and adjectives participants used in their responses. Unexpectedly, they were just as fast when participants were changing both the noun and the adjective from a previous trial. Response latencies were slower when the noun changed and when the adjective changed but not both. Responses were also slower when the comparison animals changed sizes. To test for this, several nested linear models were created and their relative fits to the data compared.

The first model included only an effect of whether the comparison animals were the same size or not. A second model that added a main effect of noun was compared to this simpler model. The evidence was somewhat stronger for the model that included the main effect of noun ($\lambda_{ADJ} = 3.0$). A third model added a two-way interaction, and there was clear evidence of the interaction ($\lambda_{ADJ} = 5.6$). A fourth model added a main effect of adjective. However, this did not provide a greater fit to the data than the simpler model ($\lambda_{ADJ} = 0.4$). The evidence was highly in favor of a fifth model that included a three-way interaction ($\lambda_{ADJ} > 1000$).

Discussion

In generating a response, participants first made a decision as to express the size of the snake as being large or small. In order to express this idea, they had to select one end of the size dimension that could capture this idea. If they wanted to express the idea that the snake was large, they would have to compare it to

something smaller. If they wanted to express the idea that the snake was small, they would have to compare it to something larger. This decision was made independent of what animal was large and what animal was small. After making this decision, they then anchored their response to whatever animal occupied the appropriate foil they chose.

In support of this interpretation, the findings clearly showed that participants repeated referent sizes. When the bird and the fish changed size from one trial to the next, there was a strong tendency for participants to avoid repeating the animal they had used on a previous trial. Instead, they preferred to change animals. If a participant compared the snake to the larger animal on one trial, he preferred to compare the snake to the larger animal again, even if the larger animal was no longer the same. This finding was quite unexpected because any tendency to switch nouns must have overcome any lexical priming effects. The evidence suggests, then, that what speakers were doing was much more than just selecting which words to use.

I propose that speakers created relational schemas and that this was what they were repeating. A relational schema can be thought of as an abstract description of the comparison, and developing a schema in any given instance may be construed as a series of nested decisions. First, one must select the dimension of comparison (e.g., as the operation COMPARE(SIZES)). After the dimension is selected, attention is focused on a particular foil (e.g., FOCUS-ON(LARGE)). Following this, an anchor object is selected to form the basis of the comparison. In the present task, the anchor object was selected from the

display on the basis of the foil. For example, if the foil was LARGE, the anchor object would have been the large animal. This in turn dictated the comparison that had to be used. Thus, the relational schema must be something like:

COMPARE (SIZES)

FOCUS-ON (LARGE)

ANCHOR-IS (BIRD)

SMALLER-THAN (SNAKE, ANCHOR)

I assume that all three of these components must be included in the construction of the preverbal message. The schema must have a dimension, a foil, and a referent.

The results of the response latencies were unexpected. A likely explanation is that before participants could generate a response, they had to first perceptually parse the scene and that this process was faster if aspects of the scene remained the same from the previous trial. In particular, the fastest response latencies occurred in those conditions in which the sizes of all three animals were the same as on a preceding trial. If the size of the snake changed, however, then the time it took participants to initiate a response slowed considerably. Speakers were also just as slow to initiate a response when all three animals changed size compared to when just the snake changed size. If the slow down in response latencies was the result of having to use a different word (either a different noun or a different adjective) then the response latencies for when participants switched both the noun and adjective should have slowed as well. The failure to find this results suggests that effect was not at the lexical level.

Chapter 7. Experiment 3

The purpose of the present experiment was to further investigate the structure of preverbal messages involving comparisons by examining the effect that lag has on the tendency to repeat relational schemas. In this experiment, lag was manipulated in order to assess two accounts of why relational schemas were repeated. Lag as it is being used here refers to the number of intervening trials between responses on test trials. A lag of zero, for example, means that there are no intervening trials between test trials, while a lag of one means that there is one intervening trial.

Studying the effects of lag has proven useful in understanding and differentiating many phenomena. Semantic priming commonly dies off after lags of one or two, whereas perceptual priming has been observed across many lags (McNamara, 2005), suggesting these are different mechanisms. Syntactic repetition effects have been found across lags of 10 when responses are spoken (Bock et al., 2007; Bock & Griffin, 2000) but not when they are written (Branigan, Pickering, & Cleland, 1999), suggesting that writing and speaking place different demands on the language producer. Also, syntactic priming has been observed across many lags when the dependent variable is the choice of structures produced but not when it is latency of response (e.g., Smith & Wheeldon, 2001; Wheeldon & Smith, 2003). While no compelling reason for why this difference exists, this it useful to researchers because it offers new phenomenon to explore. Finally, different explanations of syntactic repetition

make different predictions with respect to the effects of lag (e.g., Bock & Griffin, 2000; Pickering, & Branigan, 1998). So, knowing whether a repetition effects survives across lags or can tell us something about the underlying mechanisms behind the effect.

One explanation for the repetition effect is that relational schemas are constructed in working memory and will be repeated so long as they are still available. During the construction of a preverbal message, the speaker has to make a number of decisions about what to say and how to say it. With respect to relational schemas, the products of these decisions are operations like, COMPARE (SIZES), FOCUS-ON (LARGE), and ANCHOR-IS (BIRD). Once made, these operations remain active, but only for a very short period of time. If another comparison can be made within this short time period, then it should be easier for the speaker to reuse these operations than to construct new ones. As a consequence, he should be more likely to repeat schemas. If, however, the speaker shifts his attention to a different task, such as constructing an unrelated message, then the contents of working memory will be displaced by the contents of the new task. When it comes time to produce another comparison, the previous schema will no longer be available, and the speaker will have to construct a new relational schema. As a result, the speaker will be just as likely to use the same schema as they will be to switch to the alternate.

A second possibility is that the operations that comprise each relational schema exist in long-term memory. The combination of the stimuli a speaker sees along with the intention to describe these stimuli in a particular way establishes a

retrieval cue to specific information in long-term memory. For example, an intention to describe a display containing a very large snake and a large bird would be linked to the set of operations that lead to the preverbal message, BIGGER-THAN (SNAKE, BIRD). The intention to describe a display containing a small fish, a medium-sized snake, and a large bird, could be described in more than one way, so it would be linked to two sets of operations. One set leading to the production of the preverbal message, SMALLER-THAN (SNAKE, BIRD) and the other leading to the production of the preverbal message, BIGGER-THAN (SNAKE, FISH). When a speaker has the same intention to describe the same stimuli, the retrieval cue he constructs accesses the same operations he used previously. The result is a tendency to repeat comparisons. When short-term working memory is interrupted with a secondary task, such as producing a different message, then the retrieval cues linking the intention to describe a particular visual scene to specific operations are lost. However, they can quickly be regained by establishing new retrieval cues in working memory, such as asking speakers to compare the same three objects again. Providing that the long-term representations decay slowly, one might expect that the most recent information in long-term memory will be accessed faster, or more easily, and so will be more likely to be chosen. Therefore, this long-term memory account predicts that repetition effect will be found beyond lags of zero.

In this experiment, participants were again shown three objects on a computer screen and told to compare the object in the middle (a cross) to one of the two other objects (a circle and a cylinder). Unlike the first two experiments

where speakers produced the same type of comparison on every trial, in this experiment speakers had to produce two kinds of comparisons, one concerning the size of the objects and the other concerning the colour of the objects. Relational schemas, as hypothesized, contain three nested decisions. The outermost decision determines the dimension of comparison. By asking participants to make comparisons based on size and colour, they should be generating two different relational schemas.

The same stimuli were used in both the colour and the size comparison tasks. Participants were told to compare the objects in terms of their size when they saw the word "size" at the top of the computer screen, and to compare their colour when they saw the word "colour" at the top of the computer screen. The advantage of using the same stimuli is that it provides tight control over any potential perceptual differences between the two tasks. Any tendency to repeat cannot be attributed to differences in the stimuli themselves, and so must be due to the messages participants are constructing. In order to keep the two tasks clear in their minds, participants were told to use different words to name the same stimuli on the two different tasks. When the task involved size comparisons, participants were told to use the words, "cup," and "plate" to refer to the circle and the cylinder. When the task involved colour comparisons, participants were told to use the words, "tube," and "spot."

To summarize, if relational schemas are constructed in short-term memory, then repetition effects of the same magnitude should be found in this experiment, but only at lags of zero. If, however, relational schemas are stored in

long-term memory, then it should be possible to find repetition effects that survive across lags of one and possibly, two.

Method

Participants

Twenty-five University of Alberta students served as participants in this experiment. All were native English speakers and all had normal or corrected-to-normal vision. Two participants made an unusually high number of speech errors (more than twenty percent speech errors in at least one task) so their data was excluded from the analysis. The final analysis was based on the data from twenty-three individuals.

Materials and Apparatus

Stimuli consisted of pictures of a cylinder, a cross, and a circle. An example of the stimuli can be seen in Figure 7.

The objects were presented in five different sizes and five different colours. The five sizes were: very small (1.4° x 1.4° degrees of visual angle as viewed 60 cm from the computer screen), small (2.9° x 2.9°), medium (4.8° x 4.8°), large (3.8° x 6.7°), and very large (8.1° x 8.1°). The circle was always small, the cylinder was always large, and the cross was either very small, medium, or very large. The five colours were: white (luminance was 45.16 cd/m^2), light grey, (35.84 cd/m^2), medium-grey (22.58 cd/m^2), dark grey (8.96 cd/m^2), and black (4.48 cd/m^2). The circle was always light grey, the cylinder was always dark grey, and the cross was either white, medium-grey, or black. The background

luminance of the computer screen was 45.16 cd/m^2. The cylinder and the circle appeared 8.5° of visual angle to the left or right of the cross, measured centre to centre.

Participants were instructed to compare the objects in terms of their size whenever the word "size" appeared at the top of the computer screen and to compare the objects in terms of their colour whenever the word "colour" appeared at the top of the computer screen. Both words were presented 7.1° of visual angle above the cross as measured from the center of the cross to the center of the word. Both words were presented in Arial Black. The names, "cup," "tube," "plate," and "spot," were displayed 10.7° of visual angle below the objects they labeled, as measured from the center of the cross to the center of the word. The luminance of all four words was 28.45 cd/m^2.

The stimuli were displayed on a 400 Mhz PowerPC G4 apple computer monitor, and the experiment was run using the ESExpt program (Dixon, 2009).

Procedure

Participants were told that throughout the experiment they would see pictures of three objects. They were told that when the word "size" appears at the top of the computer screen they should compare the object in the middle to either the object on the left or on the right in terms of its size. Specifically, participants were told to imagine that they were helping a carpenter who was building a table. The centerpiece for the table was to be a cross, but the carpenter didn't know how big he should make the cross. There was also going to be a medium-sized cup and a small plate on the table. Participants were instructed to tell the carpenter

whether the cross was bigger or smaller than either the cup or the plate. When the cross was very small, participants were told to always compare it to the plate, when the cross was very large, participants were told to always compare it to the cup, and when it was a medium-sized they were told that they could compare the cross to either the plate or the cup.

Participants were then told that when the word “colour” appears at the top of the computer screen they should compare the object in the middle to either the object on the left or on the right in terms of its colour. They were told to imagine that they were helping an artist who was painting a still life of some common objects. In the center of the painting was going to be a cross, but the artist didn't know how light or dark he should paint the cross. There was also going to be a spot of light, and a tube of paint in the painting. Participants were instructed to tell the artist whether the cross was lighter or darker than the tube or the spot. When the cross was white, they were told to always compare it to the spot, when the cross was black, participants were told to always compare it to the tube, and when it was a medium-grey they were told that they could compare the cross to either the spot or the tube.

Participants were given the instructions for the colour task first followed by three examples of how they should respond in this task before they were given the instructions for the size task (which also had three examples). In order to provide a gradual transition to the experiment, participants were then given 48 practice trials divided into two parts. In the first part, the names of the objects appeared at the bottom of the computer screen along with the three objects. Thus,

participants could see what object names they were supposed to use. In second part, the names were not presented. During the practice trials the experimenter monitored what the participants said checking to see if they were able to recall the correct names and answering any questions if necessary. If a participant needed more practice after the 48 practice trials were completed, then the experimenter quit the program and restarted it from the very beginning, cycling through another 48 practice trials. Almost all participants, however, were able to remember which names went with which tasks after the first part of the practice. After the experiment was finished, each participant was given a brief questionnaire in order to identify whether or not she or he was a native speaker of English.

Design

The experiment contained 360 trials divided into two blocks of 180 trials each. Within both blocks there were 90 colour trials and 90 size trials. The colour trials were separated by zero, one, or two size trials. Two trial sequences were coded. In one sequence, a colour trial followed a size trial. In the other, a size trial followed a colour trial. These two sequences were and randomly selected for each participant with replacement. The probability of a colour trial following another colour trial (and conversely of a size trial following another size trial was 0.25. The probability of a colour trial being separated by one size trial (or of a size trial being separated by one colour trial) was 0.5. The probability of a colour trial being separated by two size trials (or of a size trial being separated by two colour trials) was 0.25. The order of task and lag number was randomized for each participant in each block.

Within the colour task, the colour of the cross was randomly determined on each trial for each participant. The probability of the cross appearing black was 0.25, the probability of it appearing white was 0.25, and the probability of it appearing medium-grey was 0.5. The colour of the cross as well as the side on which the tube and spot appeared was randomly determined on each trial for each participant. Within the size task, the probability of the cross appearing small was 0.25, the probability of it appearing large was 0.25, and the probability of it appearing medium-sized was 0.5.The size of the cross as well as the side in which the cup and plate appeared was randomly determined on each trial for each participant.

This was an entirely within-subjects design. Lag was an independent variable, while the choice of noun and adjective on the previous same-task trial were predictor variables. The dependent variables were choice of noun and adjective on the current same-task trial.

Data Analysis

The data were fit to theoretical models using linear mixed effects analysis, and the adequacies of their respective fits were compared using likelihood ratios adjusted for differing degrees of freedom. Subject was included as a random effect and both the repetition effect for noun and adjective were allowed to vary independently over subjects.

Results

On average, 5.9% (SD = 3.1) of all responses were speech errors, 0.6% (SD = 0.7) were judgment errors and 0.9% (SD = 1.6) were anchoring errors.

Within the colour task, 5.7% (SD = 3.2) were speech errors, 0.6% (SD = 0.8) were judgment errors and 0.9% (SD = 1.7) were anchoring errors. Within the size task, 6.1% (SD = 3.0) were speech errors, 0.6% (SD = 0.6) were judgment errors and 0.9% (SD = 1.6) were anchoring errors.

Colour task.

The average repetition effect for the colour task, presented in logits, can be seen in Figure 8. The figure appears to show that the large noun repetition effect quickly disappears at lag 1 but that the adjective repetition effect may survive across all three lags. Four models of theoretical interest were constructed and their relative fits to the data were compared. The first model included only an effect of lag. The second included an effect of noun at lag zero only. The evidence was strongly in favour of the model that included the effect of noun ($\lambda_{Adj} > 1{,}000$). A third model added a main effect of adjective. When this was compared to the second model, the evidence was in favour of the model that included the effect of adjective ($\lambda_{Adj} = 3.19$), although the evidence was not overwhelming. A fourth model included three main effects, one of lag, one of nouns, and one of adjectives. When compared to the third model, the fit for this model was much worse than if the effect of noun was limited to just lag 0 ($\lambda_{Adj} < 0.001$). Thus, the model that provided the best fit for the data included an effect of adjective across all three lags and an effect of noun, but only at lag zero.

Size task.

The average repetition effect in the size task, presented in logits, can be seen in Figure 9. The graph shows a similar pattern of results as in the colour task.

There appears to be a large noun repetition effect at lag zero disappearing at lag 1, accompanied by an effect of adjective across all three lags. The same four models used in the colour task were constructed and how well they fit the data was compared.

The first model included only an effect of lag. The second included an effect of noun at lag zero only. The evidence was strongly in favour of the model that included the effect of noun ($\lambda_{Adj} > 1{,}000$). A third model including a main effect of adjective fit the data better still ($\lambda_{Adj} = 4.13$). A fourth model included three main effects, one of lag, one of nouns, and one of adjectives but was a much worse fit to the data than if the effect of noun was limited to just lag 0 ($\lambda_{Adj} < .001$). Thus, the model that provided the best fit for the data included an effect of adjective across all three lags and an effect of noun, but only at lag zero.

Discussion

When participants were given two of the same tasks in a row (e.g., colour task followed by another colour task), there was a large tendency to repeat nouns. This effect was similar in magnitude to the noun repetition effect found in the first two experiments. However, one single intervening trial was enough to eliminate this large repetition effect. The repetition effect disappeared both when participants performed a size comparison task and when they performed a hue comparison task.

These results are consistent with the idea that relational schemas were constructed in short-term working memory. When a speaker constructed a

preverbal message involving a comparison, he made a number of decisions about what he was going to say. For example, he decided whether he was going to compare two objects in terms of size or hue, and whether he would compare the size of one object to something smaller that it or to something larger than it. These decisions determined what kind of message he was going to express, for example, whether he was going to say, "The cross is bigger than the plate," or "The cross is darker than the spot." The operations that went into the construction of a preverbal message remained active in working memory, but only for a short period of time. If the speaker had to generate another comparison of the same kind (i.e., two hue comparisons in a row, or two size comparisons in a row) then the operations in a previous relational schema should still have been available. Because it is easier to reuse an available schema than it is to construct a new one, the speaker was more likely to repeat the schema he used from a preceding trial. If, however, he had to generate a new message, then the contents of working memory were replaced by the operations being constructed for the new message.

Whereas the large noun repetition effect disappeared after lag one, the tendency to repeat adjectives seems to have survived across two intervening trials. This suggests that there were two different mechanisms influencing what speakers chose to say. I propose that there was a short-lived repetition effect that was the result of schemas being maintained in working memory, and another overlapping lexical repetition effect. The lexical repetition effect involved some form of long-term memory priming and may have involved both adjectives and nouns.

There is, however, an alternative explanation for the present results. It is

still possible that the operations that went into the construction of a relational schema existed in long-term memory, but that the retrieval cues that accessed them were insufficiently distinctive. While the stimuli participants saw throughout the experiment were the same, the responses they had to produce to these stimuli differed according to task. Assuming that retrieval cues are constructed automatically from a combination of speakers' intentions and the stimuli they saw, the retrieval cues that accessed different schemas in the present experiment would have been very similar. When participants were faced with two of the same tasks in a row, the preceding schema may have overcome any competition from the alternate schema, and so speakers repeated schemas when the lag was zero. However, after an intervening trial, they would have had to access a different schema. Now the previously generated schema no longer has any advantage over its alternative. The result would also have been a loss of the repetition effect.

Chapter 8. Experiment 4

A fourth experiment was conducted to determine whether the repetition effect would survive when participants have to produce different messages to different stimuli on the intervening trials. In this experiment, as in Experiment 3, participants saw three objects and were told to compare the object in the middle to one of the other two in terms of either its size or its hue. Unlike Experiment 3, where they always saw the same three objects, in this experiment participants saw different stimuli depending on whether they were engaged in a colour task or in a size task. On half of all trials participants were shown pictures of the same cylinder, circle, and cross as in Experiment 3. They were instructed to always compare these objects in terms of their hue. On the other half of all trials participants were shown pictures of the snake, bird, and fish from Experiments 1 and 2. They were instructed to always compare these objects in terms of their size.

If the operations that go into the construction of a preverbal message involving a comparison are maintained in short-term working memory, then the repetition effect should be present at a lag of zero, but disappear at lags of one and two just as it did in Experiment 3. If however, these operations exist in long-term memory and the retrieval cues that accessed these operations were insufficiently distinctive, then the repetition effect should appear in this experiment at lags greater than zero.

Method

Participants

Twenty-four University of Alberta students served as participants in this experiment. All were native English speakers and all had normal or corrected-to-normal vision. The data from one participant was not included in the analysis because he was not following instructions; thus, the analysis is based on the data from twenty-three participants.

Materials and Apparatus

There were two sets of stimuli used in this experiment. One set included the same pictures of a snake, bird, and fish used in Experiments 1 and 2. The stimuli, their dimensions, and the means of presentation were the same as in Experiment 1. The other set of stimuli consisted of line drawing of a cylinder, a circle, and a cross. These stimuli, their dimensions, and the means of presentation were the same as in the colour task of Experiment 3.

The stimuli were displayed on a 400 Mhz PowerPC G4 iMac computer monitor and the experiment was run using the ESExpt program (Dixon, 2009).

Procedure

All aspects of the procedure was the same as in Experiment 3, with the exception that rather than giving participants a cue word informing them whether to compare the pictures in terms of size or colour, they were told to always compare the pictures in terms of size when they saw animals and to compare the pictures in terms of colour when they saw the circle, cross, and cylinder.

Participants were then shown three examples on the computer illustrating when each type of response should be made.

Participants were told that they would not know in advance which trial type they were going to see. They were given 18 practice trials, during which time the experimenter checked to see if they were able to recall the proper names and answered any questions if necessary. (None were asked.) After the experiment was finished, each participant was given a brief questionnaire in order to identify whether or not she or he was a native speaker of English.

Design

The experiment contained 456 trials divided into two blocks of 228 trials each. Within a block of trials there were 114 colour (experimental) trials and 114 size (filler) trials. Experimental trials were separated by zero, one, or two filler trials. One third of the experimental trials were separated by zero intervening trials, another third of the trials were separated by one intervening trial, and a final third were separated by two intervening trials. The order of task and lag was randomized for each participant in each block.

Within the color task, the probability of the cross appearing black was 0.25, the probability of it appearing white was 0.25, and the probability of it appearing medium-grey was 0.5. The side on which the tube and spot appeared was randomly determined on each trial for each participant. Within the size task, the probability of the snake being small was 0.25, the probability of it being very large was 0.25, and the probability of it being medium-sized was 0.5. The side in which the fish and bird appeared was randomly determined on each trial for each

participant.

This was an entirely within-subjects design. The independent variable was lag and the predictor variables were choice of noun and adjective on the previous experimental trial. The dependent variable was the choice of noun and adjective on experimental trials.

Data Analysis

The data from experimental trials were fit to theoretical models using linear mixed effects analysis, and the models were compared using likelihood ratios adjusted for differing degrees of freedom as explained previously.

Results

On average, 3.4% (SD = 3.1) of all responses were speech errors, 2.2% (SD = 1.7) were judgment errors and 1.8% (SD = 2.4) were anchoring errors. Within the color task, 3.2% (SD = 4.6) were speech errors, 1.3% (SD = 1.3) were judgment errors and 1.1% (SD = 2.2) were anchoring errors. Within the size task, 3.7% (SD = 3.5) were speech errors, 0.9% (SD = 0.8) were judgment errors and 0.7% (SD = 0.9) were anchoring errors.

The tendency to say "*The cross was lighter than the cup*" as a function of previous noun and adjective across all three lags can be seen in Figure 11. The graph appears to replicate the findings from Experiment 3, showing a large repetition effect of noun at lag zero accompanied by a repetition effect for adjective across all three lags. Four models of theoretical interest were constructed and their fits to the data were compared.

The first model that was constructed included a main effect of lag only.

The second model added an effect of noun at lag zero only and provided a much better fit to the data ($\lambda_{Adj} > 1{,}000$). A third model that included a main effect of adjective fit the data better still ($\lambda_{Adj} = 508.52$), while a model that included a main effect of noun with a main effect of adjective and of lag provided a much poorer fit to the data ($\lambda_{Adj} < .001$). Thus, the best fitting model was one that included an effect of adjective at all three lags and an effect of noun at lag zero only.

Combined Data from Colour Task in Experiment 3 with Data from Colour Task in Experiment 4

The results of Experiments 3 and 4 were combined and re-analyzed to see if it was possible to obtain a clearer picture of the results at lags one and two. Visually inspecting the data, the results of Experiments 3 and 4 seemed to be similar. However, the evidence for repetition effects at lags past zero tended to be weak. One reason for this may have been that there were relatively few trials at lags 1 and 2, and small effects may have difficult to discern. If more data were used in the analysis, then it might be possible to obtain a clearer picture of what the results might be. It is possible to combine the data from the colour task in Experiment 3 with the data from the colour task in Experiment 4 because participants saw the same stimuli and made the same comparisons in both. Although the nouns participants used were different, the stimuli and the adjectives were the same. Thus, it is possible to match responses made to stimuli in Experiment 4 with the responses made to stimuli in Experiment 3.

The average repetition effect for the data from Experiments 3 and 4 can be

seen in Figure 12. The figure now shows a more stable effect of adjective at lags one and two along with the large repetition effect of noun at lag zero. A model that included an effect of lag was compared to one that added an effect noun at lag zero. The evidence was strongly in favour of the model that included the effect of noun ($\lambda_{Adj} > 1{,}000$). A model that added a main effect of adjective fit the data better still ($\lambda_{Adj} > 1{,}000$). Finally, there was strong evidence against a model that included a main effect of noun along with an effect of adjective and of lag, over one that limited the effect of noun to lag zero ($\lambda_{Adj} < .001$).

Discussion

In two experiments and in two different tasks (one a size comparison another a colour comparison task), participants showed a large tendency to repeat comparisons to the same referent hues (or sizes) from the preceding trial. This repetition effect, however, was very short lived. After only one intervening trial, this tendency to repeat comparison to objects of the same size or hue disappeared. Taken with the results of Experiment 3, these results are consistent with the view that relational schemas are constructed in short-term working memory. Speakers repeat relational schemas when the operations used to generate a preverbal message are available in working memory. Speakers repeat schemas because it is easier to reuse an active structure than to construct one from scratch. So, there is a repetition effect at a lag of zero. However, if the contents of working memory shift, then the operations that went into the construction of a former relational schema are no longer available, and the speaker has no choice but to generate a

new schema. He is now just as likely to use a different schema than he is to use the same schema because both describe the situation equally well. The result is the loss of the repetition effect at lags of one and two. This was true both when the same stimuli were associated with different messages (Experiment 3) and when different stimuli were associated with different messages (Experiment 4).

Interestingly, the adjective repetition effect persisted across two lags. Furthermore, the magnitude of this effect did not seem to be affected by lag. This provides additional support that there were two mechanisms affecting how speakers responded. There are several reasons to think that the longer lasting repetition effect was lexical. First, most other variables that might have influenced how speakers responded were controlled. Speakers produced sentences with the same number of conceptual roles, the same thematic roles, and the same syntactic structures. Second, many other studies have shown that lexical repetition effects can survive across many intervening trials and across long intervals. For example, Monsell (1985) has shown that speakers are faster to name words they have named before, even when there have been as many as 100 intervening trials between responses. While this effect represents repetition priming and not a repetition effect as I have defined them, this finding still suggests that benefits to accessing words can last a great deal of time. Finally, there was some suggestion of lexical repetition effects in Experiment 2. In that experiment, responses were more likely when speakers repeated relational schemas and lexical items, compared to when they repeated just relational schemas. This finding shows that there was some additional benefit that could not be explained simply by repeating

relational schemas alone.

Finding evidence for two mechanisms that influence what speakers choose to say has important implications for theories of speech production. Most models of production assume, either explicitly or implicitly, that speech begins with the formulation of a preverbal message and that this message determines which lexical concepts are activated. Finding that speakers sometimes repeated lexical items and not schemas suggested that preverbal messages were not the sole determinant of what was said.

I propose that the production of a response began with the formulation of a preverbal message but that activation spread to lexical items before the preverbal message had been completely formulated. Most of the time, production proceeded in a top-down manner with the propositions that comprised a relational schema determining which words were chosen for expression. Sometimes, however, individual words were highly activated and influenced how messages were constructed. In other words, there was feedback from lexical items to the preverbal level. This idea is similar to other cascading models of production that incorporate feedback (e.g., Dell, 1986) except that feedback is being fed into the message-generation stage of production.

With respect to the present experiments, this means that speakers began formulating a response by making the decisions necessary to generate a preverbal message. In particular, speakers began by making the three decisions that were needed to formulate a relational schema. As these decisions were being made, some activation from words such as, “bird,” “fish,” “bigger,” and “smaller”

spread upward into the preverbal message level and influenced which referent was selected. This in turn determined which preverbal message was chosen. For example, if the word “fish” was highly activated, it may have caused the preverbal message BIGGER-THAN (SNAKE, FISH), to be chosen over the alternative, SMALLER-THAN (SNAKE, BIRD). Most of the time, the decisions that were made were determined by what decisions preceded each level. So, the choice of which referent to use was made based on which foil had been selected. However, sometimes, there was enough activation being received from the lexical level to influence which referent was used. In this way, both the words and the propositions that went into producing a response were activated, and that both influenced what speakers choose to say.

Chapter 9. General Discussion

The purpose of this, the final chapter, is to explain what new knowledge has been gained about how speech is produced. This chapter will be divided into five sections, each of which will deal with important implications related to relational schemas and speech production. In the first section I will explain relational schemas. The most important finding of this dissertation was that speakers used these schemas to construct preverbal messages involving comparisons. So, it will be important to understand what these structures are and how speakers use them. I will explain that relational schemas are abstract descriptions of the comparative process, that they are comprised of three nested decisions, and that all three decisions are necessary in order to produce a message involving a comparison.

In the second section, I will explain why speakers repeated relational schemas. I will argue that schemas were constructed in working memory. When they were available, speakers were more likely to reuse a schema rather than construct a new one. This is why there were strong tendencies to repeat schemas in all four experiments. I will then argue that producing an unrelated message displaces the previous schema from working memory, making it unavailable to speakers. This was why the repetition effect disappeared at lags of one and two in Experiments 3 and 4.

In the third section, I will address lexical repetition effects. I will begin by reviewing the evidence for a lexical repetition effect that was distinct from the

schema repetition effect. I will explain why this result is surprising, given the reasonable assumption that speakers construct preverbal messages before they select specific words to express these messages. I will then suggest that production was probabilistic, rather than deterministic. Most of the time, speakers constructed relational schemas first and these schemas determined what words speakers produced. Sometimes, however, particular words were selected first, and a response was built around these words.

In the fourth section, I will examine the advantages and disadvantages of the methods used in the present experiments. A form of exact repetition was used in which speakers produced a small number of sentences multiple times. This methodology provided a simple yet effective means of examining the structure of preverbal messages involving comparisons. I will argue that despite some of its disadvantages this methodology offers a promising new way of investigating structures involved in speech production.

In the fifth, and final, section, I will offer suggestions for future research. In particular, I will propose specific ways in which the present findings can be replicated and extended with the production of locatives. I will then propose a number of specific experiments that could prime different alternatives for each of the three decisions that go into a relational schema. Finally, I will suggest that relational schemas may offer an alternative explanation for linguistic markedness. I will propose a specific experiment that may test this idea and explain what the potential results might mean.

Relational Schemas and Messages of Comparison

I asked two questions in Chapter 4. The first was, "Can any repetition effect that may be observed provide some insight into the structure of preverbal messages?" The second was, "How will speakers choose between two messages that are equally valid descriptions of a display they have been asked to describe?" In this section, I will focus on answering just the first question. In the following section, I will focus on answering the second question. The answer to the first question is yes. Speakers constructed messages based on structures I have called "relational schemas." A relational schema is a way of describing the process of constructing a preverbal message that involves a comparison. This process involves three different types of decisions. One decision is needed to determine which dimension is going to be used in the comparison. For example, a speaker must decide whether he is going to compare two objects in terms of their sizes or their hues. Another decision is needed to determine what value along this dimension will act as a foil in the comparison. For example, the speaker must decide whether to compare a snake to something large or to something small. Or, a speaker must decide whether to compare a cross to something light or dark. Finally, another decision must be made to determine what referent will be used as an anchor in the comparison. So, if a speaker is going to compare a snake to something small, then he must select an animal (or some other object) that can convey the value, "small."

One might object, however, that it is perceptual saliency that is driving the repetition effect and not any tendency to repeat relational schemas. For example,

the larger picture might be more likely to attract participants' attention than the smaller picture, or it might be easier (or faster) to process making it more likely to be chosen as an object of comparison. This would result in a tendency to repeat comparisons to the larger object even when the identity of that object (i.e., whether it is a bird or a fish) has changed. However, repetition effects for both the smaller and the larger relations were roughly the same size in Experiments 1 and 2. Also, repetition effects of the same magnitude were found in comparisons involving both hue and size in Experiments 3 and 4. Moreover, in Experiment 3, participants were making hue and size comparisons to the same stimuli. If perceptual saliency really were driving this repetition effect, this would mean that hue is as salient a perceptual cue as size. Therefore, it seems much more reasonable to conclude that participants were constructing relational schemas.

These three decisions can be represented in a propositional format. Two examples of these propositions can be seen in the columns below. Column i., contains an example of the operations used to construct a comparison involving size while column ii. contains an example of the operations used to construct a comparison involving colour. The fourth row in both columns contain the preverbal message that begins linguistic encoding.

i. COMPARE (SIZES)	ii. COMPARE (COLOURS)
FOCUS-ON (LARGE)	FOCUS-ON (DARK)
ANCHOR-IS (BIRD)	ANCHOR-IS (TUBE)
SMALLER-THAN (SNAKE, BIRD)	LIGHTER-THAN (CROSS, TUBE)

I will make three assumptions about relational schemas. The first

assumption is that all three decisions are necessary for the production of a message involving a comparison. The decision of which dimension to use is necessary because speakers need some property with which to make a comparison. There are seemingly an infinite number of ways that two objects can be compared. They can be compared in terms of quantity, quality, heat, distance, taste, texture, tactility, how much they cost, wackiness, and distance from a viewer, to name just a few. The speaker must decide which dimension is important for his purposes. Without this choice, the speaker has no basis on which to build a comparison.

The decision of which foil to focus on is necessary because all comparisons require a foil. Foils are what make a comparison a comparison. They provide the contrast needed to express particular features about a given topic. If a speaker wishes to compare X to something else in terms of its size, he has a choice of comparing X to something larger, smaller, or the same size as X. The speaker must decide which of these will fulfill his communicative intent. Without this choice, the speaker can produce an utterance (e.g., "The snake is five meters long") but it would not be a comparison.

The decision of which anchor to use, is needed in order to communicate specific dimensional values to an audience. An anchor is a specific referent that embodies the dimensional value the speaker intends to express. An anchor is a specific referent that is, for example, either tall or short, fat or thin, good or bad. If a speaker wishes to compare X to something that is "large," then an appropriate anchor will be a referent that is associated with the concept, "large" (e.g.,

elephants, planes, buildings). Without this choice, the speaker cannot communicate what foil he has chosen to his partner.

Successful communication of a comparison depends, in part, on the selection of an appropriate anchor. An anchor is appropriate when the listener is able to correctly infer the dimensional value the speaker wants him to infer. To do this, the speaker must select an anchor with which he and his listener have common experiences. If they don't, the result will be a misunderstanding. Suppose, for example, that a speaker says, "The snake is smaller than a dog." If the speaker's experience with dogs involves only chihuahuas while his partner's experience involves only Great Danes, then the size-anchor his partner infers will not be the same size-anchor as the one intended by the speaker. If, however, both the speaker and his partner have similar experiences with dogs, they will be more likely to share similar ideas of how big a typical dog is. This means that the size-anchor in the listener's mind will be of a similar magnitude to that in the speaker's mind. The end result will be successful communication (at least with respect to the size of the snake).

In addition to assuming that all three decisions are necessary, I propose that relational schemas have the same structure regardless of what is being compared. Some examples of different kinds of comparisons can be seen in sentences (i) to (x) below.

(i) Edmonton is colder than Mexico city.

(ii) Jim Kerry is wackier than John Kerry.

(iii) Edmonton is the coldest city I know.

(iv) You are the most cynical person I have ever met.

(v) India's economic growth is fast.

(vi) These sheets are clean.

(vii) Her energy is boundless.

(viii) This is yummy.

(ix) I am as cultured as you are.

(x) Mrs. Clinton was as willing as Mr. Obama to lead the country.

While these ten sentences are all comparisons, they are different kinds of comparisons. Sentences (i) and (ii) contain comparative adjectives whereas (iii) and (iv) contain superlative adjectives. It is my contention that all four would have been produced with the same kinds of relational schemas. For example, both (i) and (iii) would have begun with the selection of TEMPERATURE as a dimension for the comparison. Then, a decision had to be made with respect to which value along the temperature dimension was going to be used as a foil- HOT or COLD. In both, Edmonton is being compared to something warmer, so HOT was chosen as a foil. Finally, a decision had to be made about what anchor was going to be used to express this value. In (i), one city was selected to express this value. In (ii), however, the set of all cities was selected to express this value.

Sometimes, the anchor in a relational schema may not be explicitly stated. Examples of such comparisons can be found in sentences (v) - (viii). However, speakers must still make the same three decisions as when they are expressing comparisons that contain anchors. For example, "fast" in sentence (v), probably means with respect to other countries, and not relative to the growth of bamboo or

mountains. “Clean” in sentence (vi) probably means with respect to other bed sheets, not with respect to hospital operating rooms. “Boundless” in sentence (vii) probably means with respect to other women, not with respect to machines.

In the tasks used in the present paper, the anchor was explicit and was selected from the display on the basis of the dimensional focus. For example, if the dimensional focus was LARGE, then the anchor object would have been the large animal or the large shape. However, in real life the selection of an anchor may depend largely on the speaker’s conceptual knowledge. So, the comparison in (iii), may contrast India's growth to the growth of all other countries, only to developing nations, or it may involve a comparison to India’s own economic growth in the past. Which of these is the intended comparison will vary with the speaker’s personal experience, with the discourse context, and with the speaker’s communicative intent.

So far, the examples given have all involved contrast. However, relational schemas might also be used to express how one entity is like another. This too is a kind of comparison, but it is one that emphasizes similarities not differences. Examples of comparisons that involve similarity can be found in sentences (ix) and (x). The same structures that would have produced preverbal messages involving contrasts would have been used to produce messages involving similarities. For example, in sentence (x), the speaker would have first selected WILLINGNESS as a dimension in the comparison. This would have then been followed by a decision to use WILLING as a foil (as apposed to UNWILLING), because both referents in this sentence are willing to lead. Finally, Mr. Obama

would have been selected as an anchor. The difference between comparisons that involve similarities and those that involve contrasts, is that they express how a referent is like another entity (as willing as) rather than express how a topic is not like another entity (it is more, or less willing).

The third, and final, assumption that I make about relational schemas is that they can have default values. In schema theories, a default value is a value that would otherwise be true and which people assume to be true unless there is reason to think otherwise. For example, the schema for "table" probably includes a value for number of legs. If the default value for number of legs is four, then people will assume that any new table they hear of has four legs. With respect to relational schemas, a default value would be a preference to choose one foil over another. For example, a preference of speakers to choose comparisons to something small rather than something large, something short, rather than something tall, or something slow rather than something fast. I will not speculate as to the origins of such default values. Instead, I will simply assert that it is possible that such default values exist and that they may be used by speakers in the construction of relational schemas.

A default value could influence the comparisons speakers make in the following way. Suppose a speaker wanted to compare the size of a snake to some other animal. According to relational schema theory, the first decision he has to make is which dimension to use. In this example, the decision has already been made to use SIZE. The second decision he has to make is which value will he use as a foil in his comparison. Because his comparison involves size, he must choose

between comparing the snake to something small or to something large. If the default value is SMALL, for example, then he will be more likely to choose SMALL. This means that the anchor he will select will be something small, and the utterance he produces will have the form, "The snake is bigger than X," where X represents something smaller than the snake (e.g., a sparrow, a worm, a chihuahua).

Why Repeat Relational Schemas?

In the previous section, I answered the question of whether or not repetition effects could provide some insight into the structure of preverbal messages. In the following two sections, I will address the question of how speakers choose between two messages that are equally valid descriptions of a display they had been asked to describe. Predominantly, the way that speakers made their choices was by repeating relational schemas they had used in a preceding comparison. If, for example, a speaker had made a comparison to a large object he was more likely to make a comparison to the large object again. This was true both when repeating schemas meant repeating nouns and when it meant switching nouns.

In Chapter 8, I argued that relational schemas were constructed in working memory. Working memory is a short-duration, capacity-limited memory system that both stores and manipulates information in the service of a particular task (Baddeley, 1992; Baddeley & Hitch, 1974; Daneman, & Carpenter, 1980). With respect to the present experiments, this taskwas the construction of a preverbal message involving a comparison. The construction of these messages required a

number of decisions be made, such as which dimension, which anchor, and which referent to use. The products of these decisions can be thought of as operations such as, COMPARE (SIZES), FOCUS-ON (LARGE), and ANCHOR-IS (BIRD). Once made, these operations remained active for a short period of time. When it came time to produce another, similar, message these operations were already activated and so were more likely to be used again. Thus, speakers were more likely to repeat a relational schema they had just produced than to use an alternative schema. Importantly, this was true even though the alternate described the visual display equally well.

When speakers produce a different message, the contents of working memory were replaced with new information that were the product of decisions needed for this different message. With this shift, the operations from former relational schemas were no longer available to the speaker, and so the speaker has to start from scratch. Given that the two preverbal messages were equally valid, speakers were just as likely to select one as they were to select the other.

During the normal course of a conversation, speakers need to make many decisions very quickly. For example, speakers have to decide which speech acts to use, how to order information for expression, how to refer to entities, and what perspectives to adopt. As a conversation goes on, new referents are mentioned and new predications about old referents are made. The speaker may introduce new topics, or need to comment on a new topic his conversational partner introduced. This means that a speaker has to be able to make new decisions, and be able to express new relationships on the fly. If old operations were to remain active in the

speaker's mind, there would be a risk of him repeating what he has just said. So, it is important that the speaker be able to replace the contents of working memory rapidly as the situation warrants.

One of the ways that speakers seem to meet the demands involved in speaking is by formulating preverbal messages in small chunks. There is good evidence that speakers plan messages in units roughly corresponding to surface clauses before they begin linguistic encoding (Clark, 1994; Grimes 1975). Once this unit, or chunk of a message has been constructed, then it is passed onto the stage in which it is formulated into language. After releasing this information, the speaker is free to begin formulating the next preverbal message. The advantage of doing things this way is that there is a division of labour that speeds production. The linguistic encoder need not wait until all speech is conceptualized before starting to retrieve words, assigning them grammatical roles, and selecting syntactic structures. This implies that working memory is constantly making decisions and producing new operations to act as input for linguistic encoding. The context in speech is constantly changing. The speaker needs to be able to express these operations and then to move on to the next thought, formulate that thought, then pass that information on to the linguistic encoder, and so on. Thus, an advantageous property for preverbal messages and working memory is to be able to move on when necessary.

Evidence for Two Mechanisms

Two kinds of repetition effect were found in this paper. One was associated with a tendency to repeat only nouns, and the other was associated with

a tendency to repeat both nouns and adjectives. Three pieces of evidence support the idea that these effects reflect two different mechanisms. First, the two effects consistently had different magnitudes. One effect was quite large, approximately two logits, while the other was much smaller, approximately one-half to three-quarters of a logit. This difference was present in all four experiments. Second, one repetition effect was affected by manipulations of the sizes of referent nouns in Experiment 2, whereas the other repetition effect was not. When the sizes of the referent nouns changed, participants switched the nouns they used. However, the smaller tendency to repeat adjectives was unaffected by these changes. Third, the large repetition effect disappeared after one intervening trial was inserted between responses, whereas the smaller repetition effect remained across lags of one and two. I propose that these differences reflect evidence for two different mechanisms in production. One reflected a tendency to repeat relational schemas. This tendency was independent of lexical items, was quite large, and was short-lived. The other reflected a tendency to repeat specific words, was smaller, and was more persistent. Again, by "word," I mean any of the many representations (conceptual, semantic, lexical, phonological) that are associated with the production of a word.

In some respects this result is quite surprising. Most, if not all, theories of speech production assume that speech is produced in three serial stages, with the formulation of a preverbal message preceding, and therefore determining, the selection of words (e.g., Bock & Levelt, 1994; Dell, 1992; Garrett, 1988; Levelt, 1989; Roelofs, 1992). Suppose, for example, that a participant in Experiment 1

saw a medium-sized snake. According to this serial processing view, he would have begun by constructing a preverbal message. As was argued earlier, this would have involved making three nested decisions about which dimension, foil, and referent to use. As these are nested decisions, he would have first had to decide which foil he was going to use; would he compare the snake to the smaller or the bigger animal? This decision would then determine which referent was used, the bird or the fish. Having constructed a preverbal message such as, SMALLER-THAN (SNAKE, BIRD), activation then spreads onto the next level of production- linguistic encoding. It is at this level that a linguistic representation of the to-be-uttered sentence in constructed. The problem with this serial-processing theory is that it does not predict an independent lexical repetition effect, at least not within the present experimental paradigm.

I propose that activation cascades from the preverbal message stage to a point at which lexical items are selected and that there is some feedback from lexical items back to the preverbal stage. The idea is consistent with other theories of production that assume some form of cascading of information across various levels in production (e.g., Carammaza, 1997; Dell, 1986; Roelofs, 2003). An important feature of cascading models is that activation at a lower level in production can begin before the choices at a higher level have all been made. With respect to the present experiments, this might have meant that activation of some lexical concepts began before the preverbal message that a speaker was going to express was completely constructed. As a speaker began making the decisions involved in constructing a preverbal message, some activation spilled

down to the next level of production, activating some lexical concepts. Most of the time, the preverbal messages were constructed first, and this determined which lexical concepts were activated, and thus which words were produced. Sometimes, however, one lexical concept was highly activated and this influenced what preverbal messages were expressed.

In addition to a cascading flow of information, one more assumption is needed to explain the present results. There also needs to be some form of constraint satisfaction imposed at the preverbal message. These constraints would demand that the input coming from lexical items be appropriate to the speaker's intention and the situation he finds himself in. Such a constraint would limit this input to the lexical items that fit into the relational schema that was being constructed. So, even though a lexical concept such as, CUP, might be highly activated, it cannot fit into a relational schema that is meant to compare the size of a snake to either a bird or a fish. If, however, the lexical concept BIRD, is highly activated and it is allowed within the evolving relational schema, then it may influence which message is constructed. The fact that the schema repetition effect was so large and the lexical repetition effect much smaller, suggest that production generally proceeds from top to bottom. In most cases, it is the choice of which foil to use that determines which referent, and therefore, which lexical concept to use for expression. However, because the process is probabilistic and contains feedback, sometimes speakers' choices are determined by words and not preverbal messages. However, as I have mentioned above, this remains a

speculation and future research is needed to explain exactly why and how these two mechanisms work together to produce a given response.

Comments on the Present Methodology

Studying what happens at a preverbal stage in speech production is difficult for two reasons. If speakers are allowed total freedom to say what they want, then there may be too much variability in their responses, and it will be very difficult to measure any consistency in their responses. Bock (1996) called this the problem of "exuberant responding." If, however, speakers are told exactly how to respond, then there is the danger that of not tapping into the processes that naturally occur during normal speech production.

One solution to this problem is to limit the number of messages that speakers can produce while allowing them the freedom to choose which ones they do produce. The structure of preverbal messages can be studied by examining repetition effects across utterances. By forcing speakers to choose between repeating parts of a previous utterance (e.g., repeating either nouns or adjectives), and then observing what choices they make, it is possible to gain some insight into the structure of preverbal messages. In fact, this methodology is not that different from other methods that have been used to study speech production. In particular, in studies of syntactic repetition effects speakers are often asked to produce a prime sentence that contains one syntactic structure (usually a dative or an active or passive sentence). Researchers then measure the tendency for speakers to repeat the same structure (e.g., Arai, Van Gompel, & Scheepers, 2007; Bock, 1986; Melinger & Doebel, 2005). In my methods, speakers produce one

kind of message and then the tendency to repeat the same message is measured.

This method offers a number of advantages. First, it offers a great deal of control. Nuisance variables are a problem that all researchers must deal with. This is true whether you are studying speech production, or speech comprehension. Common nuisance variables include word length, word frequency, concreteness, and animacy. When the words produced on prime and target trials differ with respect to any of these variables, its raises the concern that these variables and not the ones of interest are responsible for any repetition or priming effects observed. So, researchers go to great lengths to match prime and target words the best as they can. The methodology I have used naturally controls for all of these variables because speakers are producing the same words.

In addition to providing control over lexical variables, the methodology I have used also provides control over many other variables that might have influenced what speakers said. The number and kinds of conceptual roles were the same across utterances, as were the thematic roles and the syntactic structures. All of these have been shown to affect what speakers choose to same under some circumstances (e.g., Bock, 1986; Griffin & Weinstein-Tull, 2003; Hare & Goldberg, 1999). However, because these variables were constant throughout each experiment (e.g., the syntactic structure of all responses were the same), the effects that these variables might have had can be discounted.

Another advantage of the present methodology is that there was no need to deceive participants about the purpose of the experiment. Some methods that are used to study speech production make it necessary to deceive participants with

respect to the true purpose of the experiment. For example, the picture description task is often embedded within the guise of a memory test (e.g., Bock, 1986). However, this then raises the question of whether asking speakers to try to remember sentences they are producing causes them to focus on the surface form of the sentences they are producing, and thereby influence how they describe these pictures. With a method such as this, it is incumbent upon the researcher to prove that this methodology was not influencing speakers' choices of which structures to use. In contrast, no such deception is necessary with the present methods.

A third advantage of the present methods is that it can easily be extended to participants and to situations that might otherwise be difficult to study. For example, the present experiments could easily be used with children. How language develops in children is an important area of research. However, when one deals with very young children, one faces a number of limitations that one does not face with adults. Children's attention spans are shorter, they may understand less of the instructions given to them, and their vocabularies are more limited. If however, they can produce simple sentences involving comparisons, then it is possible to use them as a participant in a study such as the ones I have conducted.

The present methods could be used to investigate linguistic structures that speakers would not normally produce on their own. For example, speakers almost never produce a passive sentence with an animate agent and a non-animate patient. Speakers prefer to say, “The man hit the window,” rather than, “The

window was hit by the man." If a researcher wanted to study the processes or structures that go into the construction of structures such as these, it would be very difficult to get speakers to produce these structures on their own. It might be possible to get them to produce structures using the methods.

While there are many advantages to using the present methods, there are some disadvantages as well. One possible disadvantage was the use of exact repetition. Researchers interested in isolating specific structures in speech rarely, if ever, have used exact repetition as a methodology. It is much more common to ask speakers to produce utterances that involve partial (but not exact) repetition. For example, syntactic priming studies usually examine the tendency for speakers to repeat syntactic structures across sentences that contain different content words. By varying the meanings of the two sentences, the lexical items, and phonological forms contained within, the researcher is presumably isolating the effect of the syntactic structure. Exact repetition is more commonly seen in studies on implicit memory, procedural learning, and automaticity (e.g., Challis & Sidhu, 1993; Grant & Logan, 1993; Logan, 1990; Pashler & Bayliss, 1991). In these kinds of study, the interest is on understanding whether or not people will respond faster or more accurately with repeated presentations of the same stimuli. If they do, then the focus shifts to understanding the locus of this learning effect. Does it, for example, occur during stimulus encoding? During response selection? Or during response execution?

One of the disadvantages of using exact repetition is that it is possible that speakers may be responding in a way that does not generalize to other speaking

situations. After producing the same responses many times, it may have been possible to bypass some of the stages normally involved in speech production. It may have been possible for speakers to access lexical representations, or perhaps even phonological forms, without having to first access the lexical concepts that accompany these sounds. A common experience associated with repeating a word over and over again is that the word seems to lose all its meaning, sometimes called "semantic satiation." Indeed, some participants in the present studies spontaneously commented to the experimenter after the study was finished that they felt as though the sentences they were producing had lost all meaning. Consistent with the subjective feeling that words lose their meaning, studies have shown that repeating a word over and over again can slow how these words are processed and even result in a loss of semantic priming (Sekiguchi, 1999; Smith & Klein, 1990). The implication then is that repeating the same responses multiple times may have lead speakers to generate speech that somehow bypasses the normal production processes.

While studies investigating speech production have tended to avoid using exact repetition, there is no reason why this must always be the case. Every methodology has its own limitations and no one methodology can provide all the answers. The best way forward is to use converging lines of evidence from as many different methods as is possible to use. The present methodology is, in this respect, no different. It has proven very capable of producing large, reliable effects. It has also proven to be a very simple and easy way of investigating a particular aspect of speech production that is difficult to control. However, further

research into relational schemas would certainly benefit from the use of different methodologies, such as corpora studies, scripted conversations, sentence completion, and picture descriptions in which non-exact repetition were used.

Future Directions

While few studies have examined how preverbal messages are prepared, it is an interesting and important topic of research. As Levelt (1989) pointed out, speech begins with the elaboration of an intention. This intention is the driving force behind the language we use to communicate with one another. It determines the words and syntactic structures speakers use to communicate with one another. In the present studies, for example, we saw how the elaboration of an intention to compare two objects (i.e., the construction of a preverbal message) determined which nouns and which adjectives speakers used in their comparisons. Thus, understanding how preverbal messages are constructed brings us closer to understanding how and why speakers say the things they do.

No doubt, studying how messages are constructed is a difficult undertaking. However, it is not impossible. Still, the number of studies devoted to preverbal messages are constructed is quite small compared to other topics such as how words are accessed, syntactic structures chosen, and phonological forms assembled. I have introduced one way to tap into some of these early, pre-verbal processes. There is still a great deal of work that needs to be done if the message-level is to be studied in earnest. I will now offer some suggestions as to how to proceed with research on relational schemas.

Future studies on relational schemas should attempt to replicate and

extend the findings reported in this paper. One way to extend the present results would be to examine whether relational schemas are used to produce other kinds of messages. Locatives offer a promising means. Locatives are a grammatical case that indicates where one object is relative to another. Examples of locatives include, “A is above B,” “B is below A,” “A is to the right of B,” and “B is east of A.” Locatives such as these are similar to comparisons in that they express some characteristic of an object in relation to another object. A comparison like, “A is bigger than B” expresses the size of A in relation to the size of B. A locative like, “A is above B” expresses the location of A in relation to the location of B. Locatives are also similar to comparisons in that there is some ambiguity in both. A picture of a large bird and a small snake can be described with either, “The snake is smaller than the bird,” or “The bird is larger than the snake.” Similarly, a picture of a snake above a bird can be described with either, “The snake is above the bird,” or “The bird is below the snake.” Given their similarity, it seems very likely that the same relational schemas go into constructing both comparisons and locatives. In fact, one could consider locatives as a specific kind of comparison; one in which the dimension of comparison is LOCATION.

If relational schemas are used to produce messages involving locatives, then their production should involve the same three nested decisions that are used in the production of comparisons. That is, speakers would need to decide on a dimension, a focus, and an anchor. Suppose, for example, a speaker wanted to describe the location of A in the following:

C

A

B

The first thing a speaker would have to do is to select a dimension to describe the location of A. Suppose he selected VERTICAL as the dimension. He has now chosen to describe the location of A along the vertical axis (other examples of location dimensions include HORIZONTAL, and DEPTH). The next decision the speaker must make is to select a value along the vertical dimension to act as a foil. His choices are to use ABOVE or BELOW. The third decision the speaker must make is to select a referent that can express the foil. If he selects ABOVE as a foil, then the choice of a referent in this diagram is the object in the "above" location- C. The resulting sentence will be, "A is below C."

If locatives are produced with relational schemas, then the same kinds of repetition effects that were found in this paper should be observed when producing locatives. The way to test this would be to have participants describe the location of one object relative to two other objects using the same kinds of choice and no-choice trials as in the present studies. In this hypothetical experiment, speakers will see three objects (A, B, and C), and be told to compare the location of one object, A, relative to either B or C. Across trials, speakers can repeat nouns (B, C), repeat adjectives (above, below), and sometimes they will have to choose between repeating either the noun or the adjective. The predictions are straightforward. Speakers should show a large tendency to repeat nouns when that object remains in the same location on successive trials, but they should

switch nouns when the object changes location. Furthermore, this effect should disappear after one intervening trial, and smaller lexical repetition effects for both nouns and adjectives should also be observed. Such findings would provide further evidence that speakers generate relational schemas in production.

Another avenue for future research would be to examine the relationship between lexical markedness and the tendency to repeat relational schemas. One possibility is that lexical markedness effects are really nothing more than a tendency to repeat relational schemas, and so are not really "lexical" after all. Another possibility is that they are two separate mechanisms.

According to the principle of lexical markings, the senses of certain "positive" adjectives, e.g., "big," "long," "high," "good," are stored in memory in a less complex form than the senses of their opposites, "small," "short," "low," "bad" (Clark, Carpenter, & Just, 1973). This difference in how different adjectives are stored has been used to explain why speakers tend to use unmarked adjectives over their marked counterparts. For example, Clark and Chase (1972) asked participants to describe a symmetrical picture of one object over another. Eighty percent of their participants used the word, "above" or one of its synonyms compared to the twenty percent who described the same display with the word, "below" or one of its synonyms. Clark, et al. (1973) found that people were faster to judge which of two rectangles was longer than they were to judge which of the two same shapes was shorter. Donaldson and Wales (1970) found that Scottish children learned comparisons using the adjectives, "big," "thick," and "tall," earlier (i.e., were more accurate in their responses to questions) than their

counterparts, “wee,” “thin,” and “short.” Thus, there is evidence showing that speakers prefer some adjectives over others.

This preference has been explained as a property of the words themselves. However, an alternative explanation is that this difference reflects a tendency to repeat particular choices that go into constructing relational schemas. It may be the case that default values exist for the second decision that goes into the construction of a relational schema, the decision of which foil to use in a comparison. For example, if a default value for the dimension SIZE is SMALL, then speakers will tend to choose SMALL as a foil in a comparison. The resulting utterance will involve a comparison to a smaller object. The resulting utterance will, therefore, be biased toward using the adjective “big.” Similarly, default values might exist for other dimensions. So, if default values such as THIN, SHORT, and LIGHT exist for the dimensions THICKNESS, SIZE, and DARKNESS, then speakers will tend to select these as foils, and they will be biased toward using the adjectives, “thick,” “long,” and “dark.” Thus, the presence of default values in relational schemas can explain many effects that have been attributed to lexical markedness.

However, there is an important difference between the present experiments and the experiments conducted by researchers such as Clark, which may cast doubt on this interpretation. Participants in my experiments were not free to choose the topic of their comparisons, whereas in experiments on lexical markedness they were. In all four experiments of this paper, the topic of every sentence was fixed. Speakers were told to always compare the snake, or the cross,

to another object of their choosing. However, in studies on lexical markedness, speakers were always free to select the topic of their comparisons. Fixing the topic of each sentence might have constrained how speakers construct comparisons in a way that is different that if they were free to choose the topic of each sentence. The obvious experiment to conduct is to replicate the present experiments but to allow participants to select any two objects they want.

Another avenue of research for future studies would be to examine the decisions that go into constructing relational schemas. I have argued earlier that relational schemas are comprised of three decisions. While each decision is nested within another decision, they are separate decisions. This means that it should be possible to prime each individual decision. That is, it should be possible to prime the selection of a dimension, to prime the specific foils, and specific referents. One way to test whether the first decision can be primed would be to have speakers produce comparisons involving more than one dimension (e.g., colour and size) and then let them select which dimension they use to compare two objects. Speakers should be more likely to reuse a dimension from a previous comparison than it would be to switch to a new dimension, and so the prediction is that speakers should show a tendency to repeat dimensions. For example, a speaker should be more likely to compare two objects in terms of their colour when the previous comparison they produced also involved a comparison of colours then when the previous comparison involved a comparison of size. Furthermore, this effect should be independent of the lexical items that are used in the comparisons. So, a repetition effect for dimension should be found even when

participants see different objects on every trial, provided of course that they have to compare these objects along the same two dimensions.

One way to test whether the second decision can be primed would be to have speakers respond to the same three pictures used in the present study but to vary the absolute sizes of these pictures. On every trial they should see three animals of different sizes. However, on some trials all three should be relatively small, while on other trials they should all be relatively large. Previous studies have shown a congruency effect for how participants answered questions about comparisons. For example, Audley and Wallis (1964) found that participants were faster to identify which of two lights was dimmer, when both lights were dim as compared to when both were bright. Wallis and Audley (1964) found that participants were faster to identify which of two tones was lower, when both tones were low as compared to when both were high. Ellis (1972) found that participants were faster to identify which of two people was older, when both people were old compared to when both were children. There seems to be evidence that presenting small pictures facilitates small decisions. If the three objects in the present studies were all large, this should automatically activate the concept "large." This may, in turn, make speaker more likely to select large as a foil in a comparison than its alternative, small. In other words, showing pictures of three large animals may make speaker more likely to use large as a foil, and so produce a comparison in which the snake is smaller than something else.

In conclusion, it has been argued that speakers must make three nested decisions when they construct a preverbal message involving a comparison. First,

they must select a dimension of comparison. Second, they must select a value along this dimension that will act as a foil in their comparison. Third, they must select a referent that expresses this value. These decisions are necessary and nested. In four experiments, speakers showed a large tendency to repeat comparisons to objects of the same size. They did this even when it meant overcoming a tendency to repeat words. This tendency to repeat schemas was short-lived. It was argued that this is because relational schemas are constructed in working memory. While the methods used to study the choices speakers make has its limitations, it has proven capable of producing interesting and insightful results.

Levelt (1989) has pointed out that preverbal messages are vehicles of reference and predication. Speakers intend their messages to refer to people, places, and things. They also assert and deny things about these referents. In this paper, I have shown that generating a comparison is much more complicated than simply asserting or denying things about referents. Speakers need to make several decisions in order to generate a preverbal message.

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Figure Captions

Figure 1. Dot display. Taken from Levelt (1981), Figure 4.

Figure 2. Referring expressions. Taken from Pechmann (as cited in Levelt 1989).

Figure 3. A spatial layout that can be described with a deictic, intrinsic, or extrinsic reference frame

Figure 4. An example trial sequence along with potential responses participants might have made in Experiment 1.

Figure 5. The mean proportion of the response, "The snake is smaller than the bird," as a function of the choice of previous noun and previous adjective for Experiment 1. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figure 6. The mean proportion of the response, "The snake is smaller than the bird," as a function of the choice of previous noun and previous adjective for Experiment 2. Responses are divided according to whether the noun used in the previous response was the same size or a different size as current trials. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figure 7. The time between stimulus presentation and first phoneme of, "The snake is smaller than the bird" (in seconds). Means are presented as a function of the choice of previous noun and previous adjective for Experiment 2 and are divided according to whether the noun used in the previous response was the same size or a different size as current trials. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figure 8. An example of the stimuli used in Experiment 3.

Figure 9. The mean proportion of the response, “The cross is lighter than the tube,” as a function of the choice of previous noun and previous adjective for the colour task of Experiment 3. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figure 10. The mean proportion of the response, “The cross is smaller than the cup,” as a function of the choice of previous noun and previous adjective for the size task of Experiment 3. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figure 11. The mean proportion of the response, “The cross is lighter than the tube,” as a function of the choice of previous noun and previous adjective for the colour task of Experiment 4. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figure 12. The mean proportion of the response, “The cross is lighter than the tube,” as a function of the choice of previous noun and previous adjective. Data from Experiments 3 and 4 have been combined. Error bars represent standard errors of parameter estimates that excluded the intercept. In Experiment 3, the circle was referred to as a “spot,” while in Experiment 4 it was referred to as a “disc.”

Figures

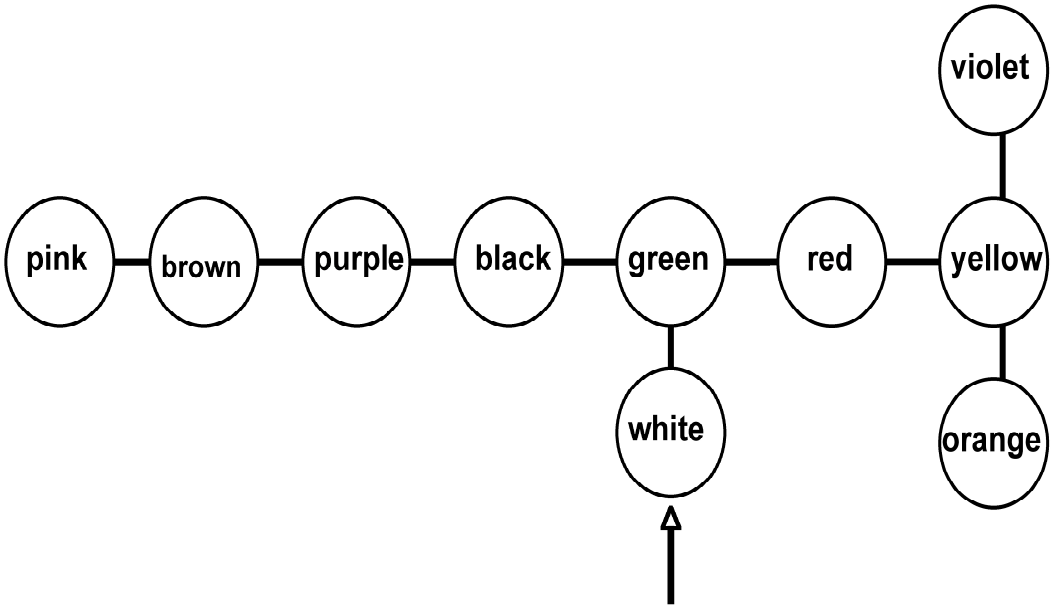

Figure 1. Dot display. Taken from Levelt (1981), Figure 4.

Figures

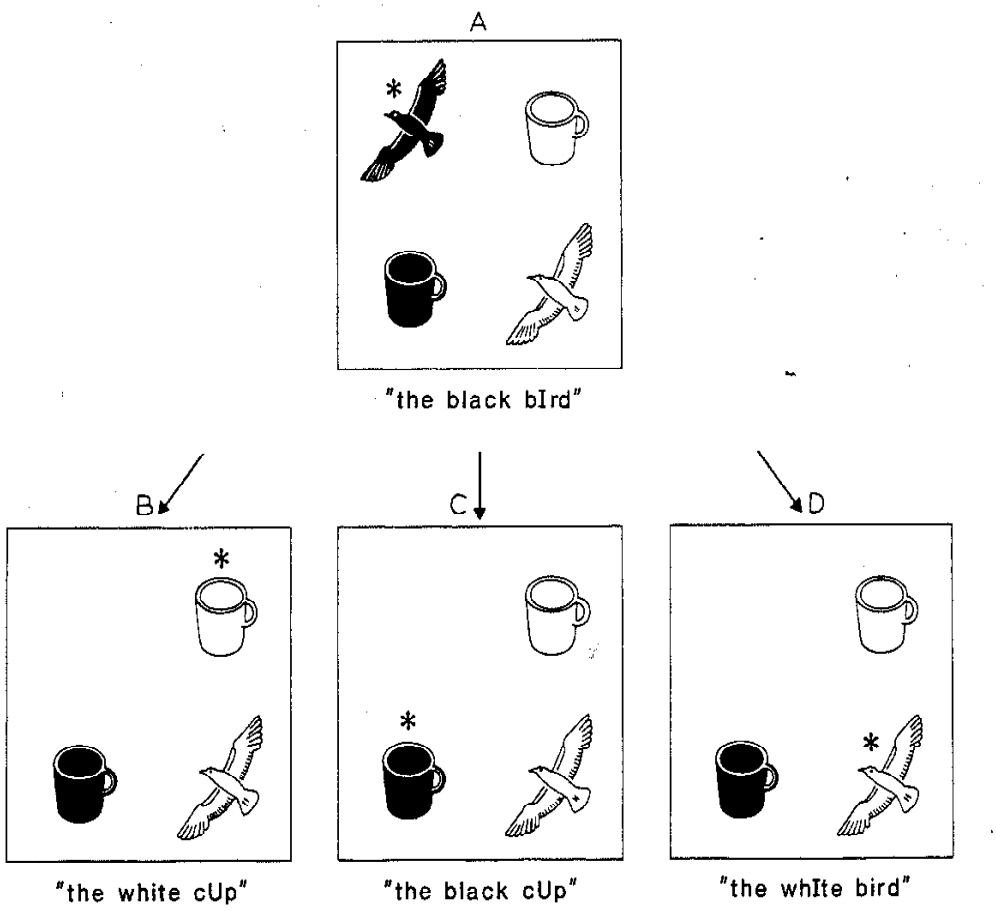

Figure 2. Referring expressions. Taken from Pechmann (as cited in Levelt 1989).

Figures

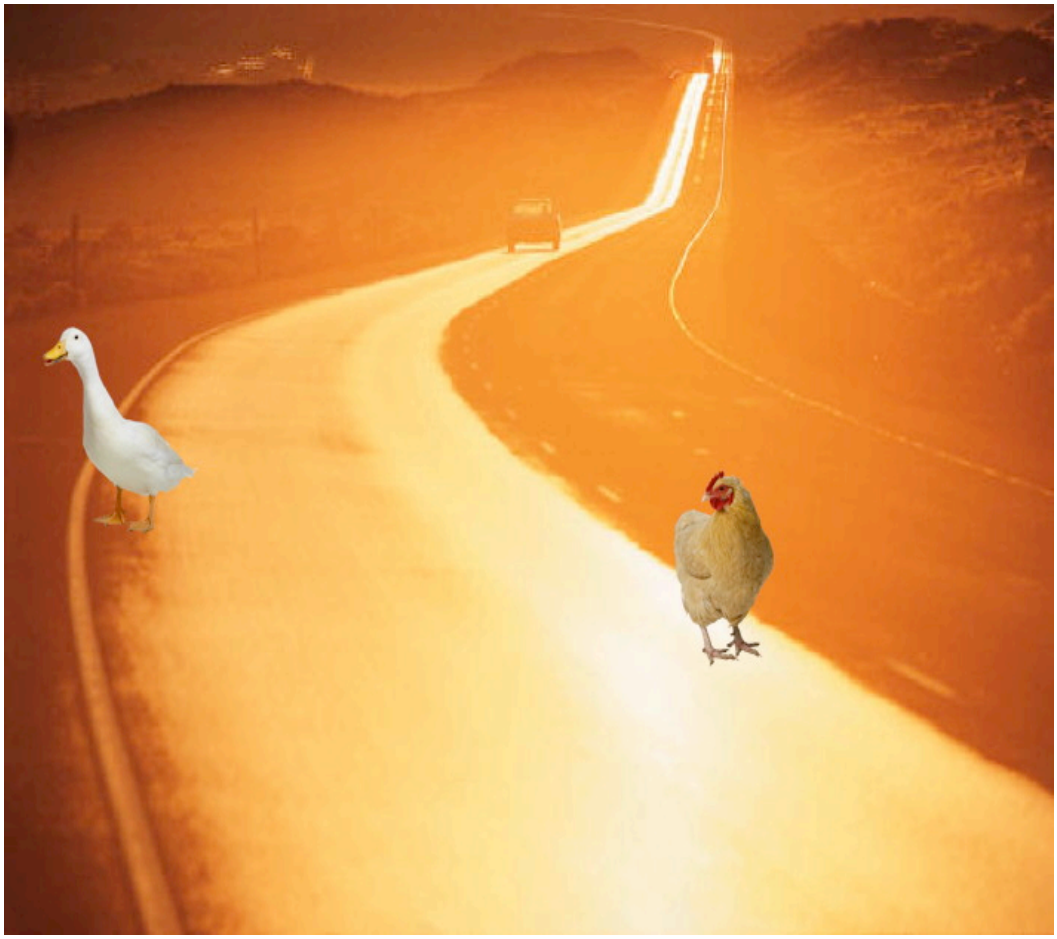

Figure 3. A spatial layout that can be described with a deictic, intrinsic, or extrinsic reference frame.

Figures

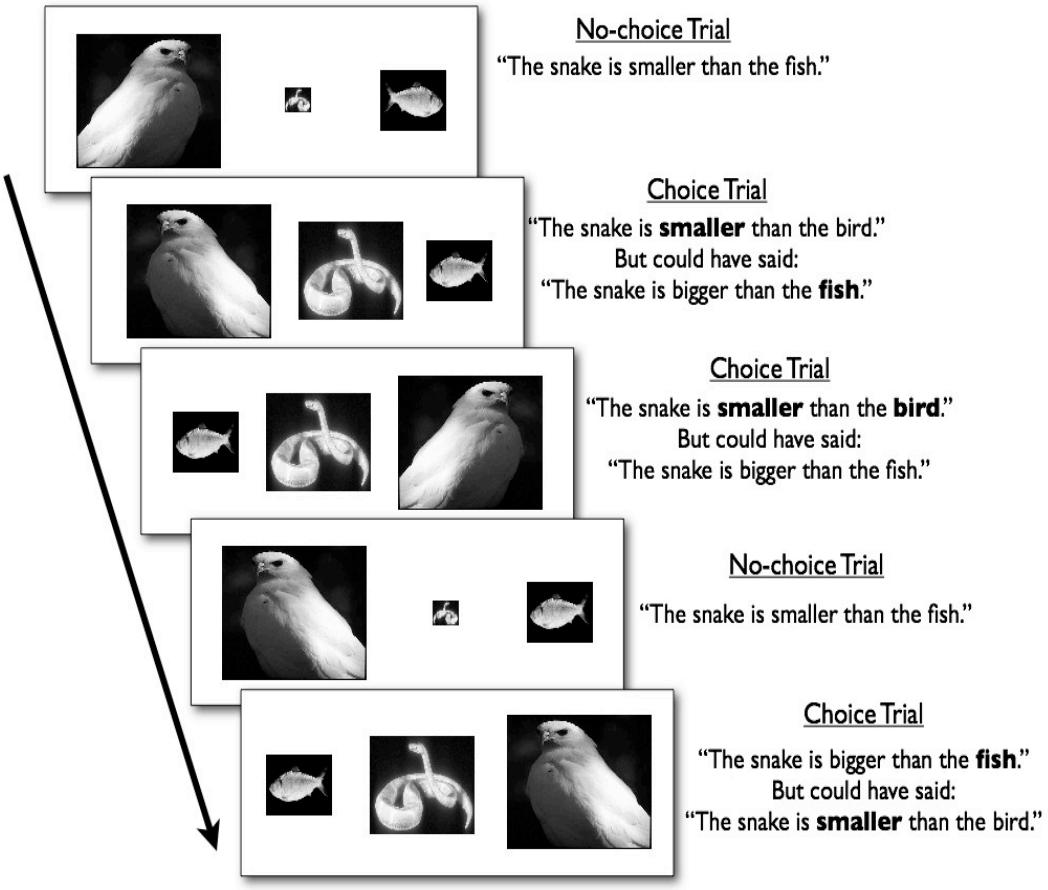

Figure 4. An example trial sequence along with potential responses participants might have made in Experiment 1. Words in bold represent repetitions.

Figures

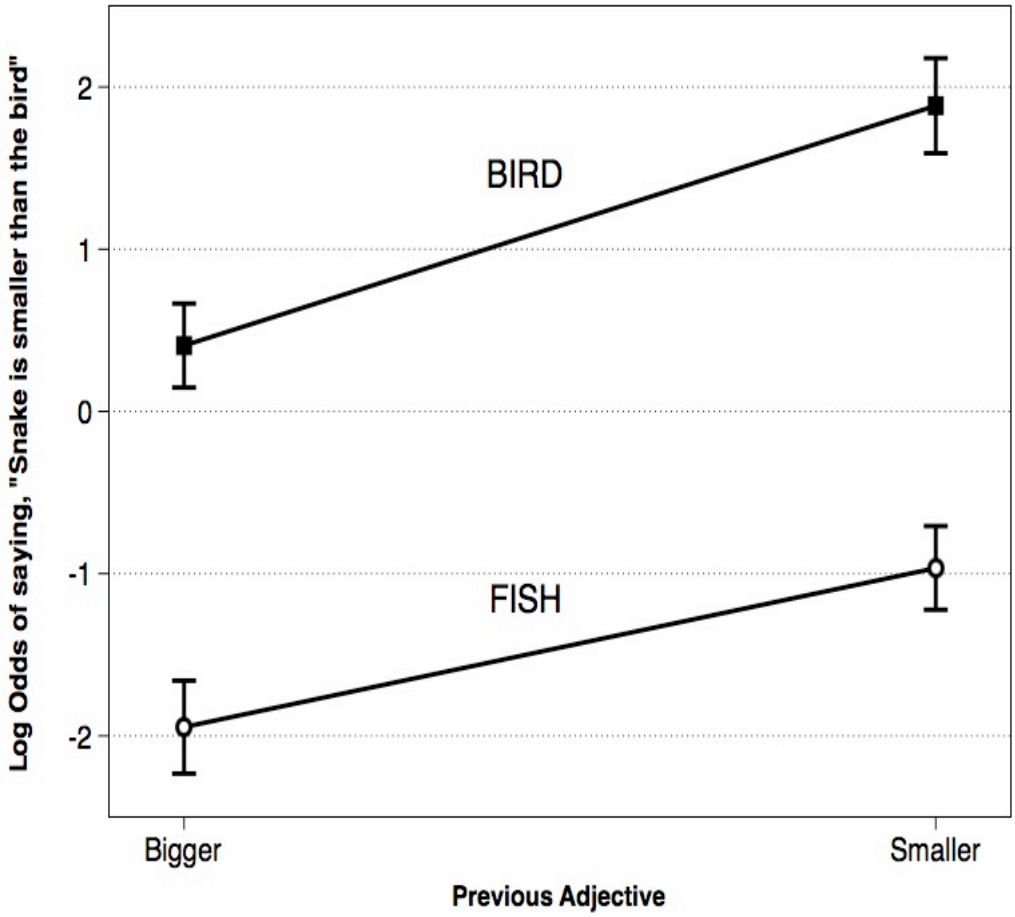

Figure 5. The mean proportion of the response, "The snake is smaller than the bird," as a function of the choice of previous noun and previous adjective for Experiment 1. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figures

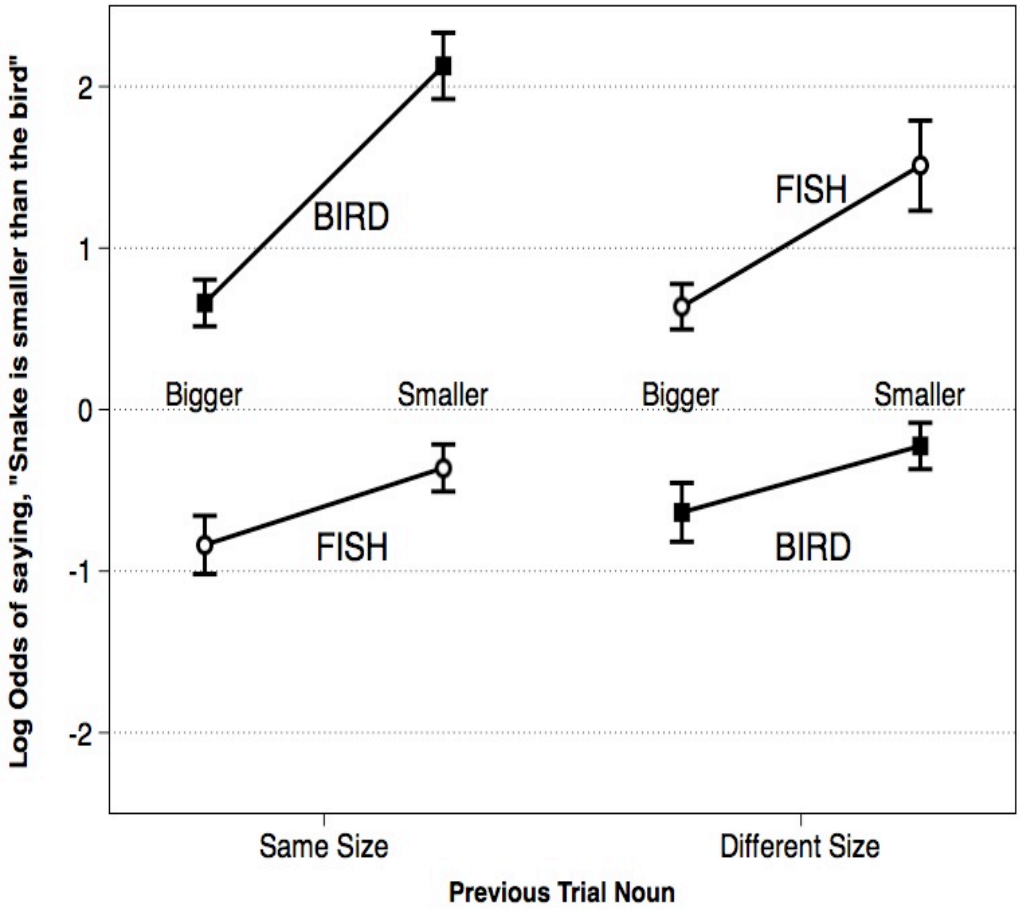

Figure 6. The mean proportion of the response, "The snake is smaller than the bird," as a function of the choice of previous noun and previous adjective for Experiment 2. Responses are divided according to whether the noun used in the previous response was the same size or a different size as current trials. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figures

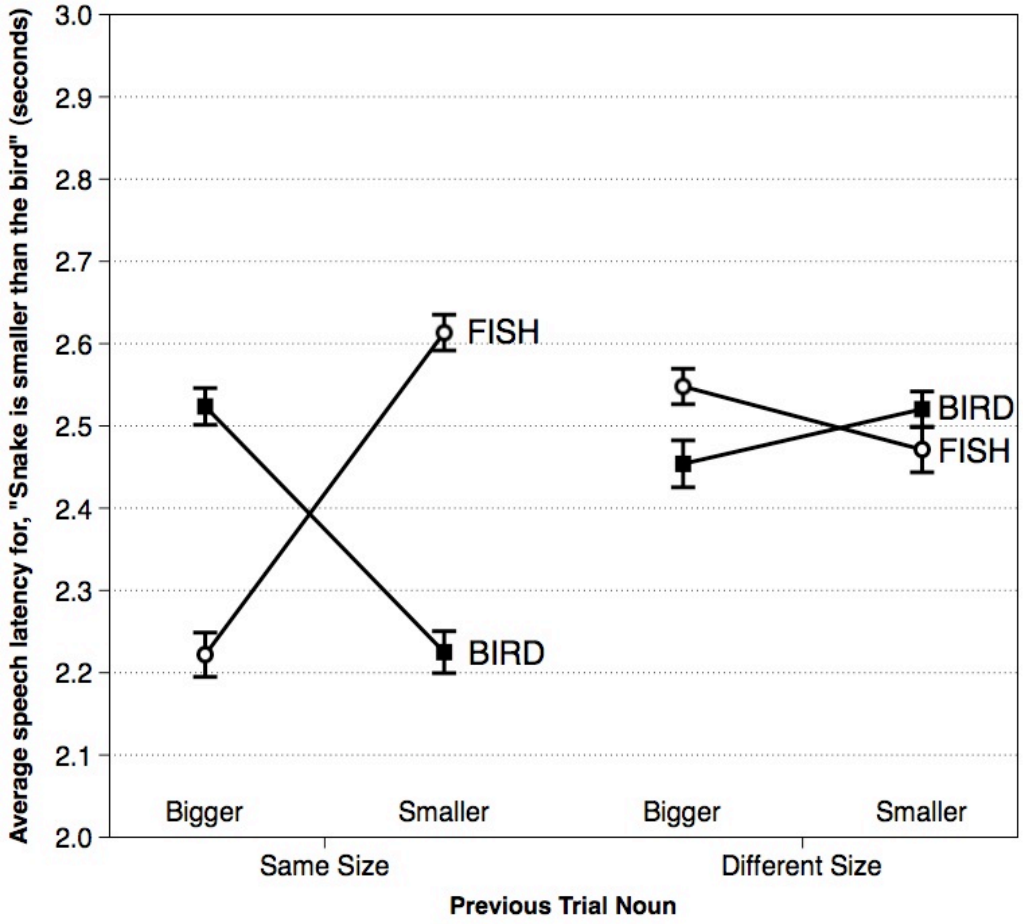

Figure 7. The time between stimulus presentation and first phoneme of, "The snake is smaller than the bird" (in seconds). Means are presented as a function of the choice of previous noun and previous adjective for Experiment 2 and are divided according to whether the noun used in the previous response was the same size or a different size as current trials. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figures

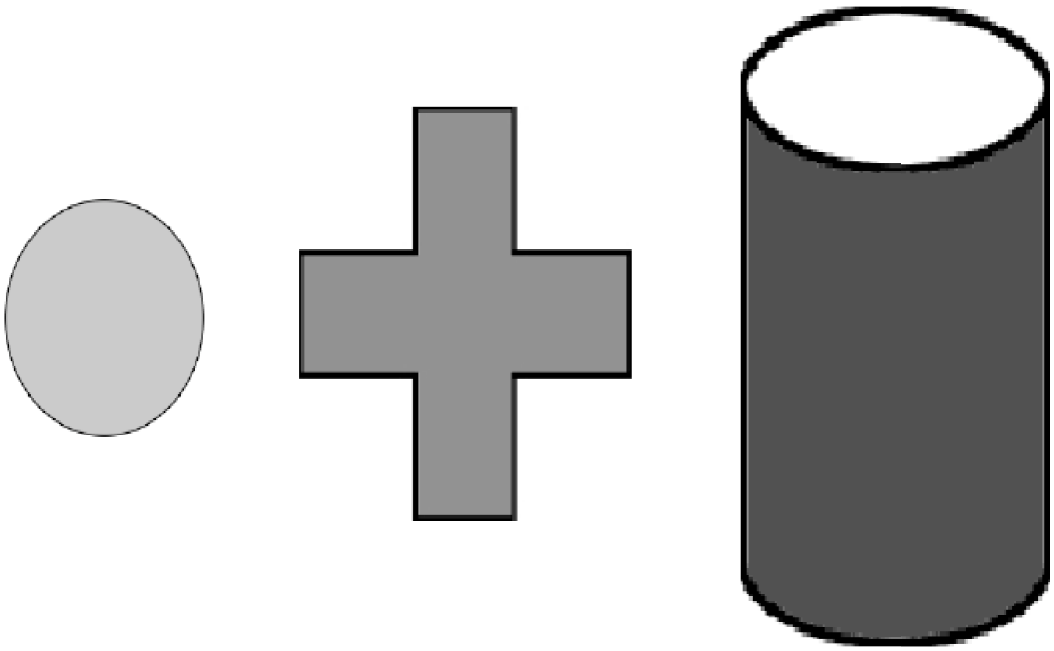

Figure 8. An example of the stimuli used in Experiment 3.

Figures

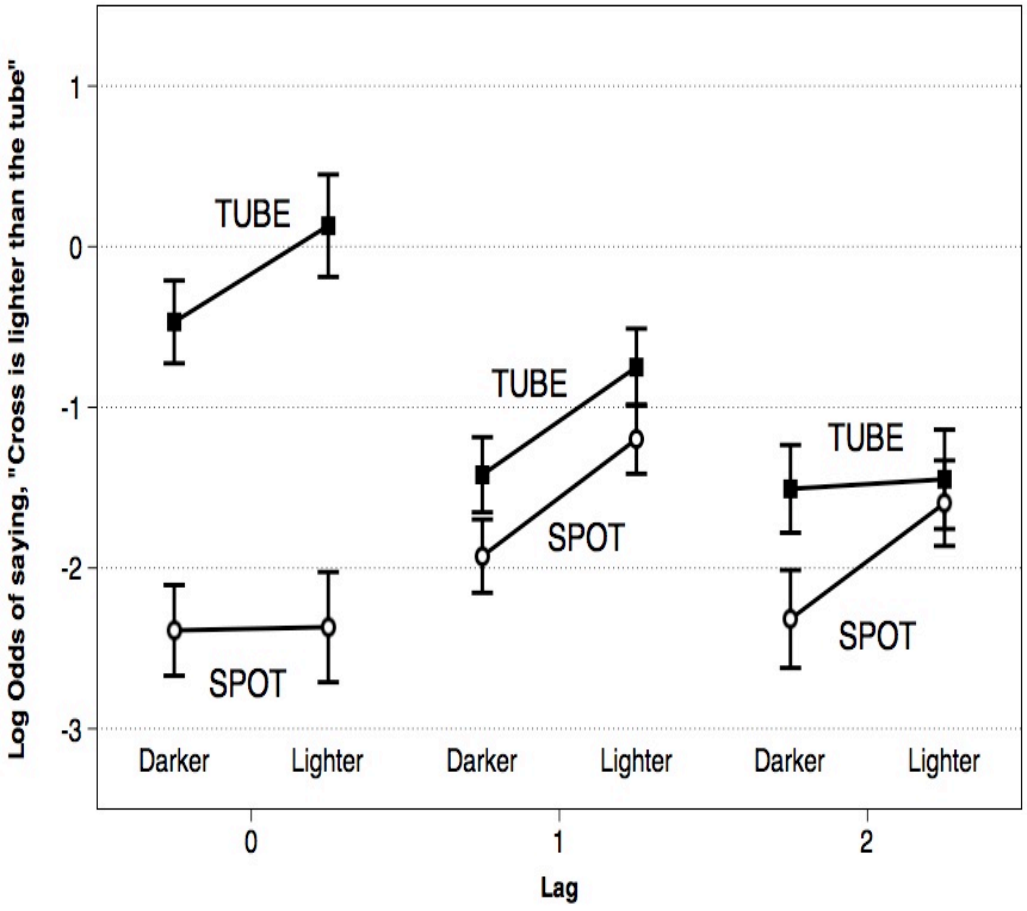

Figure 9. The mean proportion of the response, "The cross is lighter than the tube," as a function of the choice of previous noun and previous adjective for the colour task of Experiment 3. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figures

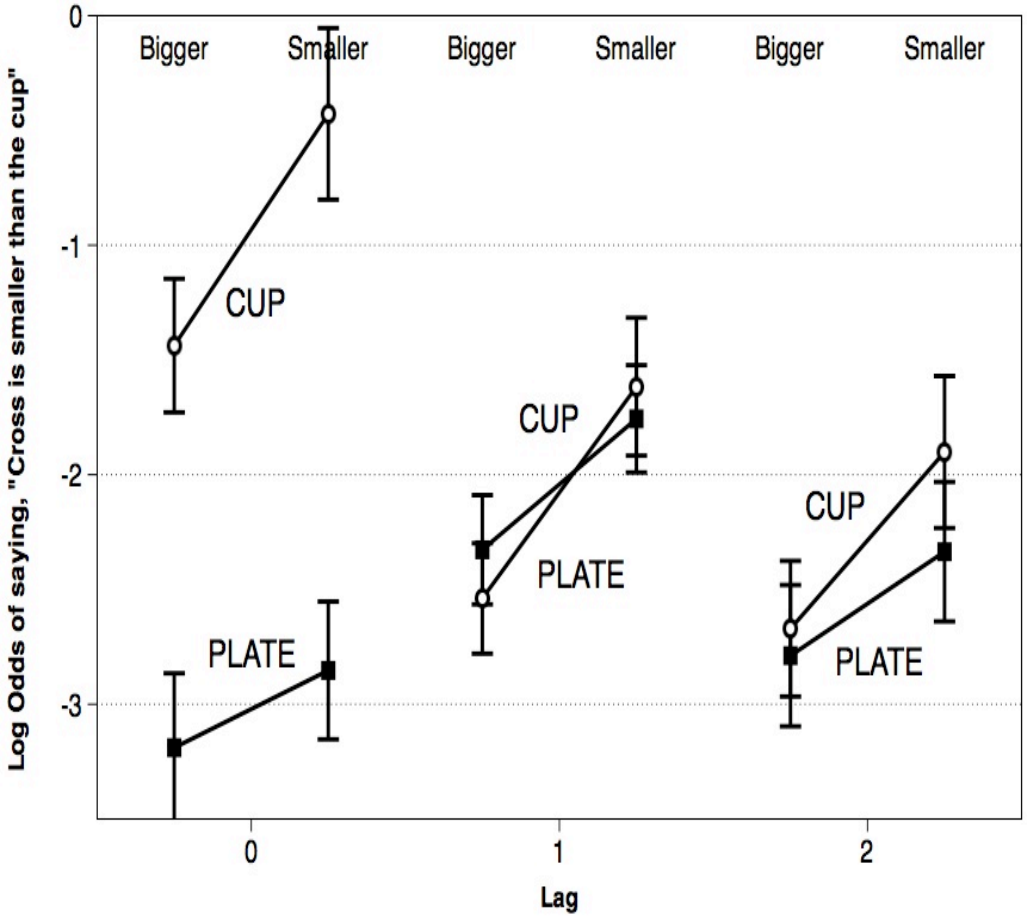

Figure 10. The mean proportion of the response, "The cross is smaller than the cup," as a function of the choice of previous noun and previous adjective for the size task of Experiment 3. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figures

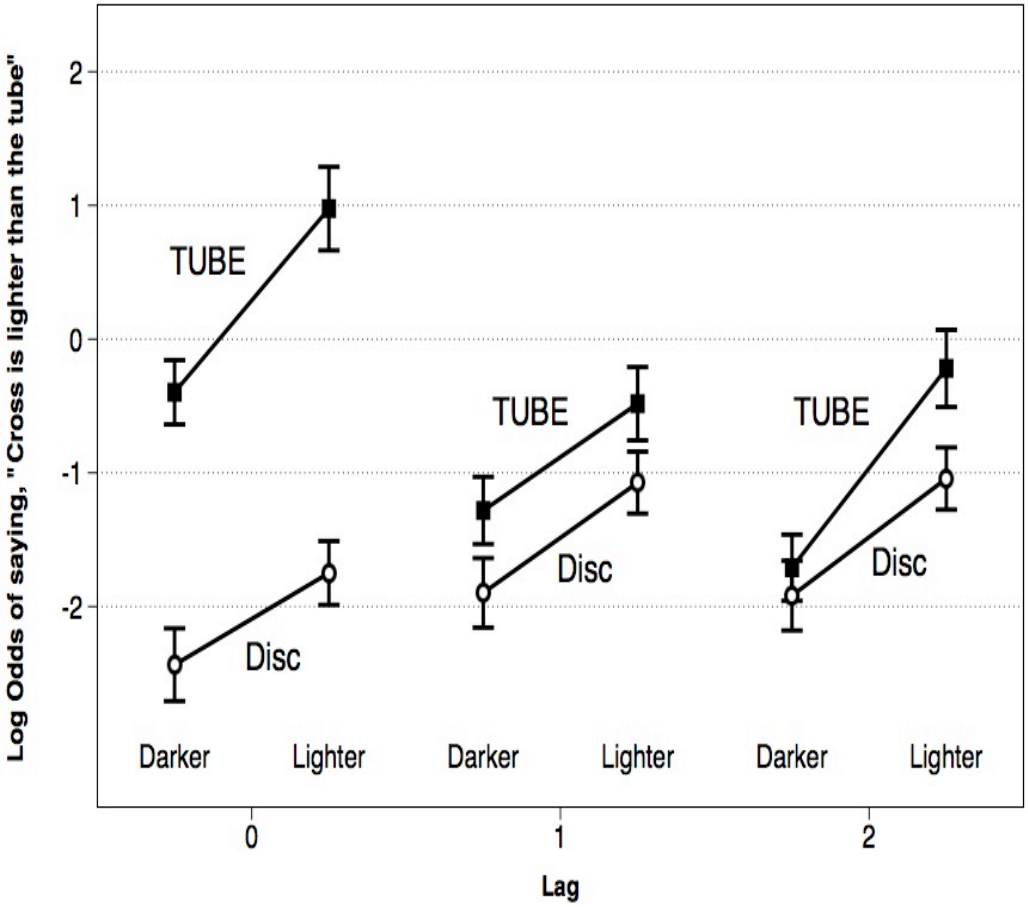

Figure 11. The mean proportion of the response, "The cross is lighter than the tube," as a function of the choice of previous noun and previous adjective for the colour task of Experiment 4. Error bars represent standard errors of parameter estimates that excluded the intercept.

Figures

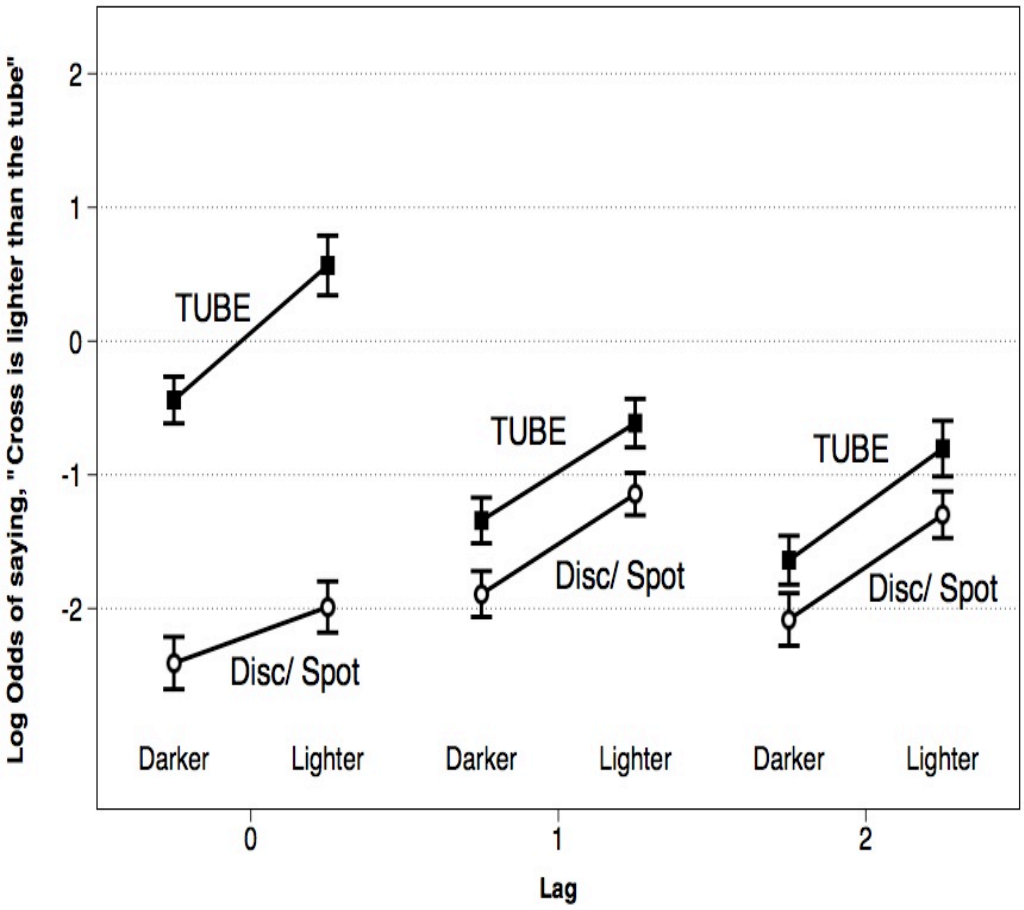

Figure 12. The mean proportion of the response, "The cross is lighter than the tube," as a function of the choice of previous noun and previous adjective. Data from Experiments 3 and 4 have been combined. Error bars represent standard errors of parameter estimates that excluded the intercept. In Experiment 3, the circle was referred to as a "spot," while in Experiment 4 it was referred to as a "disc."

Tables

Table 1. The mean proportion of the response (in logits), "The snake is smaller than the bird," as a function of the choice of previous noun and previous adjective for Experiment 1. Responses are divided according to whether the noun used in the current response was on the right or the left side. Error bars represent standard errors of parameter estimates that excluded the intercept.

Side that the noun mentioned appeared on	Previous Adjective	PreviousNoun	
		Bird	Fish
Left	Bigger	0.503 (0.276)	-2.140 (0.333)
	Smaller	1.689 (0.339)	-0.777 (0.274)
Right	Bigger	0.296 (0.280)	-1.780 (0.325)
	Smaller	2.102 (0.362)	-1.187 (0.279)

Tables

Table 2. The mean proportion of the response (in logits), "The snake is smaller than the bird," as a function of the choice of previous noun and previous adjective for Experiment 1. Responses are divided according to whether the noun used in the current response was "gazed at" by the centrally presented snake, or not. Error bars represent standard errors of parameter estimates that excluded the intercept.

Gaze	Previous Adjective	PreviousNoun	
		Bird	Fish
Gazed at	Bigger	0.414 (0.276)	-1.816 (0.323)
	Smaller	1.830 (0.336)	-0.858 (0.274)
Not Gazed at	Bigger	0.397 (0.280)	0.397 (0.334)
	Smaller	1.972 (0.370)	1.972 (0.279)