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The Effects of Representational Format and Discourse Principles on the Comprehension and Production of Temporal Order

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THE EFFECTS OF REPRESENTATIONAL FORMAT AND DISCOURSE PRINCIPLES ON THE COMPREHENSION AND PRODUCTION OF TEMPORAL ORDER

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I HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER MY SUPERVISION BY LOUISE J. RASMUSSEN, ENTITLED The Effects of Representational Format and Discourse Principles on the Comprehension and Production of Temporal Order BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Doctor of Philosophy.

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ABSTRACT

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In the present study I examined the role physical representations play in supporting distributed planning and scheduling. Specifically, I investigated the implications of different representational formats for the production of discourse as well as the later comprehension of text relating to temporal order. In the first part of the study, pairs of participants created schedules for constructing a house with the aid of either a numeric, list format, or a graphical, Gantt chart format. Participants completed the task in a non-collocated fashion, without shared visual access. In the second part of the study, after completing their schedule, the same participants answered a series of true/false statements about the order of events in a house construction schedule. These sentences were presented randomly across the independent variables preposition, syntactic arrangement, semantic constraint, and temporal order (chronological and discourse). This experimental set-up allowed me to examine the effects of prior discourse on both the production of language in a conversational context and the effects of prior discourse on the comprehension of text. My comprehension results demonstrated that features established in the previous literature which impose persistent influences on the cognitive complexity associated with language, such as syntax and iconicity, are sensitive to a pragmatic context. Further, my production results pointed to the discourse situation itself as a source of temporal information, which can provide a context for resolving local ambiguity in propositions relating temporal order. There were no persisting effects of the representational formats on later comprehension; however, results suggested differences in the relationship between linguistic behavior and performance in the context of the two representations. The present research thereby demonstrated the value of using verbal data to assess team performance. The results of this study have implications for basic cognitive science by pointing to contextual influences of discourse and representational format on comprehension generally studied in more isolated contexts.

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I. INTRODUCTION

HOUSTON: *Endeavor, Houston, before you do that, would you please confirm that GPC 4 is in norm?*

ENDEAVOR: *Affirmative, uh…GPC 4 is in norm. And the Alpha…Alpha output feedback is good.*

This exchange between a controller NASA's Mission Control and an Endeavor astronaut probably makes little sense. In addition to the specialized knowledge concerning the objects and procedures referred to, you, the reader, have no knowledge of the information that came before CAPCOM's request, the referent for the relative pronoun 'that'. Additionally, research in cognitive psychology suggests that comprehension depends on the order in which the events are mentioned. In chronological time, the '*doing that*' will take place after the '*confirming'*, but the request introduces them in the opposite order. This linguistic order reversal relative to chronological order increases the cognitive complexity associated with comprehending the sentence (Clark & Clark, 1968; French & Brown, 1977; Kavanaugh, 1979; Mandler, 1986; Trosborg, 1982). However, CAPCOM still described the events in this way, and the astronaut was able to respond to his request. The present research examines language order effects in a situation where order is determined both chronologically and with respect to a distributed discourse context, such as is the case in the example above. Additionally, I investigate the potential influences of physical representations on the production of discourse about order, and the later comprehension of order-related information. The present research will therefore examine the ability of language to function as an external representation and thereby to act as a foundation for collaborative activity.

When considered separately, the existing literature on language comprehension provides predictions for most of the independent variables in the proposed study. A fundamental claim of the proposed research is that the observed effects will vary from the predicted effects when the variables are investigated together, and in context. The following sections will address the existing research which has examined the relationship between language and cognition, specifically focusing on the ability of language to communicate information about order. Overall, this literature review will serve to highlight the focus in the existing literature on the comprehension of static linguistic features. Further, this introduction will address the potential influences of contextual factors which exist in dynamic situations where language is both produced and comprehended.

1.1 Individual versus Distributed Cognition

Temporal order is not an unfamiliar topic in psychological research. Psychologists have long noted that humans are able to think about the world, particularly for thinking about the world not just as it is, but also as it could be. This kind of reasoning is an example of our ability to reverse, and thereby abstract our thought from reality, an ability that Allen Newell referred to as ‘the great move’ (Newell, 1990).

Since the cognitive revolution of the 1960s, great emphasis has been placed upon analyzing both language and cognition, such as the phenomena mentioned above, as thoroughly mental and largely private processes. This resulted in the recognition of intensional[1] aspects of language, such as individual words (prepositions), syntax, as well as a limited number of extensional aspects, like order of mention and semantic constraints on the comprehension of written language.

This literature, however, often omits the relationship between language behavior and the environment in which it takes place, a relationship that has long been recognized within other scientific disciplines such as sociology, anthropology, and linguistics. In particular, researchers in anthropology, a field inherently interested in the role artifacts (technology and interfaces) and language play in shaping human interaction, have adopted a perspective on language that should be of conceptual and methodological interest to Human Factors psychology. Similar to Human Factors, anthropology is also concerned with the role of artifacts (technology and interfaces) in shaping or guiding behavior. An anthropological perspective on language regards the organization of language as extending beyond the mental attributes of an isolated speaker (Goodwin, 2002) to the context in which the language is used.

The working focus underlying a large proportion of the empirical work in psychology on the relationship between language and cognition seems to be that language is something humans consume, rather than something humans employ to attain a goal. This likely originates in an aspiration to get a firm grasp of basic phenomena before looking towards more complex ones. An important, and largely unresolved question concerns whether the influences on cognitive complexity that have been identified within the literature on comprehension support predictions about the language people will use

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[1] Intensional is specification with respect to internal aspects of a system. Extensional is specification of aspects of one system with respect to those of another.

to accomplish a real task, i.e., when the language is used as a tool for coordinating activities between two people who are embedded in a common context and history. For example, can we predict that people in such a context will tend to use language that describes events in chronological order because describing them in non-chronological order should be more complex to produce, and it should be more complex for the recipient to decode? A preliminary language analysis that I carried out on several voice transcripts of Mission Control communication revealed that the NASA controllers were more likely to produce sentence constructions with the main clause first, This means they were more likely to produce sentences like *'x before y'*, presenting events in chronological order, and *'y after x'*, presenting events in non-chronological order than they are to produce sentence with the main clause last. The comprehension literature (H. Clark, & Chase, 1971; E. Clark, 1971) suggests that *after* is slightly easier to comprehend when the main clause is presented last, preserving chronological order, e.g. '*after you do that, please confirm that GPC 4 is in norm*'. However, the analysis of Mission Control natural language suggests that controllers produce the main clause first construction when using the preposition after 47% more often than when they use the main clause last construction. This suggests that the findings in the comprehension literature do not extend in a straightforward fashion to language in context. Further, this preliminary evidence supports the notion that an account of the cognitive complexity associated with language should take pragmatic influences into account.

The present study will investigate the psychological consequences of language organization in the context of a larger set of extensional influences, such as different communicative purposes and representational support, and I will therefore discuss each in more detail in the following sections.

1.2 Pragmatics and Comprehension

A primary difference between cognition as it has been studied in traditional comprehension paradigms and cognition as it unfolds in applied contexts concerns the breadth and the nature of the reasoning content. By breadth, I am referring to the types of considerations that speakers and recipients make when they produce and decode language. For example, speakers are likely to choose language that satisfies multiple goals, ease of comprehension only being one of those goals. I will address one way to conceptualize discourse goals in the following section on rules for cooperation. By the nature of the reasoning content, I am referring to how speakers and recipients conceptualize the content of language. The upcoming section on rules for cooperation will address this issue.

1.2.1 Rules for Cooperation

Two related theoretical approaches to addressing the implicit rules speakers use to ensure cooperation in discourse are Gricean maxims and the Given-New principle.

1.2.1.1 Gricean maxims.

The philosophy of language, a field that to a large extent has developed into the study of pragmatics, has identified a number of implicit maxims, or rules, that speakers appear to follow in order to facilitate cooperation in discourse. Gricean maxims are an example of such rules. Grice’s (1975) maxims assume that speakers design their utterances to facilitate listener comprehension. Conversational maxims organized along four dimensions (Grice, 1975) dictate that one should:

Quantity:

1) Make one's contribution to the conversation as informative as necessary.

2) Not make one's contribution to the conversation more informative than necessary.

Quality:

1) Not say what one believes to be false.

2) Not say that for which one lacks adequate evidence.

Relevance:

1) Be relevant (i.e., say things related to the current topic of the conversation).

Manner:

1. Avoid obscurity of expression.

2. Avoid ambiguity.

3. Be brief (avoid unnecessary wordiness).

4. Be orderly.

These maxims introduce the possibility that speakers might formulate speech that manipulates order of mention relative to order of occurrence on purpose, in order to facilitate comprehension. However, a potential pragmatic purpose for reversing order of mention could be related to implicit conventions concerning when certain information should be introduced. That is, it is possible that speakers mention events out of chronological order to enhance quantity, e.g., to alert listeners to important information. Grice (1981) indeed has explored this possibility and has identified the linguistic phenomenon of implicature. An implicature is anything meant, implied, or suggested distinct from what is explicitly said. Implicatures can be part of sentence meaning or dependent on conversational context. For example, if you ask me how my day was, and I reply *'how about those Reds?'* by changing the topic, I am implying that I would rather not discuss how my day was. It is possible that speakers use order of presentation in a similar way, to imply or suggest meaning. Importantly, within this view, implicature cannot be determined simply by looking at an isolated sentence or utterance—rather it emerges from the context. Further, it suggests that there may be pragmatic constraints on the order in which we talk about objects and events.

1.2.1.2 The Given-New principle.

The Given-New principle is another example of an implicit convention which suggests the presence of influences of order of presentation relative to a communicative, or discourse context. Chafe's (1972) maxim of antecedents, or the Given-New principle, states that one communicates New information, relative to the conversational context, on the basis of Given, or already established information.

If information has been discussed recently, speakers generally consider that information as Given. For example, you ask me whether or not I have turned up the heat, and I reply *'I turned up the heat after I closed the door'*—communicating that not only have I turned up the heat, but I have closed the door to attain the same goal, raising the temperature. The order in which I mention these actions, however, is not based on the chronological order in which they occurred, rather, based on what has been established in prior discourse. *Turning up the heat* is Given and therefore mentioned first. *Closing the door* is New and therefore mentioned last.

It is worth noting that mentioning the topic of your conversation partner's request first is simply the polite thing to do. Brown and Levinson (1987) have pointed out that another important goal in conversation, in addition to cooperation, is the preservation of face. Brown et al. propose that one of the strategies speakers use to ‘get what they want’ is to avoid embarrassing the listener by being polite. One of the ways this politeness strategy may manifest itself, is in acknowledging a listener’s query through the order in which a speaker mentions objects or events.

This means that, in addition to chronological order of occurrence, order can also be conceptualized as relative to the communicative context. The idea that an individual sentence or entire paragraph is easier to comprehend when it respects a Given-New convention than when it challenges such a strategy was examined in a series of comprehension studies that all measured reading time of target sentences that were presented after context sentences provided the grounding for Given information.

Clark and Haviland (1974) presented subjects with two sentences, a context sentence which either provided a direct or an indirect context for the second sentence. For example, in the sentences *‘We got some beer out of the trunk. The beer was warm’* the first sentence provides a direct context. In the sentences *‘We checked the picnic supplies. The beer was warm’* the first sentence provides an indirect context. Clark and Haviland found that the presence of a direct antecedent (i.e., overlapping words), such as in the first sentence pair, facilitated comprehension.

Van de Kopple (1982) increased the scope of relevant context by examining the effects of contradicting the Given-New convention within paragraphs rather than sentences. He used readability preference as a dependent measure instead of the traditional reading time or response time measures. Van de Kopple found that participants preferred the topically-linked paragraphs that observed the Given-New principle, and that they remembered more information from these paragraphs as indicated by performance on a short answer memory test.

Clark and Haviland (1974) provided a process account of the Given-New effect, and concluded that presenting Given information first provides the reader with a mental scaffold onto which New information can be attached. If New information is presented first, the readers must keep New information in memory while they wait for the antecedent for this information. This account is consistent with Bransford and Johnson (1973), who found that a paragraph is more difficult to remember in the absence of a topic. Similarly, Kintsch and Van Dijk's (1978) corroborated these findings with their claim that in text processing, coherence can be established when arguments are shared across sentences. Kintsch and Van Dijk suggested that argument overlap is one of the primary means through which readers connect sentences to form a coherent mental representation of them.

The above sections suggest at least two reasons to mention Given information first: 1) to facilitate comprehension, and 2) to be polite. It is possible that the increased level of difficulty in comprehension for chronological order mismatch seen in previous studies, which examined sentences divorced from a discourse or narrative context, reflects the absence of a communicative purpose for the order reversals.

Conversational maxims, and to a certain extent the given-new principle, point to the existence of a certain complementarity between production and comprehension. If comprehension and production are indeed complementary, this suggests that findings from comprehension ought to generalize to production. If they do not generalize, as the mission control analysis above suggests, either: 1) Grice and Chafe are mistaken in their basic assumption—speakers do not try to facilitate listener comprehension, or 2) documented psycholinguistic phenomena regarding comprehension are inadequate predictors of production because the phenomena were measured without taking context into account.

To elaborate on the second and more likely alternative, the existence of pragmatic conventions could potentially mean one of several alternatives regarding the predictive value of the linguistic sources of cognitive complexity established in prior research. It is possible those low-level influences on cognitive complexity are valid, and that speakers intentionally increase cognitive complexity to ensure that listeners pay attention. Alternatively, it is possible that the pragmatic context in and of itself serves to disambiguate language and thereby reduces the cognitive complexity associated with it.

In sum, the mere existence of pragmatic influences on how people use language point to broader contextual influences on production, and thereby features which can influence comprehension. The present study systematically examined a few of the potential pragmatic influences on language production and comprehension, and thereby also investigates the degree to which the two can be thought of as complementary. This study focuses on discourse itself as a context, in addition to the representational support used to complete a cooperative task. In order to examine the influence of these contexts on production and comprehension, the following sections address existing literature on the cognitive complexity associated with language.

1.3 Syntax and Comprehension

The following section explores the existing research on language comprehension, specifically comprehension of language that describes the relationships between temporal events. I introduce the variables that have been found to affect comprehension of temporal information separately, but as we shall see, several of these variables have been found also to interact. These variables include: words, syntax, and order of presentation, also referred to as iconicity.

It is important to note that the literature presented here all specifically addresses comprehension rather than production. The primary reason for this is that psychology traditionally has tended to focus on comprehension, presumably assuming complementarity between the two. Additionally, even though the present study does not assume complementarity, I have chosen to focus on production as a context for comprehension. That is, unlike the vast majority of language comprehension research, I will investigate the implications of a production, or discourse context on subsequent comprehension.

First, I will discuss some of the early work on language comprehension, which presupposes a model of comprehension in which people encode language into a mental representation in the form of propositions. Then, I will address more recent research on language comprehension in which comprehension is conceptualized as the online construction of a spatial, or experience-based mental representation, sometimes referred to as a situation model (see Zwaan and Radvansky, 1998 for review).

1.3.1 Syntax and Language as Propositions

Decades of cognitive psychology research have addressed the relationship between the perception of spatial and temporal relationships and the comprehension of relational linguistic descriptions, usually expressed with prepositions. The methodological reason for this is that that nonlinear nature of space provides an interesting counterpart to the linear nature of language (Zwaan and Radvansky, 1998). This discrepancy provides ideal conditions for studying the reasoning processes involved in resolving ambiguity and in constructing mental representations.

The very structure of language, or syntax, provides us with a high level ordinal representation that imposes very significant constraints on how information is extracted from a sentence. Syntax provides a framework for communicating intended order in ways that transcend actual temporal order of events so that the narrative is consistent with a greater framework of narrative. Narrative content can manipulate temporal order—talk about the future first, then the present, and then the past. Yet narratives are linear: like controlled attention, they address topics in sequence (Tversky, 2004). Whether read or heard, the experience of the narrative must take place in a predetermined order. A sentence requires processing from beginning to end in order to decode its message—we cannot start in the middle or at the end and then work our way backwards. Therefore, processing the serial sentence *'I picked up the kids from school after I ran errands'* is out of order[2] relative to the order in which events actually occurred.

Early developmental evidence, relying on the assumption that children acquire and use simpler syntactic and semantic distinctions before more complex ones, suggests that syntactic arrangements that preserve the temporal order of events are easier to comprehend. Clark and Clark (1968) found better memory for sentences that preserved chronological order. Similarly, Trosborg (1982) found that children had an easier time comprehending, i.e., judging the correctness of a sentence that was read out loud as well as acting out, sentences that presented information in chronological order, that is *'x is* *before y'* and *'after x, y'*. '*X is before y'* was always the easiest of the two, meaning children made fewer errors on those than on *'after x, y'*. This is consistent with E. Clark's (1971) finding that children acquire the meaning of *before* earlier than they acquire the meaning of *after*.

These studies attributed the differential cognitive complexity associated with these relational sentences to the differential ease with which marked and unmarked distinctions are encoded into and rate at which they can be lost from memory. Sentences that reversed the order of mention of the events relative to temporal occurrence were considered marked:

Unmarked: *He tooted the horn before he swiped the cabbages.*

After he tooted the horn he swiped the cabbages.

Marked: *He swiped the cabbages after he tooted the horn.*

Before he swiped the cabbages he tooted the horn.

According to Clark and Clark (1968) and Clark and Card (1969), memory for relational information depends on a primary relation as well as a marker. For example, to remember a *before* relation, we encode a proposition containing the unmarked relation, and a marker tag that is set to zero, as it is unmarked, i.e., $before^0$. To remember an *after* relation, we encode the unmarked relation and a marker tag set to one, i.e., $before^1$. Unmarked relations are easier because they are less complex, i.e., it is easier to remember the absence of a marker, than the presence of one. Or, it is easier to misremember the presence of a marker, than the absence of one. These results supported this account by

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[2] Reversing order, although it requires syntactic and lexical adjustments, does not result in a false proposition, it is still produces a truthful description of the world.

showing that when participants remembered order of mention instead of temporal order they most often misremembered using the unmarked form. Clark and Chase (1972) further examined the marking construct in a sentence picture comparison task, and concluded that this process could also be accounted for using the marking notion. Verification response times suggested that pictures were encoded using the unmarked proposition. Within this framework, it is possible to think of order of mention as an unmarked or marked relation. Sentences mentioning events out of order are encoded as a proposition mentioning events in order, plus a tag for marking.

Clark and Clark (1968) proposed that the position of the main clause[3] is the most important cognitive feature of a sentence. That is, in computational terms, the position of the main clause is the feature of the sentence that is evaluated first. If the main clause is positioned first, the sentence is considered unmarked for clause position; if it positioned last, it is considered marked. Clark and Clark indeed demonstrated this in a study of recall of information presented in sentences varying marked and unmarked lexical items (before/after), clause position (and therefore chronological order). They found that, in expressing what they remembered, subjects made fewer mistakes recalling sentences with the main clause first, but also in recalling sentences presenting events in chronological order. So, '*x before y*' resulted in fewer mistakes than '*y after x*', but both of those resulted in fewer mistakes than '*after x, y*' and '*before y, x*'.

[3] A subordinate clause (sometimes called a dependent clause) is a clause that cannot stand alone as a complete sentence, e.g. "*before he swiped the cabbages*". Like the main clause, the subordinate clause contains a subject and a predicate; however, unlike the main clause, the subordinate clause begins with a subordinating conjunction, such as *although, because, if, since, while, before, after, when, whereas, etc*.

In expressing the information they recalled (production), however, it became evident that subjects often were only remembering the underlying sense of the sentence; not the topological order of the sentence. That is, they remembered the correct chronological order, but would express this information in a different way than it was presented to them. They might see the sentence *'y after x'* but recall the sentence as *'x before y'*. Examining these results as findings concerning production suggests that subjects preferred *'x before y'* sentences over *'y after x'* sentences' in producing their answers—i.e., main clause first, before sentences were produced more often. Clark and his colleagues saw such results as evidence that clause position is a cognitively more important feature of language than iconicity, i.e., it is more basic to cognitive organization.

It appears, however, that this conceptualization of syntax and order of mention as static influences on comprehension may be influenced by other factors. In fact, the only consensus in this literature as to the relative difficulties of syntactic constructions that reverse or do not reverse chronological order concerns the extremes, i.e., which sentence construction is the easiest, and which is the most difficult. Sentences using *before* placing the main clause first are always easiest—they present events in chronological order (*chronomc1st*, see Appendix A for naming key). Sentences using *before* placing the main clause last are almost uniformly the most difficult—it presents events in non-chronological order (*nchronomc2nd*). There is a lack of consensus as to the relative difficulty of sentences using the preposition after. Children find it just as easy to act out *before* main clause first as *after* main clause last sentences (French, & Brown, 1977). Importantly, these sentences both present events in chronological order. In the other studies the relative difficulties of *aftermc1st* and *aftermc2nd* appears to depend on the age of the participants (Adults: Clark, & Clark, 1968; Mandler, 1986, Children: E. Clark, 1971; French, & Brown, 1979; Kavanaugh, 1979; Trosborg, 1982) and the nature of the task (Recall/errors: Clark, & Clark, 1968, Acting out/errors: French, & Brown, 1979, Reading/reading time: Mandler (1986).

In large part, the literature mentioned in this section, except for Mandler (1986), presupposes a model of comprehension in which people encode language into propositions. This process of translating a sentence into a nominal proposition can either be facilitated, if the language is unmarked, or hindered, if the language is marked. More recently, language comprehension has been conceptualized as the online construction of a mental representation with spatial attributes.

1.3.2 Syntax and Language as Experience

Rather than conceptualizing syntactic aspects of language as features which can facilitate translation into a mental format, it is possible to think of syntax as a feature that can assist in conveying, or recreating a physical experience. The literature on situation models has established that comprehension is facilitated when descriptions present events in an order that is consistent with the experience people might have if they were physically acting out, or taking part in the situation described by a sentence. Ehrlich and Johnson-Laird (1982), for example, found that when spatial relations between physical objects are described in an order consistent with moving around the objects in space the sentence was read faster and was therefore easier to comprehend. For example, '*the knife is in front of the pot. The pot is on the left of the glass. The glass is behind the dish*' was easier to comprehend than '*the knife is in front of the pot. The glass is behind the dish.*

The pot is on the left of the glass'. It is not clear, however, that reading time, which has been employed extensively in the context of comprehension studies, and in this study in particular, necessarily involves a comprehension component and therefore does not lend itself to straightforward interpretation (Foss & Bower, 1986).

Much of the early literature described earlier assumed that the words we use to describe spatial and temporal relationships must be complementary in their usage. Mandler (1986) noted that perhaps the connectives *before* and *after* are not exact converses because they highlight different parts of the sentence, but she does not elaborate the entailments. In the realm of logic, it makes perfect sense, that if one can say that the Star symbol is above the Plus symbol, it should be just as legitimate to say that the Plus is under the Star (Clark, & Chase, 1972). However, when the statements refer to real objects, and not to meaningless symbols, our understanding of these objects and their relationships may not be entirely logical, and descriptions may not be complementary. For example, I would be unlikely to tell you *'the table is under the stapler'*. This suggests that our understanding of the on/under relationship is sensitive to the kinds of objects the relationship concerns. Perhaps this is due to the relative size difference between the stapler and the table, or perhaps it is not that simple. If the table happened to be located under a pile of staplers, we might have a difficult time discerning the table, and it would then make sense to point out the location of the table as under the staplers. The new questions here become: what determines which aspects (objects or events) in the environment we tend to point out, in what situations, and how do we 'point' with language?

The present research is particularly focused on these questions as they relate to events in a scheduling task. The following section on discourse order will address the question of ‘how we point with language’, which is particularly applicable in distributed work settings where participants cannot see each other, and language therefore is the only method for pointing. The next section will discuss physical representations as external constraints on how we choose which objects, events, and relationships need to be addressed explicitly. The section concerning semantic constraints will address potential characteristics of the events, and relations between them that influence the likelihood that we will discuss them explicitly.

When we talk about objects, like the example above, ‘*the stapler is on the table’*, there is no correct order of mention, that is, there is no such thing as iconic order. This means that there is not the potential for the order of language to reflect or misreflect the state of the world, as can be the case when we talk about events. Therefore discourse relating the order of events must reflect other considerations. In a speeded decision task, Zwaan and Yaxley (2003a) presented participants with word pairs that were semantically related—the relationship was either an iconic relation (the word ‘*attic’* presented above the word ‘*basement’*) or in a reverse-iconic relation (the word ‘*basement’* presented above the word “*attic’*). The participants had a more difficult time judging the semantic relatedness of the reverse-iconic word pairs. A follow-up experiment presenting the words horizontally did not replicate this effect, demonstrating that the iconicity effect is not due to the order in which the words are read. Zwaan and Yaxley (2003b) propose that a perceptual theory of lexical representation can account for these results (Barsalou, 1999; Langacker, and Pulvermüller, 1999). According to this theory, words activate a perceptual representation of their referents.

In both the previous examples, ‘*the stapler is on the table’* and *‘the table is under the staplers’* the objects that are mentioned first are those that have presumably been mentioned earlier. Likely, *‘the table is under the staplers’* may be the answer to the question *‘where is the table?’*. That is why it is mentioned first in the answer. By mentioning the object from the question first the answer ‘points’, in a figurative sense, from the object that is known to the one that is not. From this example it appears that an alternative criterion for selecting order of mention resides beyond the semantic ties between an individual statement and that which it refers to, but extends to the discourse in which the statement is embedded. If this is the case, within the view that language is used to create a perceptual experience, it is possible that the experience is sometimes best created presenting objects or events out of chronological order.

1.3.2.1 Pragmatic influences on linguistic complexity.

I propose that prior research suggesting systematic influences on comprehension of lexical/syntactic level language aspects, such as preposition, clause position, and iconicity, is likely confounded by lack of a pragmatic context. In these studies, the communicative context was exceedingly narrow, constrained to individual sentences or paragraphs. This reduces the possibility of uncovering potential interactions between these purportedly stable language attributes and pragmatic phenomena, such as discourse principles, and communicative figure/ground distinction. In other words, the determinants of cognitive complexity associated with language may look very different when the sentences have communicative purpose.

Such an interaction may take the following form. Imagine a situation in which we already discussed, and therefore established that ‘you pour the foundation before you build the frame’. Here both events are therefore given, and there is no communicative purpose to placing one or the other in the main clause. The presence or absence of a reason for one construction or the other influences the difference between the ease with which the two arrangements are comprehended. Consider a situation in which we have established when ‘pouring the foundation’ occurs relative to a set of other events, but now we introduce a previously unheard of event, such as installing the floor joists. Not only should the sentences that violate discourse order, i.e., mention New information first, be more difficult to comprehend, the sentences that 1) violate conventions for discourse order (present New information first) and 2) whose order does not match chronological order of occurrence will be most difficult of all (see Figure 1 and Tables 1, 2, and 3 for process claims).

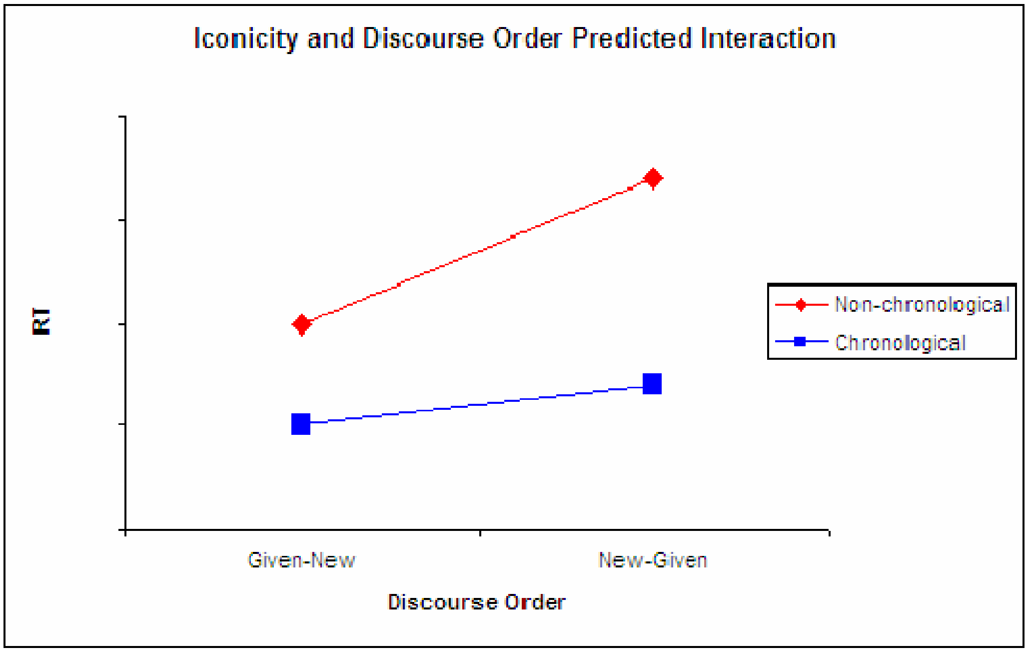

Figure 1. Interaction between iconicity and discourse order. Effect of reversing chronological order is larger when the Given-New principle is violated.

Table 1

Summary of Established and Predicted Research Findings

	Effect	Direction	Author(s)
1	Preposition	After more difficult	E. Clark (1971) Clark and Chase (1972)
2	Clause	Main clause last more difficult	E. Clark (1971) Clark and Chase (1972)
3	Chronological order (Iconicity Assumption)	Order mismatch more difficult	Clark (1965) Clark and Card (1968) French and Brown (1977) Ehrlich and Johnson-Laird (1982) Kavanaugh (1979) Trosborg (1982)
4	Discourse Principles (Given-New Principle)	Not observing Given-New principles more difficult	Haviland and Clark (1974) Kopple (1982)
5	Semantic constraints	Arbitrary constraints more difficult	French and Brown (1977) Kavanaugh (1979) Trosborg (1982) Mandler (1986)
6	Chronological order and semantic constraints interaction	Effect of chronological order reversal larger with social constraints	Mandler (1986)
7	Chronological order and discourse principles interaction	Effect of chronological order reversal larger with violation of discourse principles	Rasmussen Prediction

Table 2

Sources of Cognitive Complexity I. Replicated and Predicted Influences on Comprehension—Chronological Order.

Semantic Constraints	Discourse Order	Main Clause	Effects	Chronological Order Match
Physical	Given-Given	First		You pour the foundation before you build the frame
		Last	1, 2	After you pour the foundation you build the frame
	Given-New	First		You pour the foundation before you backfill around the foundation
		Last	1, 2	After you pour the foundation you backfill around the foundation
	New-Given	First	4	You clear the trees before you pour the foundation
		Last	1, 2, 4	After you clear the trees you pour the foundation
Social	Given-Given	First	5	You pour the foundation before you deliver the windows
		Last	1, 2, 5	After you pour the foundation you deliver the windows
	Given-New	First	5	You pour the foundation before you grade for the lawn
		Last	1, 2, 5	After you pour the foundation you grade for the lawn
	New-Given	First	4, 5	You build the access road before you pour the foundation
		Last	1, 2, 4, 5	After you build the access road you pour the foundation

Table 3

Sources of Cognitive Complexity II. Replicated and Predicted Variables on Comprehension—Non-chronological Order.

Semantic Constraints	Discourse Order	Main Clause	Effects	Chronological Order Mismatch
Physical	Given-Given	First	1	You build the frame after you pour the foundation
		Last	2	Before you build the frame you pour the foundation
	Given-New	First	1	You pour the foundation after you clear the trees
		Last	2	Before you pour the foundation you clear the trees
	New-Given	First	2, 4	You backfill around the foundation after you pour the foundation
		Last	1, 4	Before you backfill around the foundation you pour the foundation
Social	Given-Given	First	1, 3, 5, 6	You deliver the windows after you pour the foundation
		Last	2, 3, 5, 6	Before you deliver the windows you pour the foundation
	Given-New	First	1, 3, 5, 6	You pour the foundation after you build the access road
		Last	2, 3, 5, 6	Before you pour the foundation you build the access road
	New-Given	First	1, 3, 4, 5, 6, 7	You grade for the lawn after you pour the foundation
		Last	2, 3, 4, 5, 6, 7	Before you grade for the lawn you pour the foundation

Accordingly a sentence construction that preserves discourse expectations, temporal order, and emphasizes New information should be ideal. This would be the sentence construction that observes discourse order, preserves chronological order, but places the main clause last. The placement of new information in the main clause might assist in calling attention to the fact that it is indeed New information. That is, in the examples in Table 2, the sentence '*after you pour the foundation you grade for the lawn*' meets these criteria. If the preposition *before* is used, as in the sentence *'you pour the foundation before you grade for the lawn'*, the main clause must be mentioned first to preserve chronological order and since New information should be presented last, the New information must be presented in the subordinate clause. A three-way interaction could therefore emerge between preposition, clause, and discourse principles (see Figure 2).

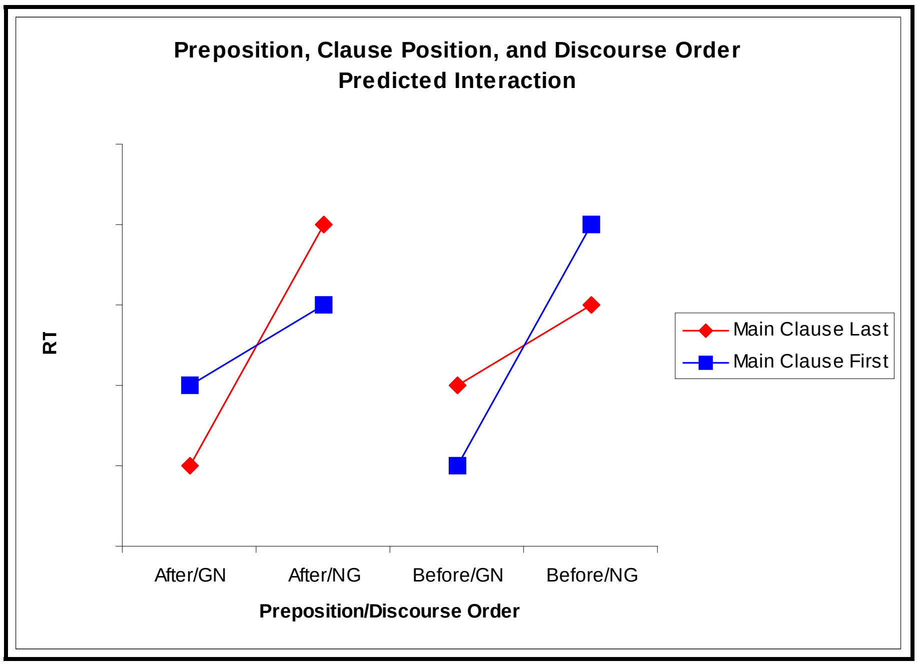

Figure 2. Three-way interaction between preposition, clause position, and discourse order.

1.4 Semantics and Comprehension

In addition to order-related complexity, the systematic influences of the semantic content and conceptual distance on comprehension have been examined also in the literature. Clark and his colleagues only examined sentences consisting of arbitrarily related events, e.g., *'he tooted the horn before he swiped the cabbages'*. The nature of the relationship between the events and the perceived distance between them may have important consequences for the ease with which propositions are comprehended. More importantly, however, these variables may potentially interact with the linguistic and discourse level influences discussed above.

1.4.1 Semantic Relationship

Even though it is possible to imagine and talk about violating physical laws, we cannot actually violate them in the physical world. Research in psychology has examined the psychological implications of reasoning about different kinds of logical relationships. Such studies, distinguish between two types of constraints: logical and arbitrary, which researchers operationalize broadly as the presence or absence of constraints on the order of events (French & Brown, 1977; Kavanaugh, 1979; Trosborg, 1982; Mandler, 1986). The sentence *'Anna went to bed after she brushed her teeth'* would be an example of a logical relationship and the sentence *'Otto washed his car before he polished his bicycle'* would be an example of an arbitrary relationship (Trosborg, 1982). All of the above studies found that logically connected sentences were easier to comprehend, as indicated by faster response times (Trosborg, 1982) and shorter time to reenact (French et al, 1977). Further, Mandler (1986) has also determined that logically constrained relationships are less sensitive to manipulation of order of mention. That is, a sentence concerning a logical relationship is as easily comprehended when sentence order does not match order of occurrence as when it does (see Figure 3). This is not the case for sentences relating arbitrary relationships. For example, there is a small response time difference between the sentences *'Anna brushed her teeth before she went to bed'* and *'Anna went to bed after she brushed her teeth'*. There is a large difference between *'Otto washed his car before he polished his bicycle'* and *'Otto polished his bicycle after he washed his car'*.

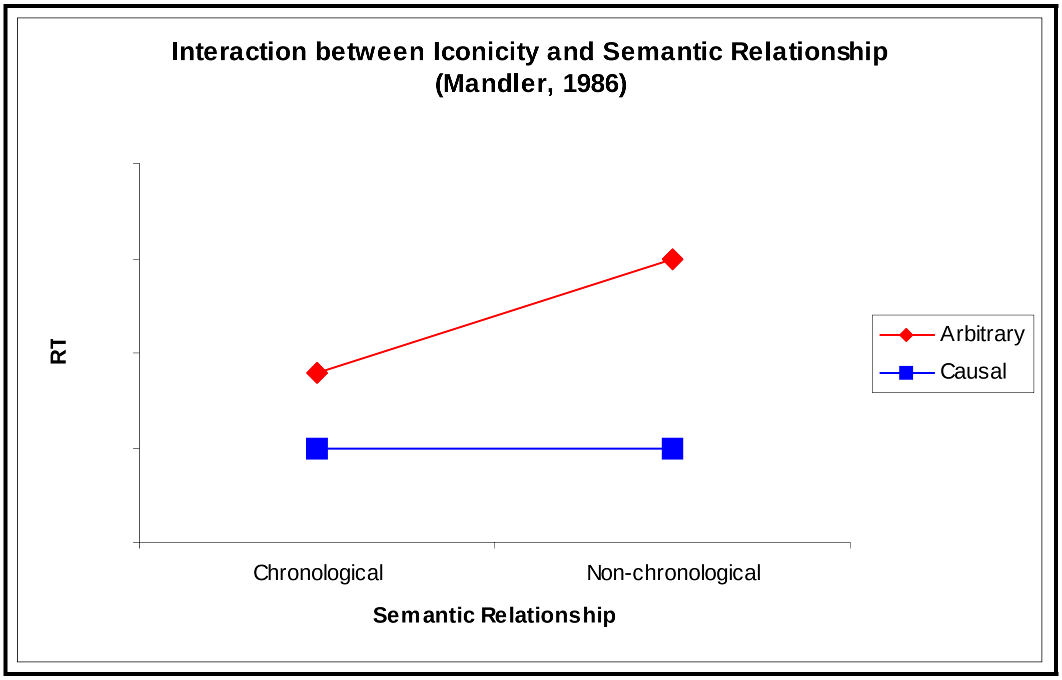

Figure 3. Interaction between iconicity and semantic relationship (Mandler, 1986).

Mandler accounted for this significant interaction between order of mention and constraint type by positing that a mental model of the logical events exists prior to the experimental situation, whereas a model of the arbitrarily related events must be constructed ad hoc. Necessarily it takes longer to construct a model than it does to retrieve an existing model from memory. A match between the order of mention and chronological order facilitates the construction of such a mental model, and the order mismatch therefore has a greater detrimental influence in the context of relationships that require model construction. This account has been corroborated by later research concerning the construction of situation models in language comprehension. Myers and O'Brien (1998) and O'Brien and Myers (1999) suggest that the building blocks for the construction of causally connected sentences are facilitated by bottom-up processes in which the words and ideas in a text resonate with concepts in semantic and episodic memory. This implies that the causal knowledge necessary to establish coherence between sentences can be directly accessed in memory (Kintsch, 2001).

In contrast to nouns, temporal relationships between actions and events are likely physically rather than logically related. The mental model literature distinguishes between the different relationships associated with actions and events.[4] Goldvarg and Johnson-Laird (2001) suggest that these can be conceptually related via either causal or deontic ties. Accordingly, whereas causal constraints adhere to physical laws (cannot be violated, similar to necessary truths), deontic constraints apply by virtue of duty or obligation and therefore adhere to social convention (and can be violated, similar to contingent truths).

The main distinction between differentially constrained (physically and socially) relationships is the kind of restriction imposed by them on the order in which events can occur. The existence of a physical relationship between events A and B entails that it is not possible for B to precede A in time. The existence of a social relationship between two events entails that it is not probable that B precedes A in time. Social constraints therefore impose weaker restrictions than physical constraints. An example of a physical constraint would be *'Anna read the letter before she burned it'*—here it is not possible to carry out the actions in the reverse order. An example of a social relationship would be

[4] In the above studies, the operationalization of 'logical' relationships is not clear. Whereas the early psychology literature examined what was referred to as 'logical' relationships, the more recent research on situation models use the term 'causal' instead. Philosophers as early as Leibniz have recognized that different kinds of truths, or logical relationships, exist: those that can be violated and those that cannot. Contingent truths can be violated but necessary truths cannot (Wilson, 1984). Necessary truths are those that it would be contradictory to deny. For example, 'squares have four sides' is a necessary truth because saying that 'squares are round' would contradict the definition. 'Stop signs are hexagonal' is a contingent truth because they could possibly be round within a different cultural convention.

'Otto washed his hands after using the restroom'. The order in which these actions are carried out is not determined by physical laws, but very much by social and cultural convention.

1.4.2 Psychological Distance

Another aspect of mental organization that can potentially influence the complexity associated with language describing relationships between objects or events concerns the perceived distance between them.

Do you *enter a restaurant* before you *sit down at a table*? Do you *enter a restaurant* before you *pay your bill*? Which of these were easier to answer? If you found that the first was easier then your performance would be consistent with Foss and Bower's (1986) findings that the relationship between knowledge items that are closer to each other in a conceptual hierarchy are easier to comprehend.

Foss and Bower specifically examined the psychological distance between goals and actions that supported those goals. Goals and actions that were further removed from each other were more difficult to understand. For example, the goal-action pair *'Sue wanted to protect the environment so she made a sign'* was more difficult to understand than *'Sue wanted to protect the environment so she joined a rally'*. Similarly, Myers, Shinjo, and Duffy (1987) presented participants with pairs of sentences that were causally related to each other, but varied in the extent to which the causal relations were close or distant. Reading times indicated that causally close sentences were processed faster than causally distant sentences.

A more recent study by Franklin, Smith, and Jonides (2007) has demonstrated that the psychological distance between two actions, operationalized as number of interceding actions, interacts with variables such as where the action resides within the action hierarchy. The data from this sentence-verification study suggests that sometimes, depending on their familiarity with the subject matter, participants respond faster when actions are far apart in the routine and at other times they are faster when actions are closer together. Franklin et al., therefore provide evidence for both distance and reverse-distance effects.

This, however, suggests an explanation for the Given-New phenomenon that Haviland and Clark (1974) overlooked. It is possible that the finding that violating the Given-New principle increases comprehension time is confounded with psychological distance. Clark and Haviland intended a difference between the sentence pairs based on direct and indirect grounding, but perhaps the real difference was one of psychological distance. The relation between the sentences *'we got some beer out of the trunk. The beer was warm'*, is indeed direct, but in the sentence *'we checked the picnic supplies. The beer was warm'* the *picnic supplies* can be regarded as a superordinate concept, and the magnitude of the distance between *picnic supplies* and *beer* could be the determining factor in the magnitude of the difference in comprehension found in this experiment. To adequately control for this potential influence, context sentences that involved less remotely related concepts, but nevertheless different lexical items, should be included. For example, *'we checked the beverages in the trunk. The beer was warm'* does not immediately ground by providing the same lexical items in the context and target sentences, but should still be easier to comprehend than when the context involves *picnic supplies*.

Clark and Haviland did examine the effects of increasing the inferential steps between sentences without changing the noun in order to see if the mere re-mention of the noun was the source of the effect, and found that inferential steps reduce the advantage for comprehension of observing the Given-New principle. For example, *'Ed wanted an alligator for his birthday. The alligator was his favorite present'* was more difficult to comprehend than *'Ed was given an alligator for his birthday. The alligator was his favorite present'*. Again, here it is possible that the difference in comprehension is due to differences in the states identified in each sentence. The first context sentence refers to a hypothetical, a state of 'want', whereas the target sentence refers to a state of 'having'. It takes time to establish the relation between the two, just as it takes time to establish the relation between *picnic supplies* and *beer*.

1.5 Representational Format and Cooperation

So far I have addressed potential communicative, or pragmatic, contextual influences on the cognitive complexity associated with stable linguistic features. Another contextual factor that may have important influences on cognitive complexity concerns the nature of persisting external representations available to support, or provide reference for the content of language.

In real-world distributed work domains, like Mission Control, representations, displays, charts, diagrams, etc., often form the foundation for communication. The objects and events that the communication refers to, the things that are reasoned about, talked about, and pointed to, exist and are shared between participants by way of these representations. Just as objects and events, and the relationships between them, can be more or less prominent in our physical environments, the representations of objects, events and their relationships can be more or less prominent in the displays and interfaces we use to reason about the environment. A representation can hide or enhance an object or relation or conceptual entity (Palmer, 1977; Greeno, 1983, Norman, 1987). For example, to represent the difference in size between a horse and an elephant, I can tell you that a horse weighs 600 kilos and an elephant 4500 kilos, or I can show you two lines whose lengths represent the weight of a horse and that of an elephant (see Figure 4.)

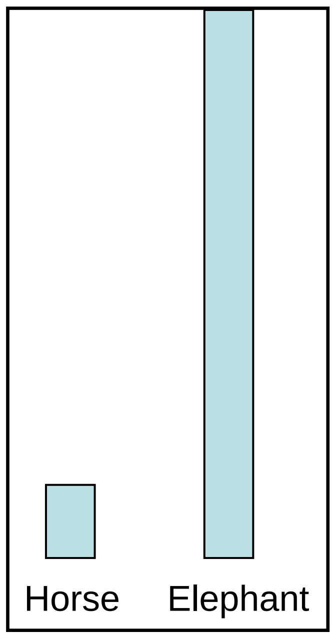

Figure 4. Graphical representation of relative size. The difference between a horse and an elephant.

The numbers tell you what each animal weighs individually, whereas the line representation allows you to get an immediate impression of the difference, or the relationship, between the weights of the two animals. So, where one representation highlights individual entities, the other makes the relationship between them more prominent. Consistent with this view, Carswell and Wickens (1990) found that in simple line graphs of two data points, the two data values were processed as configural dimensions, allowing viewers to integrate information from the two dimensions perceptually.

Similar to representations of spatial relationships, like the one above, representations of time can make use of space to enhance the relative durations of events and the relationships between them. In Figure 5 the graphical representation makes the relationship between events Star and Plus readily apparent, whereas the numeric representation informs about the exact points in time at which the events begin and end.

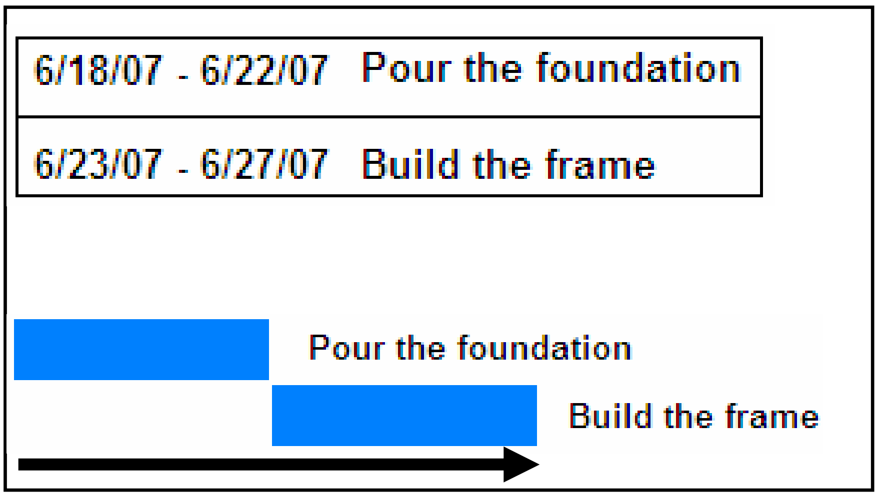

Figure 5. Graphical versus list format representations.

The following sections will explore both the individual and distributed level implications of representations that make relationships more or less apparent.

1.5.1 Individual Cognition

Physical representations have the ability to structure experience (Larkin, and Simon, 1987; Suchman, 1987; Lave, and Wenger, 1991; Hutchins, 1999; Goodwin, 2002; Rasmussen, and Shalin, in preparation). The current study predicts that the form of the experience will influence the structure and content of the language used to talk about them, and therefore the ease with which that language is comprehended. Particularly, having reasoned about temporal relationships on the basis of a corresponding spatial representation is likely to enhance one's ability to resolve order related ambiguity, such as arises when order of mention does not match order of occurrence.

The literature on metaphor provides evidence for the effect of the format of the representation on subsequent spatial reasoning. The use of spatial prepositions to describe temporal relationships has inspired researchers to propose that the cognitive relationship between space and time is metaphorical in nature (Lakoff, 1993). People who speak English often use the same prepositions, words such as '*on*,' '*in*,' '*around*,' and '*through*' to indicate time as well as location. For example, compare *'I will meet you <u>at</u> the store,'* to *'I will meet you <u>at</u> 3pm'*. *T*hese linguistic examples show how time may be thought of metaphorically in terms of space. Lakoff defines metaphor as a mental, rather than as a linguistic construct. That is, the tendency to conceptualize one mental domain in terms of another. Lakoff and Johnson (1980, 1999) have identified seven conceptual metaphors for time:

1. Time is a container (bounded)
2. Time is a landscape we move through
3. Time is something moving towards you
4. Time is a pursuer
5. Time is a changer
6. Time is a resource
7. Time is money

The reciprocal nature of metaphors 2 and 3 become evident in their examples:

2. We're coming up on Christmas.
3. Christmas is approaching.

In metaphor 2 the agent is moving and the temporal 'landscape' is stationary. In 3 the agent is stationary and time in motion. Gentner, Imai, and Boroditsky (2002) and Boroditsky and Ramscar (2002) have investigated the psychological status of these metaphors, the ego-moving and the time-moving metaphor, by showing that physical experience of movement can change people's thinking about time. They asked people either standing in line at an airport (ego-moving) (Gentner et al.) or riding in a train (perception of world moving past) (Boroditsky et al.) a question designed to reveal conflicts between the ego-moving and time-moving metaphors, namely: *'This Wednesday's meeting has been moved two days forward. When is the meeting?'* This has two possible interpretations – one where the meeting is moved to two days later, Friday and one where it is moved to two days earlier, Monday. This can be explained by assuming that the *Friday* reading is based on metaphor 2, where the observer is moving towards the meeting, which is viewed as a stationary event in a landscape. Moving the meeting forward by two days means that the observer will not "reach" the meeting until two days later. The *Monday* reading is based on metaphor 3, where the meeting is seen as moving towards the stationary observer. Moving the meeting forward by two days therefore results in the meeting "reaching" the observer two days earlier. Participants standing in line replied Friday more often, and people riding the train replied Monday more often. This supports the hypothesis that experience in space can change thinking about time.

The present study manipulates representational format such that some participants will experience a representation that is more spatial in nature—a graphical representation. A pilot run of this phase of the experiment revealed the possibility that participants experiencing the graphical representation temporarily adopted a certain way of reasoning about time that is different from the way time is conceptualized when experiencing a list format representation. After completing half their schedules, pilot participants in the graphical representation adopted the strategy of working backwards—they entered the very last event *move in,* and added tasks to the schedule working back to the middle. This kind of strategy was not seen in a pilot of the numeric representation, and it is unlikely that it will occur, since the subtraction of dates is rather cumbersome. However, the fact that the participants in the graphical condition discovered this strategy—which is analogous to the *"time is something moving towards you"* metaphor, may suggest that they are conceptualizing time as "in motion". If that were the case, when asked the question above, participants in the graphical condition should reply '*Monday'* on a more consistent basis that those in the numeric representation. When asked separately, two sets of participants experiencing the graphical representation in the pilot experiment both replied '*Monday'*. The participants experiencing the numeric representation in the pilot were not asked this question. The presence of such a reasoning strategy would suggest longer-term influences of representational format on reasoning.

1.5.2 Distributed Cognition

Past research in human factors on the role of representations in problem solving has largely focused on individual performance or the efficiency with which visual presentation supports problem solving (Bennett and Flach, 1992, Wickens and Andre, 1990, Woods, 1991, Rasmussen and Vicente, 1999, Carswell and Wickens, 1990, Vicente and Rasmussen, 1990). The principles extracted from such an individually focused research may or may not afford a straightforward extension to account for and assist in the support of collaborative work. In the context of a distributed workplace, in which the reasoning processes, such as planning and scheduling, are often carried out in a cooperative fashion, a pertinent question becomes how the differences in individual reasoning strategies afforded by different representational formats affect the social exchange. Is there a positive relationship between how easily a relationship is determined in a graphical representation, such as duration, and how much it is talked about? That is, perhaps the relationship is talked about more because it is explicit. Or, is the converse true, relationships that are explicit in the representation are talked about less. It is possible that if a relationship is 'salient', the speaker will need less information to refer to it because there are fewer other competing relationships from which the target has to be distinguished (Beun, & Cremers, 1998). Or, perhaps it is not necessary to discuss the relationships when they are 'salient' because they are explicit and their articulation would violate Grice's principle of quantity.

Zacks and Tversky (1999) examined the influence of representational format, bar graphs and line graphs, on how people describe the information presented in the graph. Similarly, they investigated the influences of distinct verbal descriptions on the creation of representations. Zacks and Tversky found that bar graphs were described in terms of discrete comparisons between individual data points, using terms such as '*higher'*, '*lower'*, '*greater than'*, and '*less than'*. Information that was presented as lines were described as trends between the data points using terms like '*rising'*, '*falling'*, '*increasing'*, and '*decreasing'*. In their representation creation experiment, when given a discrete comparison description, participants drew bar graphs more often and when given a trend assessment description, they drew line graphs more often.

A potential limitation to Zacks and Tversky's investigation is that the production of descriptions was not for someone else. In an applied context, such as mission control, descriptions are always for someone else, someone that is listening to verbal descriptions, or someone reading written descriptions in the shift handover logs. This kind of criticism can apply to the vast majority of language production studies and all the literature that examines linguistic descriptions of representations. The present study will examine whether we still tend to describe or discuss the informational aspects of representations that are apparent when we are producing these descriptions for someone else who is also looking at the same representation. For example, do people experiencing a graphical representation tend to discuss simultaneity more because simultaneity is spatially represented in graphical representations, than participants experiencing a numeric representation, in which simultaneity is implicit? If the converse is true and people tend to discuss information more when it is not apparent in the representation, i.e., it requires some cognitive effort to derive, this would suggest that, at least in a collaborative situation, humans have the ability to use language to make up for shortcomings in the representation.

1.6 Implications for the Study

The following sections describe how I used the various research findings described so far to inform the design of the current study.

1.6.1 Language and Discourse Manipulations

The present study strived to examine the previously established findings regarding lexical items, syntax, and iconicity (linguistic reversal relative to chronological order) as main effects that influence comprehension. However, I also investigated the potential influences these low level influences on cognitive complexity within a discourse context by including all lexical item by syntax by iconicity by discourse order combinations.

The present study extended the findings of Clark and Haviland (1974) and van de Kopple (1982) to examine the effects of violating the Given-New principle in a situation where the Given information has been established in the context of prior conversation, not simply in an immediately preceding sentence or paragraph. In order to obtain a baseline for determining the effect of introducing New information, I included a condition in which all information was Given. Even though a complete factorial design would have included a condition in which all information was New (where all information is ungrounded), this condition would not provide baseline information over and above that which was obtained from the Given-Given condition.

Some research has suggested a relationship between reading comprehension and permanent attributes of the readers cognitive abilities. MacDonald, Just, and Carpenter (1992) found a link between working memory capacity and comprehension of syntactically ambiguous text. Readers with larger working memory capacity are possibly able to maintain more than one mental representation of the text for a longer period of time. Therefore I included three measures of cognitive ability relating specifically to spatial abilities and short-term memory, mainly the Card Rotations and Cube Comparisons tests (both from Ekstrom, French, & Harman, 1976), as well as the Sentence Span test (Daneman, & Carpenter, 1983).

1.6.2 Semantic Manipulation

The present study investigated the implications of a conceptual distinction between different types of constraints: physical and social by, investigating their potentially differential implications for the comprehension of order. I did not include arbitrary relationships. Their influence on comprehension has already been investigated, and more importantly, because the experimental tasks, as is the case with the majority of real world work tasks that lend themselves to scheduling, contain very few, if any, truly arbitrarily related events.

1.6.3 Psychological Distance Manipulation

The present study controlled for psychological distance. For example, in house construction, the steps *pouring the foundation* and *building the frame* are carried out in near succession, whereas the steps *pouring the foundation* and *installing the carpet* are carried out at temporally distant time points. The psychological distance between the first pair therefore, for the purposes of the present experiment, represents a near relationship, and the second pair represents a far relationship.

Because the task domain for the present experiment concerns the relationships between actions, rather than operationalizing psychological distance as how far apart actions are in a partonomic concept structure, like Franklin et al. (2007) I operationalized psychological distance as how far apart actions are temporally within an action-sequence by number of interceding events.

1.6.4 Latent Conceptual Check

All participants were asked to indicate their answer to the question *'This Wednesday's meeting has been moved two days forward. When is the meeting?'* immediately following the schedule production phase.

1.6.5 Representation Manipulation

The present study examined the discussion of informational aspects of two types of representations that make these aspects more or less apparent. Participants completed the experimental task using either a Graphical or a Numeric representational format. Within those two formats, I examined the frequencies with which people used language describing simultaneity, such as '*during*,' '*while*,' '*same time*,' '*overlap*,' and '*middle of*'. In constrast to Zacks and Tversky (1999), the present study examined production in dyadic interaction rather than in verbal protocol without a recipient.

1.7 Study and Hypotheses

The present study will examine the production and comprehension of language about temporal relationships in two tasks that involve substantial temporal reasoning components: a schedule creation phase and a sentence verification phase.

1.7.1 Production Phase

In the first phase participants will work in dyads to create a house construction schedule, chosen for its accessibility to the general public. Participants will use either a graphical representation (Gantt chart format), or a numeric format representation (list). The dyad members will each have their own representation (in the same formats), and will not have visual access to their partner's representation. The lack of shared visual access mimics the conditions of contemporary distributed work, and promotes verbal interaction. A house construction schedule includes events that are successive and simultaneous, have physical and social semantic relationships, and are near and far in terms of psychological distance. Inherently Given and New information within the context of the discourse will emerge.

1.7.1.1 Dependent measures.

Transcripts of the verbal communication between participant dyads provided a background for performing quantitative as well as qualitative analyses. I was able to evaluate the different representation types on the basis of how long it took to complete the schedules, and how much conversation was needed to accomplish this. The amount of communication was be assessed by the ratio of words to units time. This ratio further reflected the overall task completion time and provided insight into how well the two representation formats support collaborative work. If the ratio is smaller (more silence relative to verbal activity) in the graphical condition, this would suggest that the participants feel they are able to accomplish larger portions of the task individually without involving their teammate, which may not be a desirable state of affairs in work domains where the resulting quality of the work outcome depends on teammates contributing their individual expertise.

In terms of language use, I counted the number of times the various sentence constructions assessed in the comprehension phase were used in discourse. I also counted how many times iconicity is violated, how many times it was violated in the context of given and new information, etc.

1.7.2 Comprehension Phase

The second part of the task required participants to read and verify a series of sentences that describe the temporal relationships between events that they had just reasoned about in the construction schedule task, and some new events that were not included in the scheduling task, counterbalanced across the variables discussed above: preposition, iconicity, discourse order, semantic constraint type, and psychological distance. This task provided me with a quantitative measure of comprehension, True/False verification time. It departed from the standard picture-sentence or sentence-sentence comparison task by invoking recent experience (rather than immediately previous experience) as the standard for evaluation.

These tasks provided a qualitative measure of production (verbal exchange), and a quantitative measure of comprehension (reading time) which together allowed me to compare production preferences to comprehension. For example, are the sentence constructions that are easy to comprehend also the ones we tend to produce in discourse? Although comprehension and production processes are physiologically and cognitively dissociable, Gricean principles assume a complementary relationship.

1.7.2.1 Dependent measures.

The existing literature on comprehension has employed such measures as reenactment time, reading time, response time (verification time), and accuracy. Of these, response time is by far the most thoroughly validated measure, and the one that is most readily interpreted. Response time has been recognized to consist of: reading time, comprehension time, and response selection and execution time. The present experiment employed response time as a dependent measure.

1.7.2.2 Hypotheses.

Main Effects:

H1: Participants who experience the graphical representation will complete a construction schedule faster than participants who experience the list representation.

H2: Participants who experience the graphical representation will use qualitatively different language than participants who experience the list representation.

This hypothesis is not directional: the graphical representation may elicit more discussion of duration because duration is a salient feature of this representational format, or the graphical representation may elicit less discussion of duration because duration is a salient feature of this representational format in the comprehension study.

H3: Sentence constructions with higher response times in the comprehension study will occur fewer times in the production study than sentence constructions with shorter response times.

H4: Participants experiencing the Graphical representation will be more likely to adopt the time-moving metaphor and therefore reply '*Monday*' to the conceptual metaphor question while participants in the Numeric representation will be more likely to adopt the ego-moving metaphor and therefore reply *'Friday'*.

Two-way Interactions:

H5: Sentences that reverse order of mention relative to chronological order will result in longer response time than sentences that do not. This difference will interact with semantic constraints: the effect will be larger for social relationships.

H6: The order effect will be smaller for participants who experience the graphical representation.

H7: The iconicity effect will interact with discourse order such that the iconicity effect will be small when the Given/New principle is observed and large when the Given-New principle is violated.

Three-way Interaction:

H8: A three-way interaction is expected between preposition, clause, and discourse principle such that sentences using the preposition *before* will be more easily understood when the main clause is presented first and the penalty for violating the Given-New principle will be larger when the main clause is presented first. This pattern is expected to be reversed when sentences use the preposition *after*.

II. Method

2.1 Production Phase

There were two yoked phases of this experiment. The participants' experience from the first phase fed into their experience of the second.

2.1.1 Participants

Sixty-four undergraduate students from a large Midwestern university participated in this experiment. Their mean age was 20.1 years. They received credit applied towards their grade in an introductory psychology class to meet general education requirements. Same gender-dyads participated, constructed at sign-up. Participants were discouraged from signing up at the same time as a friend and/or roommate. One pair of participants split a $150 bonus based on their performance on the experimental task.

2.1.2 Materials and Equipment

The construction schedule and events were displayed on a desktop PC with a 17" monitor. The schedules were created using Microsoft Outlook's task function. The participants wore headsets and communicated using the web-phone program Skype.[5] The on-screen activity as well as the verbal interaction (audio) between the two participants was captured using the screen capture software RiverPast.

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[5] Participants were only allowed to communicate using Skype's audio feature, and were restricted from using the chat and video-conferencing features.

2.1.3 Procedure

The participants completed the task in dyads. The construction steps were divided between the dyad members randomly but consistently across dyads, such that each member had 19 subtasks of the total 38. The participants were supplied with an empty schedule each in either the numeric, list format or in the graphical, Gantt-like format (see Figure 6 andFigure *7*) depending on their experimental group.

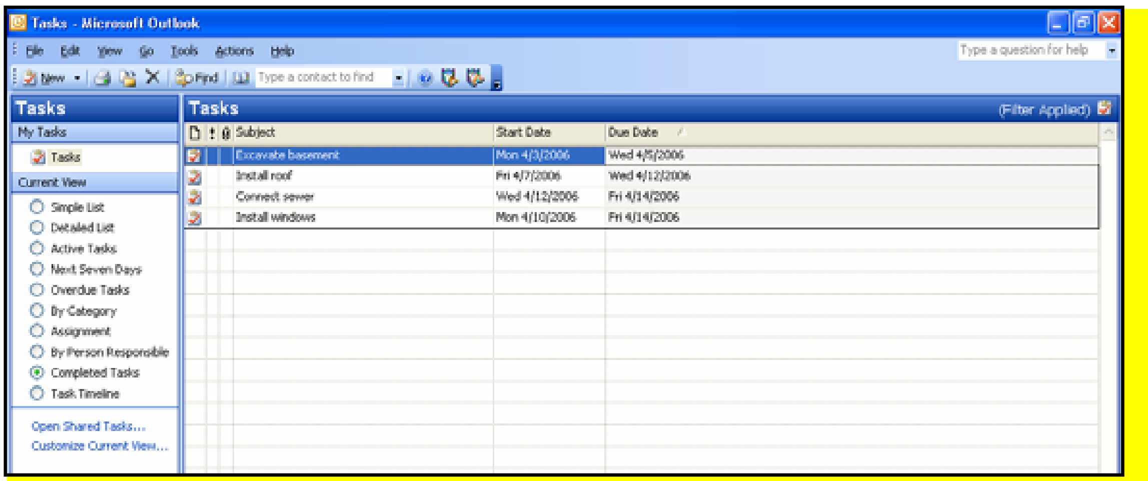

Figure 6. Screen capture from Outlook in numeric format output mode.

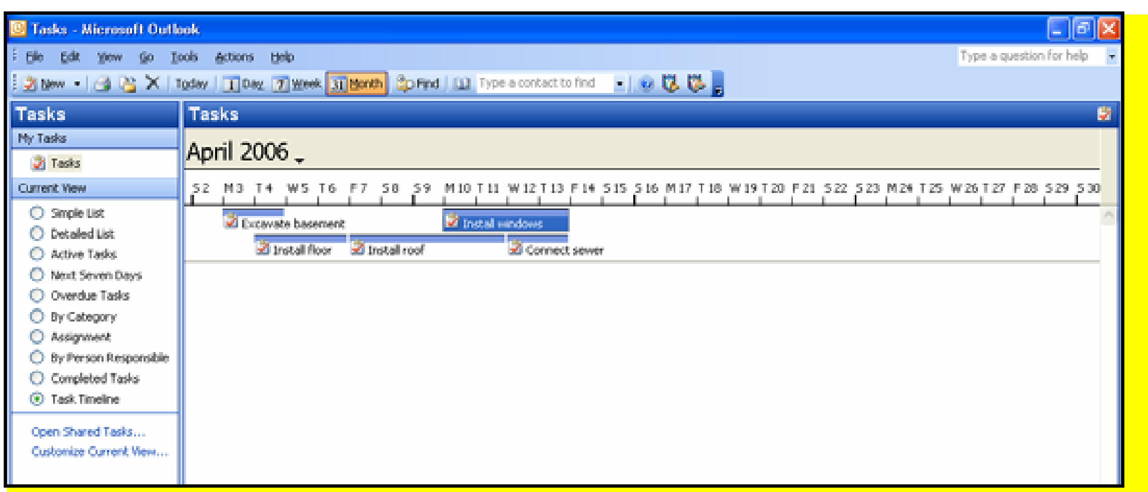

Figure 7. Screen capture from Outlook in graphical output mode.

One member drew a number determining the type of representation the dyad was going to use. The dyad members sat in separate rooms. They wore headsets providing them with auditory contact with the other member of the dyad.

Participants each began with identical empty construction schedules, and used verbal coordination to merge the construction steps that they had been assigned and filled out their schedules accordingly. They had to create a schedule that included all the construction steps such that all the steps in the schedule were completed within a three-month timeframe.

The method for entering events into the schedules was the same for both groups. Participants would enter the name of the event, select the start and end times for the event, and then press the Save and Close button (see Figure 8).

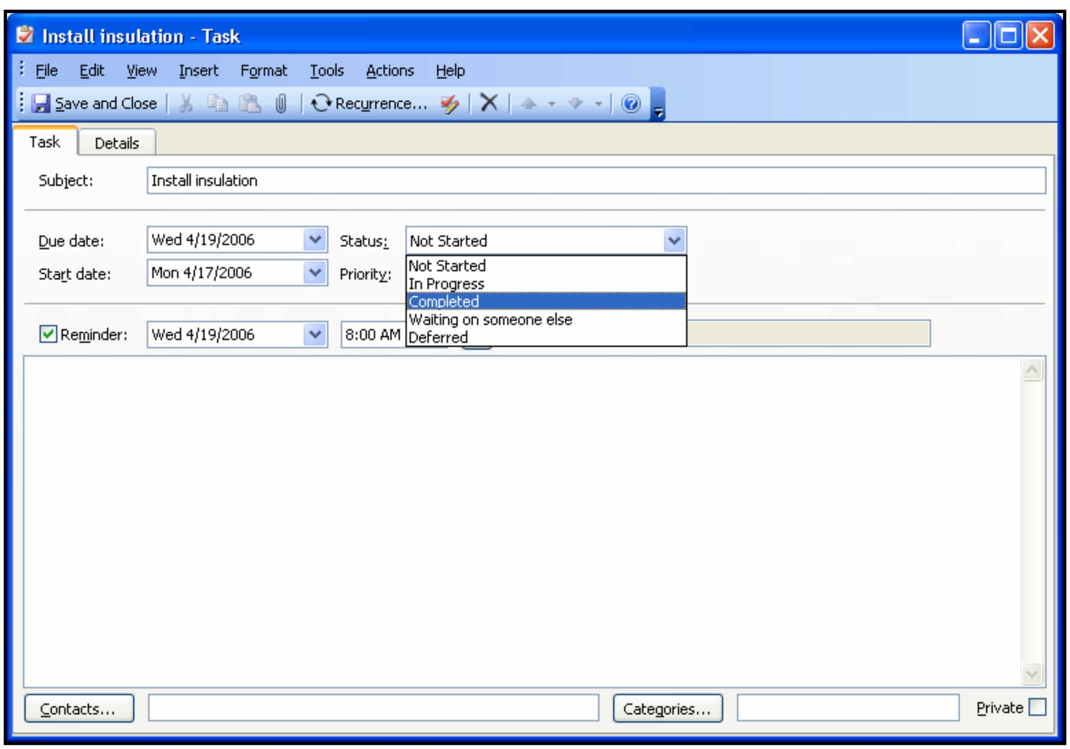

Figure 8. Screen capture of Outlook's interface for adding events to the schedules independent of schedule format.

Participants were instructed to also fill in events that belong to their partner (see Appendix B). When they had entered all the events in the schedule, and their schedule did not exceed the three-month timeframe, they had completed the production phase. This phase of the experiment took between 45 minutes and 1 and one half hours to complete including instructions. Participants had to complete the scheduling (production) experiment in order to proceed to the second (comprehension) part of the experiment.

After completing the schedules, all the participants were asked the conceptual metaphor question: “This Wednesday’s meeting has been moved two days forward. When is the meeting?” They indicated their answer in pencil on a piece of paper.

2.1.4 Experimental Task

The first experiment required dyads to create a construction schedule for a house, without co-location and communicating through an intercom (see Figure 9).

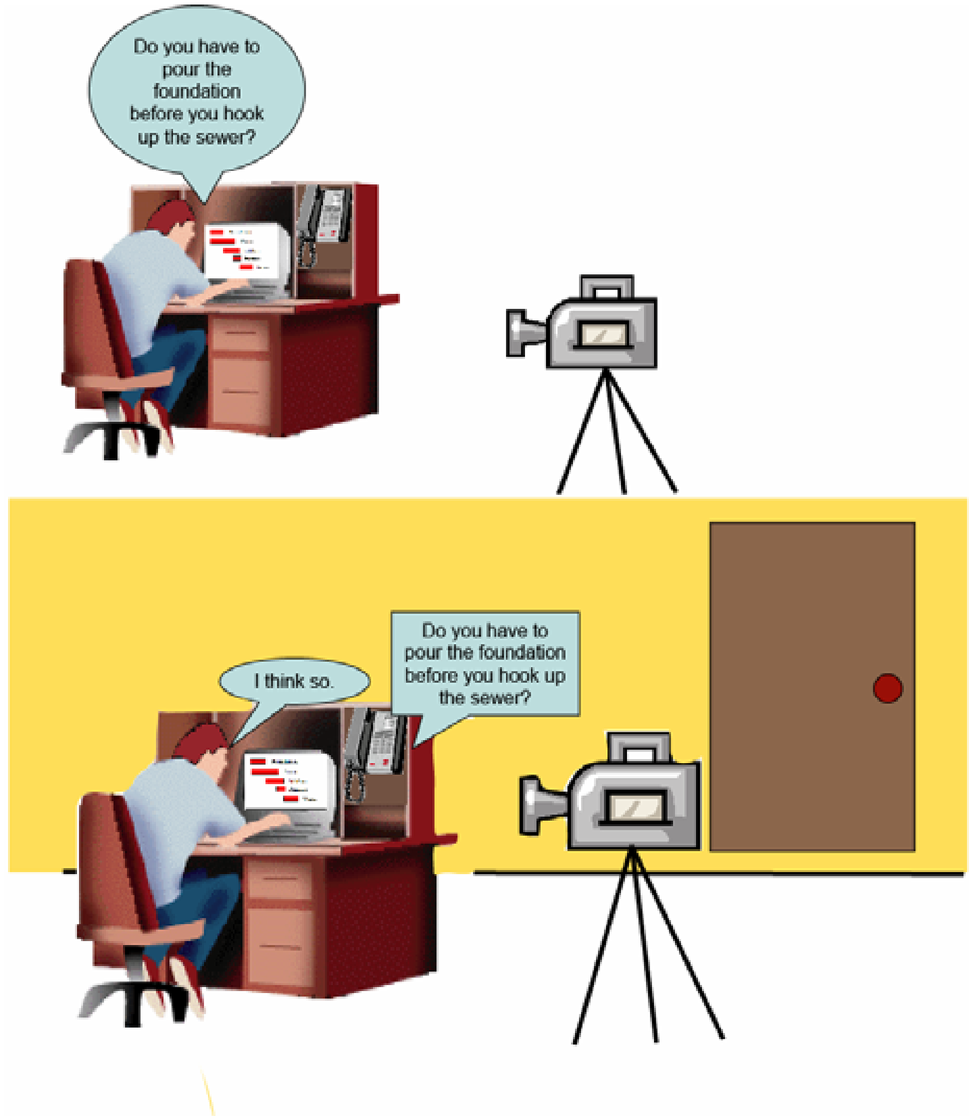

Figure 9. Illustration of experimental set-up for the production (scheduling) phase.

Both participants had access to separate physical representations of the schedule and laminated slips of paper with the names and durations of 19 different subtasks, or events (38 total) within the overall task of house construction (see Table 4).[6] Participants were asked to arrange the events in an order that ensures a fit within a three month period. To meet this constraint, events had to be arranged in successive as well as

[6] Some of the participants arranged their slips of paper by laying them out on the table next to the computer. Others arranged them by shuffling them while holding them as a deck of cards.

simultaneous order. Participants needed to negotiate a satisfactory order of these events in order to accommodate all events within a limited timeframe. That is, some of the events had to take place at the same time to attain a schedule that met the time constraint.

Table 4

Table of Given Events Included in the Production (scheduling) Task.

GIVEN	
excavate the basement	order the tile
pour the foundation	install the vinyl floor
connect to city water	tile shower stall
build the floor frame	deliver interior trim
install basement stairs	install the baseboards
build the frame	build the bookshelves
frame the interior walls	install the cabinets
deliver the roofing material	install the countertops
construct the roof	install the hardwood floor
install the windows	install the faucets
install the shingles	install the toilets
install the ductwork	connect the switches
test the heating system	install the light fixtures
install the water lines	remove the dumpsters
run the rough wiring	plant the shrubs
frame inspection	install the gutters
attach the exterior siding	install the downspouts
attach the drywall	obtain the occupancy permit
prime the walls	move in

A professional contractor assisted in the identification of the events in Table 4, which met constraints in both parts of the experiment. The terminology was accessible to novices, plausibly involved or placed temporal constraints on other events, and preserved domain semantics. For example, at one time had the event ‘build the fireplace’ in the set of 38 given events, but we decided that it did not seem to fit the type of house we were building and excluded it. The 38 events in the production study served as Given events in the later comprehension study in combination with a set of New events, which together allowed construction of a stimulus set that reflected all the independent variables in the comprehension study. However, some refinements occurred to the list of Given events after the comprehension experiment had been programmed.

2.1.5 Experimental Design

Representational format served as the single, between subjects independent variable in the production phase of the experiment. This variable had two levels, so that participants experienced either a numeric representation of their construction schedule, or a graphical format representation. The numeric representation condition provided the participants the duration of the event in numeric format, e.g., ‘9/5/05 – 9/7/05’ (see Figure 6). The graphical representation represented duration spatially as a colored portion of a rectangle. The length of the colored portion corresponded to the duration of the event (see Figure 7). When placed on the background of the construction schedule the participants could determine how much time the events required relative to the entire construction schedule.

A set of dependent measures addressed the quantifiable differences between schedules and the scheduling process. These dependent measures consisted of: number of words used in the conversation to complete the schedule, time, types of relationships discussed (successive or simultaneous) to create the schedule, and the accuracy of the schedules. To tally the types of relationships employed in the construction of the schedules I employed the rule that only relationships between events that were within one day of each other or closer were to be counted. The schedules were deemed to be more accurate the more they matched the order of only the physically related events in the schedules compared to the order produced by our construction expert. The order of socially related events, on which there were no inherent physical order constraints, was not taken into consideration by the accuracy measure, because the relationship between them is less obvious, and therefore less easy for the novice to determine. The fewer incorrect event orders in a schedule, the fewer points were added from the overall score, which means that a low score translates into good performance. This accuracy measure, however, did not account for time on task. Therefore we computed a score that reflected accuracy as a function of time.[7] We suspect that some participants did well because they took a long time on the task, and others did well because they were just good. In this instance, the time/accuracy score therefore is a better measure because it reflects quality per unit time.

Another set of dependent measures served to correlate the data obtained from the later comprehension phase of the experiment with the production data. The verbal interaction between the dyads as they were completing the scheduling task was transcribed, yielding a total of 32 transcripts. These transcripts enabled investigation of the language used in the process of creating the schedules, and correlation of this language with the data obtained from the later comprehension phase of the experiment.

In order to compare the findings in previous comprehension research relating to for example Iconicity and Clause Position to production, I coded the syntax of the sentences describing relative temporal relationships. That is, I coded whether the

[7] In doing so, we first verified that the initial accuracy measure did not correlate with time for either the graphical or numeric representations, r(14)=0.0826; 0.341, $p > .05$.

‘before’/’after’ sentences had the main clause first or the main clause last. I also counted the occurrences of lexical items indicating simultaneity: ‘*during,*’ ‘*while,*’ ‘*overlap,*’ ‘*middle* (*of*),’ and ‘*same time’*—these relationships were explicitly represented in the graphical representation and implicitly represented in the numeric representation. Additionally, I counted the number of occurrences of relative pronouns: ‘*that’*, and ‘*this’*.

2.2 Comprehension Phase

2.2.1 Participants

The same 64 participants participated as individuals in the comprehension experiment. For this phase of the experiment, all participants received modest gifts from the university bookstore, such as pens, highlighters, cups, or stickers in addition to 5 credits towards their psychology class.

2.2.2 Materials

The sentences were displayed in different randomized orders on a computer. The participants used the F and J keys on a standard keyboard to indicate whether the sentence was true or false. The computer recorded the participant’s response and their true/false judgment.

I measured variation due to the stable cognitive attributes of the participants by administering the Daneman and Carpenter Sentence Span Test (Daneman, & Carpenter, 1983), to measure working memory capacity, as well as a the Cube Comparisons and Card Rotation tests (both from Ekstrom, French, & Harman, 1976) to measure spatial ability. It is possible that the comprehension of text that describes events in the reverse order in which they occurred involves, not the maintenance of multiple mental representations, but rather a form of rotation, or righting of this order. In this case spatial abilities would serve as a better predictor of the comprehension of different syntactic arrangements.

Participants also filled out a demographics questionnaire that included their experience with house construction. It was likely that the speed with which the participants completed their schedules depended on the amount of experience with house construction, so I wanted to at least control for this.

2.2.3 Procedure

Both dyad members performed the comprehension task separately at the same computers they had used to complete the production task. The participants completed one practice block of 8 trials and experimental blocks of 48 trials. They placed their left and right index fingers on the F and J keys. The keys were clearly marked True and False. The computer presented sentence, one at the time, and waited for the participant's response. After responding to a block of practice sentences, the participant engaged the experimental block. After the participant indicated a response, the computer waited 3 seconds before presenting the next sentence. An auditory tone warned the participant 1 second before the next sentence appeared. The comprehension task took about 10 minutes to complete.

Participants were told that they would view instructions for constructing a house that other participants in a similar experiment had written (see Appendix C). The participants were instructed that this other (hypothetical) experiment may have used events that were not part of the construction schedule that they had completed, and that they should indicate whether this is a valid instruction in general. Participants were supplied with a practice instruction set that included new events to ensure that they understood the response criteria. For example, participants could have been asked to evaluate the instruction *'you pour the foundation before you install the beams'*, in which the event *installing the beams* was not an event in the schedule they created. This was, however, a valid order of events and participants should have accepted this as a credible instruction.

After the comprehension task, the participants completed the covariate measures. One participant would fill out the Cube Comparisons and Card Rotations tests while the other completed the Sentence Span Test, and when finished they would switch. Subsequently they would both fill out the demographics questionnaire. The covariate measures and the questionnaire took about 25 minutes to complete.

2.2.4 Experimental Task

The second phase of the experiment required participants to read and evaluate a series of temporal relations, including events included in the construction schedule they created and some new events that were not included in their schedule.

These statements represented all combinations of the main variables of interest: preposition type, chronological order correspondence, semantic constraint type, discourse order correspondence, and psychological distance. A proportion of the sentences asked them to verify the temporal relationship between events that were included in their scheduling task (Given) and events that were not (New). Table 5 presents the New events that were not part of the production task:

Table 5

Table of New Events.

NEW	
purchase the lot	Test the heating system
obtain the permits	connect the electrical outlets
order the lumber	lay the attic insulation
clear the trees	apply the wallpaper
schedule the excavation	install the water softener
cut the driveway	install the water purifier
stake the homesite	install the interior doors
install the septic tank	stain the baseboards
connect the temporary utilities	install the interior window trim
place the foundation forms	install the interior door trim
waterproof the foundation	install the mirrors
deliver the lumber	install the closet hardware
install the floor joists	tile the shower stall
install exterior trim	install the shower doors
backfill around the foundation	install the drapery rods
grade for the lawn	install the garbage disposal
install the exterior doors	install the attic stairs
apply the roof felt	pick out the appliances
blow in the wall insulation	install the dishwasher
finish the drywall surface	install the range
plaster the ceilings	install the refrigerator
build the chimney	install the garage doors
install the gas lines	install the attic vents
install the exterior vents	attach the shutters
deliver the furnace	finish the yard grading

The sentences were constructed around eight event contexts. These were selected based on the requirement that they had a significant number of relationships with other events in the schedule: *pour the foundation, build the frame, attach exterior siding, build the floor frame, construct the roof, attach the drywall, install the ductwork,* and *run the rough wiring* (see Table 4). These central construction events have a large number of other events that are either dependent on them or were somehow temporally constrained by these primary events. The primary events were paired with a secondary event either from the list of events from the production task (for Given-Given sentences) or from the list of New events that were not included in the production task. Each of these secondary events was used no more than three times throughout the eight contexts (never with the same primary event). The same secondary event was never used twice in the same cell. For example, ‘test the heating system’ only occurs once in the Causal, Near, Given-Given cell to avoid confounding the variables of interest with content. Because participants saw the same primary context six times, the secondary events also appeared multiple times to mask the repetition of primary events. Late changes in the stimuli for the production phase resulted in a change in the role of the *build the fireplace* event, as a New event rather than, as designed, as a Given event.

2.2.5 Experimental Design

This experiment employed a 2x2x2x2x3 factorial split-plot repeated measures design with only prior representation as a between-subjects variable, using response time as a dependent measure

The independent variables investigated in this experiment were clause position, iconicity, semantic constraint type, and discourse order. Psychological distance was a control variable. Clause position (main clause first/main clause last), iconicity (chronological order/non-chronological order), semantic constraint type (physical/social), and psychological distance (near/far) each had two levels. Discourse order correspondence (given-given/given-new/new-given) had three levels. Note that the preposition types before/after are results of the combinations of clause position and iconicity (see Table 6).

Table 6

Prepositions Types Before/After Embedded in the Interaction Between Clause Position and Iconicity.

	Main Clause First	Main Clause Last
Chronological	X is before Y	After X, Y
Non-Chronological	Y is after X	Before Y, X

The sentences were constructed in collaboration with an experienced house construction contractor, who rated the temporal, semantic, and psychological distance relationships presented by the sentences. Semantic relationships included physical or social constraints. Events with hard, physical constraints, where one event necessarily had to take place *before*/*after* another were labeled physical. Events without such hard constraints but where some social convention existed dictating that one should take place *before*/*after* another were labeled social. For example, the foundation must be in place prior to installing the flooring, illustrating a physical relationship. But, the roof need not be in place prior to laying flooring, although a social convention exists for economic reasons. Psychological distance was determined based on chronological distance within the schedule created by our expert. See Appendix D for a complete list of sentences.

This provided for 48 different sentences. Twelve foil sentences were added that required a False response such that 20% of the total 60 sentences required a False response. The proportion of foils departed from the traditional 50% for several reasons. First, because socially constrained sentences would not be unambiguously false—i.e., it was possible to reverse the order of events and preserve truth. False sentences must therefore come from the physical category. Also, the task cover story (evaluating sentences written by other participants) could not plausibly result in 50% false statements. Participants were told that if they get a certain percentage correct they would receive a reward (that in fact everyone received) to guard against thoughtless misses. The eight contexts were assigned to the independent variables (a, b & c) using a Latin Square, as shown in Table 7. Thus a participant in group 1 would observe all six 000 sentences in context 1, all six 001 sentences in context eight, all six 010 sentences in context seven, etc. Context was counterbalanced, but otherwise unanalyzed. With 80 participants and 8 contexts, each context-independent variable combination appeared 10 times.

Similarly, a latin-square was used to assign contexts to the 12 foil sentences. Sixteen unique combinations of contexts were created using the false sentences. The 8 true sentence/context groups were combined with the sixteen false sentence/context groups (repeating the true combinations once) for a total of 16 groups.

Table 7

Latin Square for Assignment of Contexts to Independent Variables.

			Context							
Psychological Distance	Main Clause	Order Correspondence	1	2	3	4	5	6	7	8
0	0	0	1	2	3	4	5	6	7	8
0	0	1	2	3	4	5	6	7	8	1
0	1	0	3	4	5	6	7	8	1	2
0	1	1	4	5	6	7	8	1	2	3
1	0	0	5	6	7	8	1	2	3	4
1	0	1	6	7	8	1	2	3	4	5
1	1	0	7	8	1	2	3	4	5	6
1	1	1	8	1	2	3	4	5	6	7

2.2.5.1 Counterbalancing.

Sixteen between-subjects groups had been created counterbalancing discourse order, as well as the other independent variables, across the eight contexts. Discourse order was supposed to have been counterbalanced for each subject, meaning that each subject should have seen 20 given-given, 20 given-new, and 20 new-given sentences. Due to a late change in the stimuli in the production experiment—an event that should have served as a given event was actually a new event. Table 8 shows the actual distribution of the levels of discourse order within the sixteen groups, after the event in question had been coded correctly. Groups marked with a star (*) are the groups that are most affected by the coding changes.

Table 8

Number of Stimuli per Level of Discourse Order within the 16 Groups.

	1*	2*	3	4	5	6	7*	8*	9*	10*	11	12	13*	14*	15	16
GG	22	22	19	19	19	19	23	23	24	24	20	18	18	19	20	21
GN	18	18	21	21	21	21	19	18	18	19	20	21	22	21	20	20
NG	20	20	20	20	20	20	18	19	18	17	20	21	20	20	20	19

III. RESULTS

Although participants experienced the production task first and the comprehension task second, I will present results for comprehension task first. The literature provides better predictions for this task. Also, the comprehension results are important for the interpretation of the production task.

3.1 Sentence Verification Task: Language Comprehension

3.1.1 Preliminary Analysis

The following section describes the series of data-winnowing and statistical procedures that were carried out in order to determine the best, and in this case, most conservative model for describing the data.

The comprehension data set had only one observation per cell. A total of 13.43% of these observations was missing or deleted for several reasons. Incorrect responses resulted in 4.69% of all the observations being excluded. Because only causally connected sentences could reliably be classified as either true or false, only incorrect causally connected sentences were excluded. Additionally, response times 3 standard deviations from the mean were excluded as outliers, resulting in the exclusion of 1.44% observations. Due to the design error, 3.65% of the cells were empty. Additionally, in order to that there was exactly 1 data point per cell for each participant, the wrongly coded stimuli were simply left out of the final analysis, accounting for an additional 3.65% of excluded observations. Having missing scores in a split-plot results in a slight correlation between the subjects and experimental conditions potentially compromising the interpretability of higher-order interactions (Kirk, 1994).

Three approaches to data analysis addressed the ambiguity of the unbalanced design by identifying a consistent pattern of significant effects that did not depend on a specific approach to the management of the ambiguity: 1) Replacement of missing scores with estimates based on the subject means, condition means, and regressed means, 2) fitting subject effects to the data first, and using the resulting residuals in an ordinary unbalanced ANOVA, and 3) an ordinary, unbalanced ANOVA using Type III SS, adjusted for the presence of all effects in the model. The first two analyses serve as checks against spurious effects in the analysis. In addition, the unbalanced design precludes the use of SAS's repeated function, which automatically provides sphericity tests. In the cases involving the variable with three levels, I assume violation of sphericity and use the Geisser-Greenhouse correction. The results section below focuses on those results that are robust using all three approaches. Next, the three approaches are briefly presented, focusing at the end on the third and simplest approach, which supports more extensive analysis.

3.1.1.1 Replacement of missing scores.

A common approach to the management of an unbalanced design is to replace missing scores. I carried out three separate analyses using different approaches for replacing missing scores. First, I replaced missing scores by substituting in condition means, second by substituting with subject means, and finally using SPSS's missing value analysis to compute missing data through a regression algorithm. The patterns of significant effects resulting from using these different approaches for replacing missing scores were not different (see Appendixes E-G for full ANOVA tables, Appendixes H-J for full ANOVA tables on Log transformed scores, and Appendix K for means). These analyses all suggested the presence of two three-way interactions, discourse order by iconicity by semantic relationship, and discourse order by clause position by semantic relationship, as well as two two-way interactions involving psychological distance by semantic relationship, and iconicity by clause position (see Table 9 for summary of significant results). These interactions subsume all main effects, precluding the option of collapsing across a variable to balance the design.

3.1.2 ANOVA on Residuals after Fitting Subject Effects

Another approach to managing the unbalanced design is to assign subjects all ambiguous variance (i.e., variance that could be a treatment effect or could be a subject effect). A preliminary model included only variables for the 64 subjects, with the resulting residuals then submitted to a second repeated measures ANOVA—testing against an aggregated error term (see Appendix L for full ANOVA table).[8] To examine the possibility that this procedure inappropriately assigned variability to subjects I adjusted the raw scores for my covariates, and used those residuals in the same second analysis, and I got the same patterns of results, although still without breaking out separate error terms (see Table 9 for a summary of effects across these different analyses, and Appendixes M-O for full ANOVA tables).

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[8] Using an aggregated error term inflates power. I also ran the analysis with separate error terms for each effect. This did not change the pattern of significant results.

Table 9

Summary of Significant Omnibus Results.[9]

	Raw	Log	LSmeans	Raw	Log
	Missing Scores	Missing Scores	Subject Residuals	Condition Means	Condition Means
DISCO	**	**	**	**	**
ICON*REP					
SEMREL	**	**	**	**	**
DISCO*CLAUSE		*			
ICON*CLAUSE	**	**	**	**	**
DIS*CLAUSE*REP					
DISCO*SEMREL				*	
DISCO*SEMREL*REP					
DIS*SEMREL	**	*	*	**	**
CLAUSE*SEMREL*REP				*	
DISCO*ICON*DIS	*				
DISCO*ICON*SEMREL	**	**	**	**	**
DISCO*DIS*SEMREL					*
DISCO*CLAUSE*SEMREL			*	**	**
DISCO*ICON*DIS*SEMREL		*			
REP*DISCO*ICON*DIS*CLAUSE		*			
REP*DISCO*ICON*DIS*SEMREL	**	*			

[9] ** indicates significance level of <.05. ** indicates significance level of <.01.*

Table 9

Summary of Significant Omnibus Results (Continued).

	Raw	Log	Raw	Log
	Subject Means	Subject Means	Regressed Values	Regressed Values
DISCO	**	**	**	**
ICON*REP		*		*
SEMREL	**	**	**	**
DISCO*CLAUSE				
ICON*CLAUSE	**	**	**	**
DIS*CLAUSE*REP			*	
DISCO*SEMREL				
DISCO*SEMREL*REP			*	*
DIS*SEMREL	*	**	**	**
CLAUSE*SEMREL*REP	*			
DISCO*ICON*DIS				
DISCO*ICON*SEMREL	**	**	**	**
DISCO*DIS*SEMREL		*		*
DISCO*CLAUSE*SEMREL	**	**	**	**
DISCO*ICON*DIS*SEMREL				
REP*DISCO*ICON*DIS*CLAUSE				
REP*DISCO*ICON*DIS*SEMREL				

The same three interactions that were significant in the previous analyses were also significant using this method of analysis. The three-way interaction between discourse order, clause, and semantic relationship, $F(2, 124)= 4.470$, p =.0120 is not significant using a correction for sphericity, F critical (1,11)=4.84, $p > .05$.

3.1.3 Omnibus Results—Unbalanced ANOVA

This ANOVA uses only original data, with no substitutions and without first removing subject effects. The response times were not normally distributed. Therefore, I first confirmed that the patterns of results were robust in the presence of a log transformation (see Appendix P for full ANOVA table).

I then proceeded to analyze the unbalanced, untransformed dataset. Because non-significant terms in the model could be spuriously reducing the Type III sums of squares for the error terms in an unbalanced dataset I removed non-significant higher order interactions from the model. I analyzed the data again first without the insignificant six-way and its error term, then without the insignificant five-ways (and their error terms), and lastly without insignificant four-ways (and their error terms). Borderline significant five-ways, and four-ways were included, using the > .2 criteria for exclusion (Kirk, 1995) (see Appendixes Q-S for full ANOVA tables). One 5-way interaction (representation by discourse order, by iconicity by psychological distance by semantic relationship, $F(2, 106) = 5.96$, $p < .0054$) was initially significant in the full-model version of the missing-values analysis (see Appendix T for full ANOVA table, and Appendix U for means). However, this interaction was not significant when other insignificant five- and four-way interactions had been subtracted from the model. I therefore think it is spurious and uninterpretable and I will not analyze it further.

There are some F-ratios that are much smaller than 1, which suggests that homogeneity of variance should be checked. I used Fmax (Hartley, 1950) to check homogeneity of variance for the significant effects reported below (see Appendix T, footnote on ANOVA table). With this many DFs, any departure from one is significant, suggesting the need for Box adjustment due to violations of homogeneity of variance[10], as well as specialized tests for simple effects using error terms specific to the cells

[10] The Box adjustment for homogeneity of variance, like adjustment for sphericity, reduces the degrees of freedom in the critical F denominator. For the completely randomized factorial design the reduced degrees of freedom are equivalent to the smallest number of scores per group minus one, i.e., original degrees of freedom divided by the number of groups. In the spirit of the box adjustment, for the critical F I divided the error terms in our within subjects design by the number of groups.

included in the contrast of interest (Keppel, & Wickens, 2004).

The analysis of raw data suggested the presence of one three-way interaction, discourse order by iconicity by semantic relationship, and two two-way interactions involving psychological distance by semantic relationship, and iconicity by clause position. The three-way interaction between discourse order, clause, and semantic relationship was not significant in this analysis, and given that it was only marginally significant when I adjusted for subjects effects and sphericity, I will not analyze it further.

Hypotheses five through eight predicted interactions between iconicity and semantic relationship, iconicity and representation, iconicity and discourse order, as well as a three-way interaction between discourse order, iconicity, and clause. None of the predicted interactions were significant (see Appendix T for ANOVA table—only significant results will be reported in the text, for non-significant results see appendix). One significant three-way and two significant two-way interactions were stable across analyses, and are reported below.

3.1.3.1 The effects of semantics and discourse order on order reversal.

The interaction between discourse order, iconicity, and semantic relationship was consistently significant across the different methods of analysis and with raw scores, $F(2, 106) = 10.710$, $p < .0001$. This unexpected three-way interaction subsumes two predicted two-way interactions, which I will review in the following.[11]

The previous literature suggested an interaction between semantic relationship and iconicity, such that the effect of an order reversal should be magnified in the context

[11] The error term in these analyses consist of data specific to each comparison. So the differences in degrees of freedom reflect differences in the number of contributing datapoints.

of arbitrary relationships. I had predicted an interaction between iconicity and discourse order, such that the effect of an order reversal should be magnified in the context of a violation of discourse order (see Figure 1). Neither of these two-way interactions were significant, $F(2, 124)=1.35; 0.01$, $p = .2618; .9929$ respectively, however the above mentioned significant three-way interaction involving all three of these variables was significant, $F(2, 124)=10.71$, $p < .0001$. Because I had predicted interactions, though not the observed pattern, I examined the effects using a priori criteria.

Although Figure 10 presents the response times relevant to this three-way interaction, the pattern is not entirely consistent with the pattern of significance. In the case of Given-New there is an interaction between iconicity and semantic relationship, $F(1, 62)=12.19$, $p = .0009$[12] (middle panel of Figure 10). Here it appears that there is no effect of semantic relationship when the events are in chronological order.

In the case of Given-Given (top panel of Figure 10) and New-Given sentences (bottom panel of Figure 10) the main effect of semantic relationship is significant, $F(1, 63)=12.09$, $p = .0009$. Sentences with socially related events are always more difficult. The effect of order reversal does not appear to be systematically magnified in the context of social relationships for either Given-Given or Given-New respectively, $F(1,63)=2.48$, $p = .1205$ and Tukey-Kramer $F(1,63)=2.74$, $p > .05$ (see Appendix V for table of paired comparisons).

[12] I conducted the simple-simple effects analysis on the significant three-way interaction by splitting by discourse order to isolate cell specific error terms.

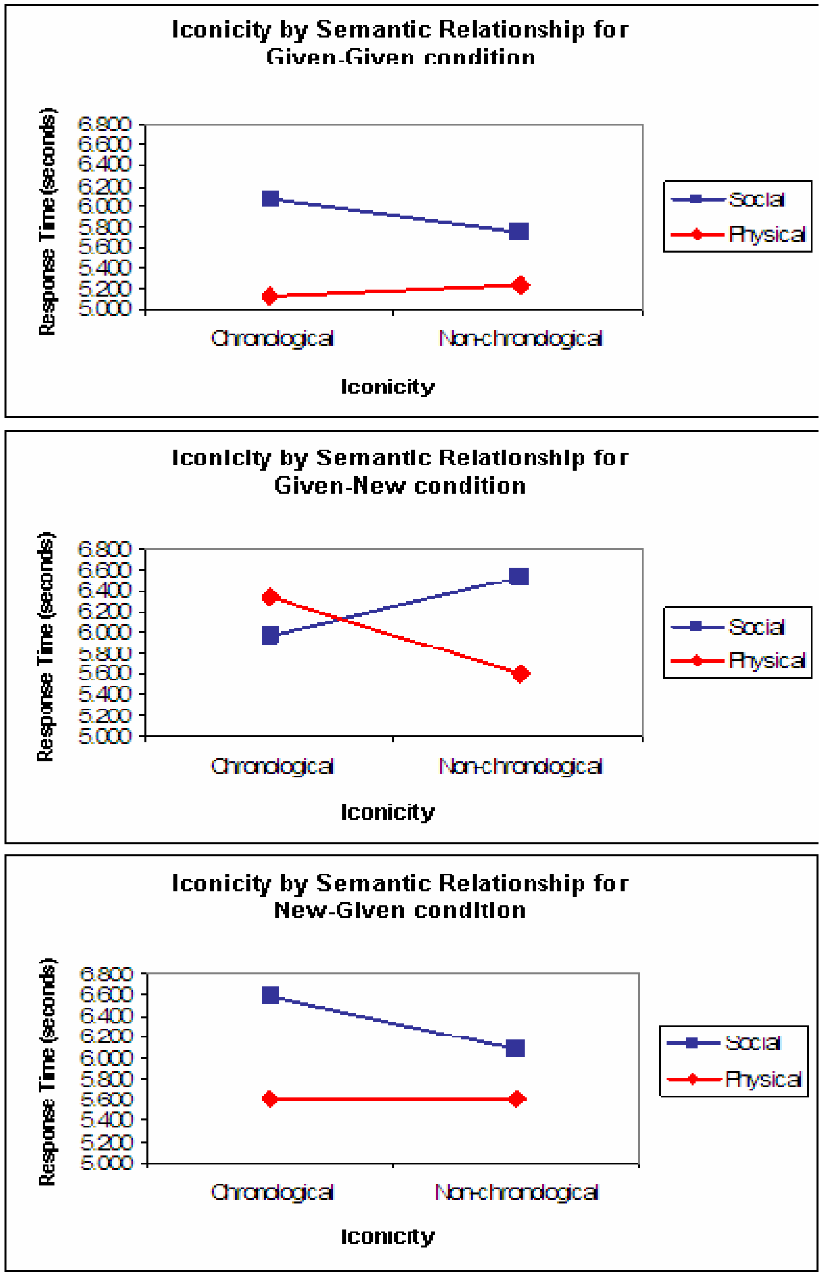

Figure 11. Discourse order, iconicity and semantic relationship as a function of response time.

The absence of systematic difficulty for order reversal also means that there is no evidence to support my prediction that sentences reversing order are more difficult in the context of a violation of the Given-New principle. There is little to no evidence that non-chronological is more difficult anywhere, except for the unpredicted Given-New circumstance in the context of social relationships, $F(1,63)=5.53$, $p = .0219$.

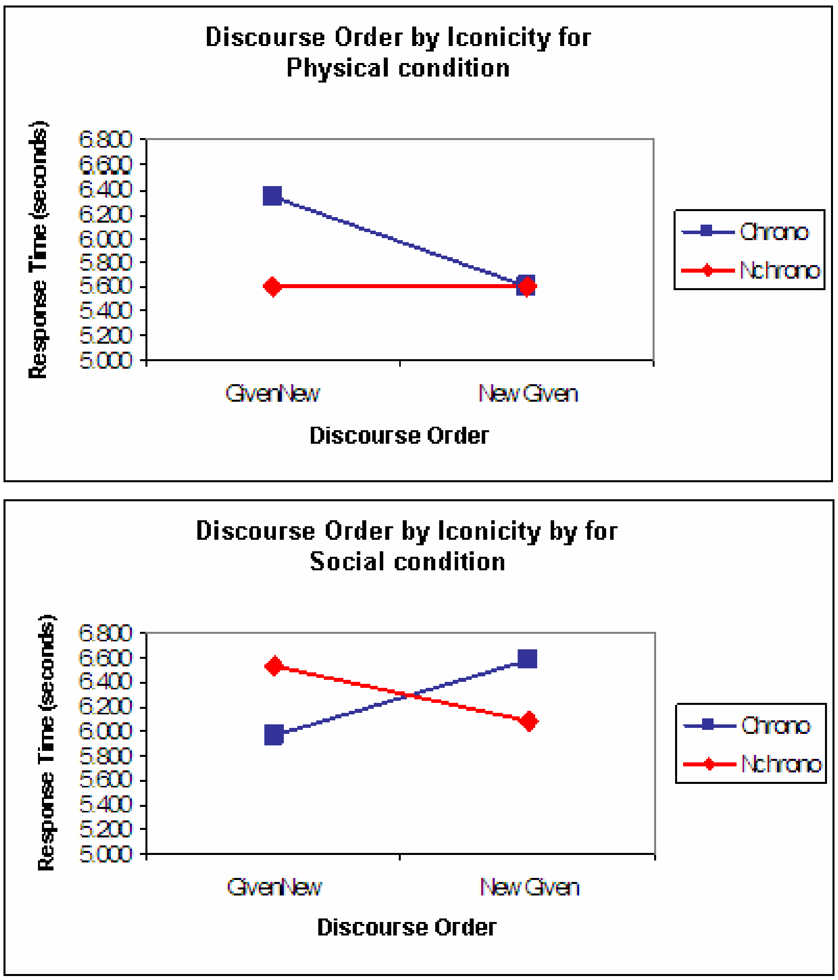

Figure 12. Discourse order, iconicity and semantic relationship as a function of response time (Figure 10 replotted).

The a priori predictions do not explain this three-way interaction. Further results involving semantic relationship appear below.

3.1.3.2 The effects of syntax on order reversal.

Previous literature has established interactions between iconicity and clause. I further predicted that those variables would interact with discourse order. This predicted three-way interaction between discourse order, iconicity, and clause position was not significant (see Appendix T). This predicted three-way interaction reflected the differences I was expecting in verification times of before/after depending on whether or not the given-new principle was violated (see Figure 13 for predictions for a two-way between iconicity and clause position based on the literature). However, only the two-way interaction involving iconicity and clause position was significant, *F(*1,62)= 7.300, p =.0090.

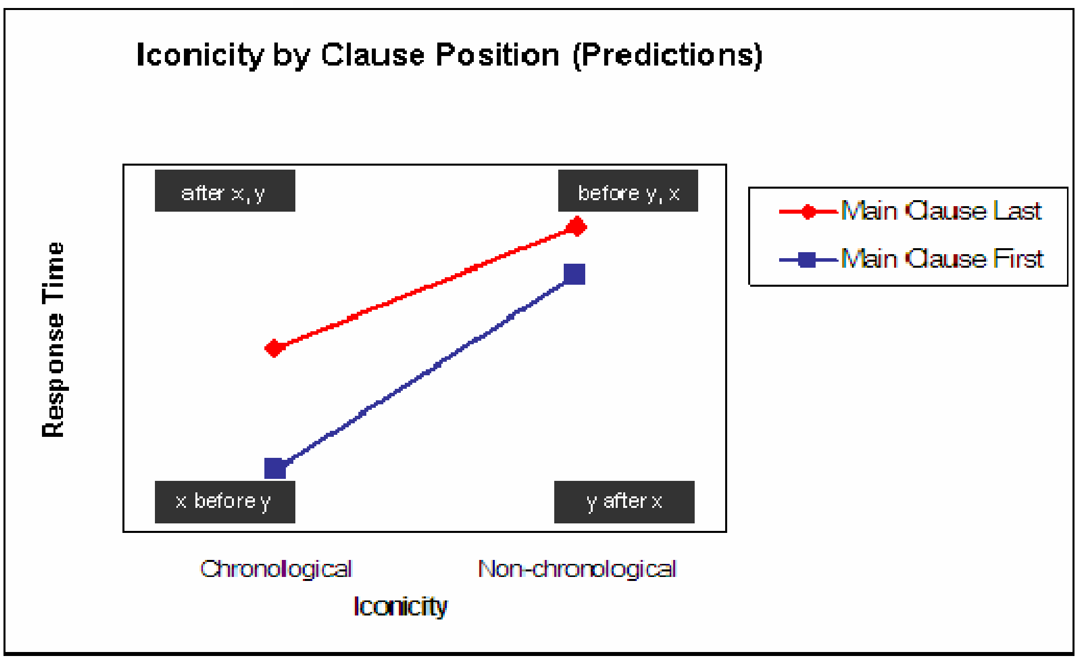

Figure 13. Iconicity and clause position as a function of response time (predicted) excluding the third variable, Discourse Order.

Any differences in the current study between *before* and *after* would emerge as an interaction between iconicity and clause position. The significant interaction therefore indicates differences between *before* and *after* (see Figure 14). The analysis of simple-simple effects revealed that *before* was verified significantly faster than *after* when the sentence preserved order, $F(1, 63)=9.96$, $p = .0025$. This difference was not significant when the sentence reversed order, $F(1, 63)=3.49$, $P = .0662$. These results also only support the prediction that sentences presenting the main clause first should be easier to comprehend when sentences preserve order. When sentences reverse order, there is no difference between main clause first and last.

In the context of this interaction, the notion that sentences preserving chronological order are easier to comprehend is only supported in the case of main clause last sentences, $F(1, 63)=12.61$, $P = .0007$. There is no effect of order reversal for the main clause first sentences, $F(1, 63)=2.16$, $P = .1466$.

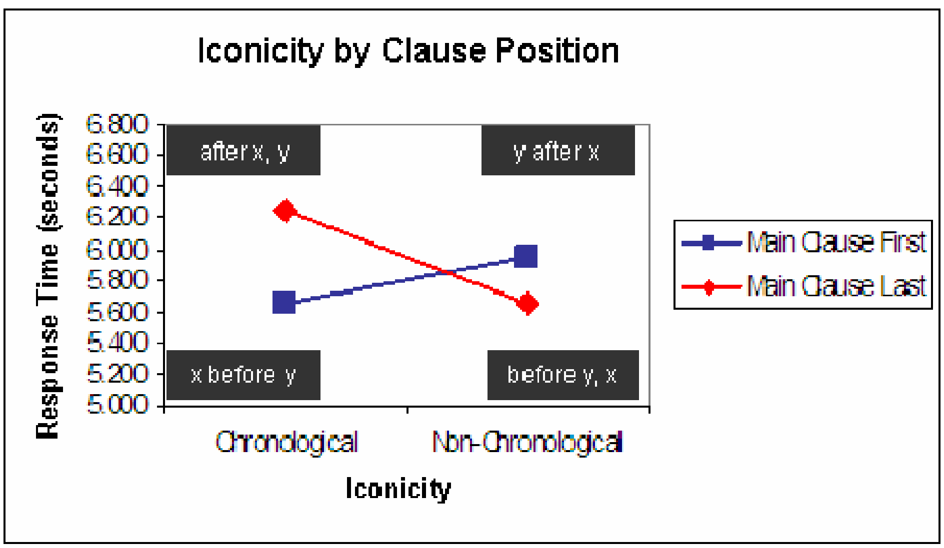

Figure 14. Iconicity and clause position as a function of response time (subject residuals, grand mean added).

Error proportions support the response time findings for iconicity by clause. Figure 15 shows the total numbers of errors in each category as a function of the opportunities to make that error. The pattern of errors, i.e., incorrectly verified causally related sentences, reinforces the unexpected pattern of response times, i.e., sentences that took longer to verify also had more errors associated with them (see Figure 15). This is mostly consistent with the response time data; sentences with *after* always result in more errors.[13]

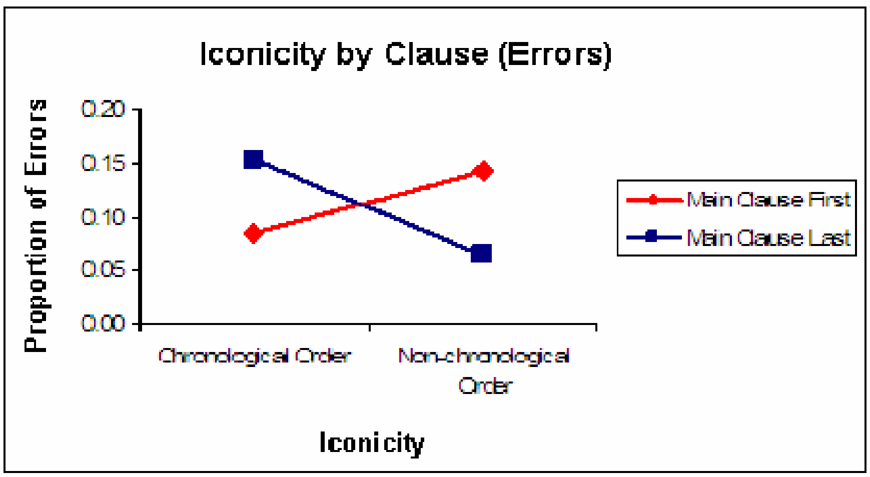

Figure 15. Iconicity by clause position, proportion of errors (physical relationships only).

3.1.3.3 The effects of psychological distance on semantic interpretation.

Psychological distance was included as a control variable. Sentences with events that were far apart should be more difficult to comprehend than sentences where the events are close together. There was no main effect of psychological distance (see

Figure ***16***). However, psychological distance did participate in an interaction with semantic relationship, $F(1, 62)= 4.690$, $p = .0300$. There were no effects of psychological distance

[13] Because these errors come from a repeated measures design, they are not independent and are not

for physically or socially related events. Semantic relationship is only important when events are near, $F(1, 63)=32.46$, $P < .0001$. This indicates that the difference between socially and physically related events depends on the perceived distance between the events.

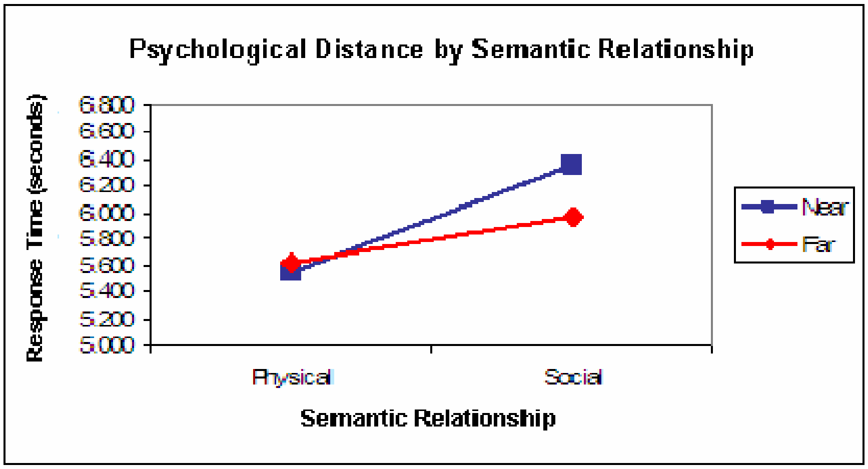

Figure 16. Psychological distance by semantic relationship as a function of response time (subject residuals, grand mean added).

3.1.3.4 Summary of Comprehension Results.

Regarding the replication of effects, the presence of an interaction between iconicity and clause position is in itself not surprising. The differences between response times associated with before and after have been demonstrated many times in the literature. My finding that *beforemc1st* constructions are verified faster than *aftermc2nd* in the context of sentences that preserve chronological order is a replication.

In terms of predictions, I had predicted two-way interactions between discourse order and iconicity and between iconicity and semantic relationship. Instead I obtained a three-way interaction involving all these variables. The predicted patterns of differences within the two-way interactions do not appear to help clarify the nature of this three-way

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appropriate for a chi-squared analysis.

interaction. It appears that the predicted difficulty associated with socially related relationships holds up across all levels of iconicity and discourse order except for chronological sentences that observe the Given-New principle. Nevertheless, the finding does demonstrate a sensitivity to new stimuli, relative to the prior task.

It was surprising, however, that there was no difference between main clause first and main clause last for non-chronological order. Similarly, the absence of a difference between chronological, main clause first and non-chronological main clause last was unexpected.

The interaction between semantic relationship and psychological distance is also surprising since psychological distance was only included as a control variable. I did not expect it to interact with my main variables of interest, but included it to make sure that I sampled equally across near and far relationships. These results indicate that other factors influencing reasoning about objects or events may be affected by the psychological distance between the events, or objects in question.

3.2 Scheduling Task: Language Production

3.2.1 Preliminary Data Analysis.

The covariate measures administered at the end of the task, the sentence span, cube comparisons, and card rotation tests yielded a set of general ability scores. The demographics questionnaire, among other things provided information about the participants' experience with house construction. These covariate measures of course yielded data points for each participant, a total of 64. In order to examine the potential influences of ability and experience on the team performance measures, I calculated team covariate scores, using a median split to classify participants as high or low on a particular covariate. For each of the ability tests, the teams were divided into three groups reflecting whether the two participants (1) both received a low score on the test in question, (2) one participant received a low and the other a high score, or (3) both participants received a high score. I performed a median split on the experience ratings and similarly assigned each team to one of three groups using the same logic as above.

3.2.2 General Findings

3.2.2.1 Equivalence of experimental groups.

When I split by representation I end up with 16 pairs and 32 participants per representation. The assignment of participants to representations was not related to the covariates (see Table 10).

Table 10

Correlations between Performance, Covariate Measures, and Representation, n = 64.

		SENSPAN	CARDROT	CUBECOMP
REP	r	-0.14434	-0.08839	-0.25286
	p	0.4306	0.6305	0.1626

This means that the participants in the two experimental groups did not differ in terms of short term memory, measured by the sentence span test, nor did participants in one group have better spatial ability than in the other, as indicated by the cube comparisons and card rotation tests. Additionally, the participants in the two experimental groups reported similar levels of experience with house construction, $t(1,30)=-0.739$, $p > .05$.

3.2.2.2 Ability-Performance relationships.

I also determined that general ability did not account for potential variance in performance. Each dyad received a performance measure. In order to convert individual ability scores to dyad scores, covariate ability measures were coded -1, 0, or +1 for each pair reflecting whether the individuals had obtained low-low, high-low, or high-high scores. The correlations between ability and performance were not significant (see Table 11).

Table 11

Correlations between Performance and General Ability, N=32.

		TIMEACC	TIME	WORDS
SENSPAN	r	0.16195	-0.13549	-0.10126
	p	0.3759	0.4597	0.5813
CARDROT	r	-0.18796	0.09867	0.15323
	p	0.3029	0.5911	0.4024
CUBECOMP	r	-0.21808	0.20689	0.19288
	p	0.2305	0.2559	0.2902

The number of words did predict the quality of the schedule, r(30)= -0.8028, $p < .01$. Additionally, the variability in scores was unrelated to time spent on the task, i.e., no evidence for a speed accuracy trade-off, r(30), 0.1677, p > .05.

To examine the effects of language on performance, I first checked whether general ability was a predictor of language use. As noted in the methods section, these language variables were a proportion of the total number of content words/constructions (those used as predictors), thereby controlling for length of the planning session. I had tentatively predicted that better performance on the spatial ability tests and the sentence span tests may predict the degree to which participants would tend to use language with complex syntactic structure. There were no significant correlations between ability (dyad-coded as above) and any of the language variables (see Table 12).

Table 12

Correlations between language and ability, N=32.

		CHRONO MC1ST	NCHRONO MC2ND	NCHRONO MC1ST	CHRONO MC2ND
SENSPAN	r	-0.1056	0.1448	-0.0610	-0.0458
	p	0.5653	0.4291	0.7403	0.8033
CARDROT	r	0.2892	0.0000	0.1657	0.2582
	p	0.1084	1.0000	0.3648	0.1537
CUBECOMP	r	0.0958	0.2445	-0.0450	0.1349
	p	0.6021	0.1774	0.8069	0.4617
		DURING	WHILE	OVERLAP	SAMETIME
SENSPAN	r	0.1610	0.0209	-0.1624	-0.2152
	p	0.3787	0.9098	0.3745	0.2369
CARDROT	r	0.1232	0.0341	0.3448	0.2501
	p	0.5016	0.8532	0.0533	0.1670
CUBECOMP	r	0.2133	0.0518	-0.1835	0.0403
	p	0.2411	0.7784	0.3147	0.8267
		MIDDLE	THAT	THIS	ANDTHEN
SENSPAN	r	0.1616	-0.0889	-0.0403	-0.0631
	p	0.3768	0.6285	0.8269	0.7316
CARDROT	r	0.3167	0.0069	0.2503	0.0650
	p	0.0774	0.9699	0.1671	0.7239
CUBECOMP	r	0.0368	0.3048	0.0882	-0.0681
	p	0.8415	0.0898	0.6314	0.7113

3.2.3 Main Effects of Representation and Language on Performance

My prediction concerning effects of the representation used to complete the scheduling task was that participants who experienced the graphical representation would complete the construction schedule faster and more efficiently, i.e., using fewer words, than participants who experienced the list representation.

I examined the equivalence of the experimental groups for the dependent measures time/accuracy, time and number of words. The participants in one condition did not appear to perform better than the other (see Table 13).

Table 13

Correlations between Representation and Performance, N=32.

		TIME/ACC	TIME	WORDS
REP	r	0.01637	-0.0032	-0.0724
	p	0.9291	0.9863	0.6939

I did not have a priori expectations as to how the schedules created by participants in the two experimental groups might differ, i.e., qualitative or quantitative differences between them. However, because I was interested in the types of temporal relationships discussed in the construction of the schedules, it seemed natural to investigate the types of relationships that were actually used in the final schedules.

An analysis of the relationships used by the participants in creating the schedules revealed that the participants in the numeric condition used significantly more simultaneous relationships (i.e., relationships where the events either overlapped, or occurred completely inside, or during other events) than participants in the graphical condition, *t(*30)=18.09, *p* < .0001. There was no difference between the graphical and numeric conditions in the number of successive relationships employed, *t(*30)=0.233, p > .05.

There were, however, numerous effects of language on the performance of the 32 dyads (see Table 14). The time/accuracy measure is reverse scored, hence the negative r-values.

Table 14

Correlations between Language and Performance.

		CHRONO MC1ST	NCHRONO MC2ND	NCHRONO MC1ST	CHRONO MC2ND
TIMEACC	r	-0.4817	-0.2366	-0.3798	-0.3698
	p	0.0052	0.1922	0.0320	0.0373
		DURING	WHILE	OVERLAP	SAMETIME
TIMEACC	r	-0.2664	-0.3910	-0.3999	-0.2623
	p	0.1405	0.0269	0.0233	0.1470
		MIDDLE	THAT	THIS	ANDTHEN
TIMEACC	r	-0.1729	-0.5887	-0.5517	-0.4586
	p	0.3438	0.0004	0.0011	0.0083

This means that language can be used as a predictor of performance.

3.2.4 Main Effects of Representation on Language

Generally, I predicted that participants who experienced the graphical representation would use qualitatively different language than participants who experienced the numeric representation. More specifically I was interested in differences in terms of the cognitive and syntactic complexity of the sentences used to describe temporal relationships, predicting that the graphical representation would allow use of more complex language. Additionally, I expected there to be differences in the number of references to duration, i.e., the number of prepositions/descriptors relating simultaneity. That hypothesis was not directional. This hypothesis was not supported. There was no difference in the pattern of relations referred to (succession or simultaneity) in Graphical versus Numeric.

Similarly, there was no correlation between any of the language measures and representation as a main effect (see Table 15).

Table 15

Correlations between Representation and Language.

		CHRONO MC1ST	NCHRONO MC2ND	NCHRONO MC1ST	CHRONO MC2ND
REP	r	-0.0120	0.0139	0.1601	0.2699
	p	0.9479	0.9397	0.3816	0.1352
		DURING	WHILE	OVERLAP	SAMETIME
REP	r	0.0697	-0.1806	0.0094	-0.3121
	p	0.7046	0.3225	0.9594	0.082
		MIDDLE	THAT	THIS	ANDTHEN
REP	r	0.1680	-0.0748	-0.2735	0.0596
	p	0.3581	0.6843	0.1298	0.7459

I did find a difference between number of questions (scaled by number of content words), $t(30)=-2.22$, $p = 0.0341$, assuming unequal variances.[14] Importantly there were more questions in the graphical condition, a mean of 219.8 and 163.1 questions in the graphical and numeric conditions respectively.

[14] I did compute using arcsine transformed proportions, but it doesn't compute for ratios larger than one.

3.2.5 Correlations Among Individual Variables

The above analyses of language main effects, however, did not test the possibility of an interaction between language and representation in their effect on performance. Therefore, because I had predicted qualitative differences in language use, I went on to explore differences in the patterns of language use for the sixteen pairs of participants using each representation. Doing so provides evidence for differences in language usage across representations.

I set out to determine whether the same or different language measures predicted performance within the two representations. Importantly, I am not looking to identify the 'best' model to predict performance, rather, to demonstrate that the models of language usage are different for the two representations.

I used the time/accuracy measure, raw time, and the total number of words within each transcript as the dependent measures in a correlational analysis. The independent variables, or predictors were the language measures (syntax and lexical items) calculated as proportions relative to the total number of predictor measures per transcript.[15] I used an arcsine transformation to normalize these proportion measures. I initially included the covariate measures as alternative explanations of quality.

The important predictors for time/accuracy in the graphical condition are *this*, *that*, *while*, and *overlap* (see Table 16). The important predictors for time/accuracy in the numeric condition are *this*, *that*, *same time*, *chronomc1st*, and *nchronomc1st* (see Appendix A for naming key). The relative pronouns "this" and that" are common to both representations. Examining content words, *nchronomc1st* (sentences presenting events in non-chronological order placing the main clause first) accounts for 36% of the variance in quality for data generated from the numeric representation, but none of the variance in quality for data generated from the graphical representation. In addition, *while* accounts for none of the variance in quality for the numeric representation but accounts for 35% of the variance in quality for data from the graphical representation. The effect of *while* is particularly surprising as the schedule quality measure does not include the socially constrained relationships such as *overlap* and *while*.[16]

Similar analyses for time and number of words continue to suggest different patterns of important content words and syntax for the graphical and numeric data (see Table 17 and

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[15] This adjusts for the total number of words—and equates those measures for time on task.

[16] Note that there were no events in the construction schedule which necessarily needed to occur at the same time—i.e., there were no physically constrained simultaneous relationships. This means that only successive relationships could be physically constrained.

Table **18**). The presence and absence of an effect provides the strongest evidence for representational differences, e.g., *while* or *overlap* in the graphical versus numeric conditions. The available power is not sufficient to distinguish between significant R^2 values. Most of the slope comparisons are different due to the presence or absence of a significant slope. In addition, the slope comparison on *that* with words as a dependent measure is significant for representation, $t(28) = 2.12$, $p < .05$.

Table 16

Correlation Matrix for Word Variables with Time/Accuracy as a Dependent Measure.

TIMEACC	Graphical				Numeric			
	Beta	Adj R-sq	t-Value	p	Beta	Adj R-sq	t-Value	P
Chronomc1st	-255.67	0.0409	-1.28	0.2213	-487.89	0.3754	-3.16	0.0069
Nchronomc1st	-125.99	0.0116	-1.08	0.2964	-432.51	0.3166	-2.82	0.0136
Chronomc2nd	-793.66	0.653	-1.43	0.1743	-1695.69	0.1677	-2.01	0.0647
Nchronomc2nd	-847.26	-0.0109	-0.92	0.3755	-2032.08	0.0114	-1.08	0.2970
During	-926.77	-0.0517	-0.51	0.6165	-1818.05	0.0808	-1.52	0.1501
While	-1698.27	0.3407	-2.96	0.0104	-437.41	0.0095	-1.07	0.3030
Overlap	-1985.04	0.2417	-2.40	0.0306	-784.99	0.0273	-1.19	0.2532
Same time	-4685.35	-0.0646	-0.30	0.7683	11303	0.2164	2.27	0.0397
Middle	-1270.46	-0.0477	-0.56	0.5824	-2144.89	-0.0212	-0.83	0.4205
That	-121.08	0.3605	-3.07	0.0082	-69.59	0.2950	-2.70	0.0173
This	-822.91	0.4293	-3.50	0.0035	-382.70	0.2193	-2.28	0.0386
Andthen	-169.65	0.1152	-1.72	0.1078	-198.42	0.2028	2.19	0.0456
Senspan	0.13	-0.0575	0.43	0.6737	0.29	0.0089	1.07	0.3048
Cube Comparison	-0.25	-0.0552	-0.46	0.6498	-0.34	-0.0035	-1.03	0.3222
Card Rotation	-0.41	-0.0113	-0.91	0.3772	-0.14	-0.0541	-0.48	0.6387

Table 17

Correlation Matrix for Word Variables with Time as a Dependent Measure

TIME	Graphical				Numeric			
	Beta	Adj R-sq	t-Value	P	Beta	Adj R-sq	t-Value	p
Chronomc1st	2200.25	-0.0567	0.44	0.6650	9550.26	0.4721	3.80	0.0020
Nchronomc1st	2564.91	-0.0103	0.92	0.3730	8469.42	0.4009	3.32	0.0050
Chronomc2nd	25525.00	0.1797	2.07	0.0574	26371.00	0.1121	1.70	0.1110
Nchronomc2nd	19840.00	-0.0125	0.90	0.3820	31225.00	-0.0093	0.93	0.3691
During	46460.00	0.0165	1.12	0.2820	34481.00	0.1024	1.65	0.1219
While	41007.00	0.3552	3.04	0.0088	8093.74	0.0165	1.12	0.2820
Overlap	63325.00	0.4944	3.96	0.0014	16994.00	0.0754	1.49	0.1582
Same time	-4685.35	-0.0646	2.27	0.0397	11303.00	0.2164	-0.30	0.7683
Middle	22516.00	-0.0582	0.42	0.6821	29899.00	-0.0404	0.65	0.5289
That	2051.33	0.1487	1.90	0.0779	1309.82	0.3406	2.96	0.0104
This	19469.00	0.4262	3.48	0.0036	5969.09	0.1531	1.93	0.0746
Andthen	3145.15	0.0424	1.29	0.2179	3729.34	0.2360	2.37	0.0325
Senspan	-0.50	-0.0710	-0.07	0.9445	-5.81	0.0294	-1.21	0.2477
Cube Comparison	10.27	-0.0240	0.80	0.4344	5.63	-0.0073	0.94	0.3610
Card Rotation	6.90	-0.0407	0.64	0.5309	0.90	-0.0692	0.17	0.8667

Table 18

Correlation Matrix for Word Variables with Number of Words as a Dependent Measure.

WORDS	Graphical				Numeric			
	Beta	Adj R-sq	t-Value	p	Beta	Adj R-sq	t-Value	P
Chronomc1st	123577.00	0.2969	2.71	0.0170	136014.00	0.3548	3.04	0.0088
Nchronomc1st	55303.00	0.1532	1.93	0.0745	124028.00	0.3202	2.84	0.0131
Chronomc2nd	164099.00	0.0106	1.08	0.2994	455277.00	0.1401	1.86	0.0847
Nchronomc2nd	227101.00	-0.0104	0.92	0.3733	792271.00	0.0831	1.54	0.1468
During	464897.00	-0.0018	0.99	0.3406	667980.00	0.1808	2.08	0.0568
While	362823.00	0.1927	2.14	0.0504	187810.00	0.1116	1.70	0.1115
Overlap	371650.00	0.0827	1.53	0.1474	178477.00	-0.0088	0.93	0.3671
Same time	124836.00	-0.0329	0.72	0.4818	176502.00	0.2000	2.18	0.0469
Middle	795409.00	0.0590	1.39	0.1853	1083267.00	0.0858	1.55	0.1430
That	43680.00	0.7177	6.26	0.0001	19863.00	0.2949	2.70	0.0174
This	244393.00	0.5486	4.39	0.0006	138894.00	0.3985	3.31	0.0052
Andthen	71502.00	0.3939	3.28	0.0055	54061.00	0.1784	2.06	0.0582
Senspan	31.43	-0.0594	0.40	0.6967	-99.59	0.0428	-1.29	0.2171
Cube Comparison	104.76	-0.0325	0.73	0.4793	66.63	-0.0366	0.69	0.5042
Card Rotation	160.13	0.0593	1.40	0.1847	6.30	-0.0710	0.07	0.9416

3.2.6 Multi-variable Language Models

I then took the significant predictor words for each dependent measure and each representation separately and put them in SAS's model selection regression procedure to identify the best adjusted R-squared model and to get the beta weights for the predictor variables, which in combination could be of different magnitudes relative to the above analysis.

While I developed models for the numeric data and for the graphical data separately, I also cross-fit the models to demonstrate that alternative representation-specific models were not equally good accounts for data generated from the other type of representation.

Compared to the previous table, in which predictor variables were analyzed separately, the beta weights here reflect the presence of other predictors in the model. In general, the terms *this* and *that* together are picking up substantial performance variance within both representations. The numeric models of language usage suggest a generally better fit for numeric data than they are for graphical data, R^2=0.6063 versus R^2=0.4419 for time/accuracy data, R^2=0.6094 versus R^2=-0.078017 respectively for time data, with the exception of R^2=0.7856 versus R^2=0.8196 for word frequency. However, the statistical comparison of R^2 values across data sets depends on N, which provides insufficient power to document statistical significance for the present data.

Similarly, the graphical models of language usage appear to be a better fit for graphical data than they are for numeric data, R^2=0.4255 versus R^2=0.1964 respectively for time/accuracy data R^2=0.6860 versus R^2=0.2610 for time data, and R^2=0.8848 versus R^2=0.3257 for word frequency, $p < .05$ in all cases. Again, the N precludes a claim of statistical significance.

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[17] All r-squared values reported are adjusted.

Comparing the right hand column of Table 19 and Table 20, sentences using chronological order provide an account for performance with the numeric representation and *overlap* and *and then* account for performance with the graphical representation. This supports the claim that different models of language account for the performance within the different representations.[18]

[18] One could possibly argue that *this* and *that* are common to both representations and they are correlated with all the other language variables. So I ran R^2 regressions on only the content specific language variables (everything but this and that). This did not provide a more revealing pattern of results.

Table 19

Adjusted R-Squared Values: Numeric Word-Models Fit to Numeric and Graphical Performance Data (time/accuracy).

NUMERIC MODELS							
FIT WITH NUMERIC DATA				CROSS-FIT WITH GRAPHICAL DATA			
TIMEACC				TIMEACC			
Variables	R^2 Adj.	P		Variables	R^2 Adj.	P	
THIS, THAT	0.6063	0.0009		THIS, THAT	0.4419	0.0089	
Variables	Beta	t-Value	P	Variables	Beta	t-Value	P
THIS	-351.13	-3.25	0.0063	THIS	-624.61	-2.21	0.0458
THAT	-69.1	-3.95	0.0017	THAT	-53.23	-1.19	0.2560
TIME				TIME			
Variables	R^2 Adj.	P		Variables	R^2 Adj.	P	
CHRONO MC1ST, NCHRONO MC1ST	0.6094	0.0009		CHRONO MC1ST, NCHRONO MC1ST	-0.0780	0.6428	
Variables	Beta	t-Value	P	Variables	Beta	t-Value	P
CHRONO MC1ST	6999.11	2.91	0.0122	CHRONOM C1ST	-2638.66	-0.35	0.7334
NCHRONO MC1ST	5566.38	2.43	0.0301	NCHRONO MC1ST	-3698.39	0.85	0.4106
WORDS				WORDS			
Variables	R^2 Adj.	P		Variables	R^2 Adj.	P	
THIS, THAT	0.7856	<.0001		THIS, THAT	0.8196	<.0001	
Variables	Beta	t-Value	P	Variables	Beta	t-Value	P
THIS	144262	5.75	<.0001	THIS	128412	2.98	0.0106
THAT	20838	5.13	0.0002	THAT	31999	4.69	0.0004

Table 20

Adjusted R-Squared Values: Graphical Word-Models Fit to Numeric and Graphical Performance Data (time/accuracy).

GRAPHICAL MODELS								
FIT WITH GRAPHICAL DATA					CROSS-FIT WITH NUMERIC DATA			
TIMEACC					TIMEACC			
Variables	R^2 Adj.	P			Variables	R^2 Adj.	P	
THIS	0.4255	0.0037			THIS	0.1964	0.0486	
Variables	Beta	t-Value	P		Variables	Beta	t-Value	P
THIS	-817.56	-3.48	0.0037		THIS	-333.33	-2.16	0.0486
TIME					TIME			
Variables	R^2 Adj.	P			Variables	R^2 Adj.	P	
THIS, OVERLAP	0.6860	0.0002			THIS, OVERLAP	0.2610	0.0552	
Variables	Beta	t-Value	P		Variables	Beta	t-Value	P
THIS	13717	3.09	0.0086		THIS	6155.54	2.13	0.0533
OVERLAP	48045	3.55	0.0036		OVERLAP	17793	1.74	0.1046
WORDS					WORDS			
Variables	R^2 Adj.	P			Variables	R^2 Adj.	P	
THAT, ANDTHEN	0.8848	<.0001			THAT, ANDTHEN	0.3257	0.0304	
Variables	Beta	t-Value	P		Variables	Beta	t-Value	P
THAT	36685	7.79	<.0001		THAT	15835	2.01	0.0651
ANDTHEN	46343	4.61	0.0005		ANDTHEN	33181	1.28	0.2226

3.2.7 Latent Representation Effects

I predicted that participants experiencing the graphical representation would be more likely to adopt the time-moving metaphor and therefore reply '*Monday'* to the conceptual metaphor question than participants in the numeric condition. A chi-squared analysis revealed that the type of representation did not predict whether participants answered *Monday* or *Friday* to the metaphor question, $X^2(1)=0.2032$, $p > .05$. Although it appeared that there was a preference for responding '*Friday'*, this difference was only approximating statistical significance, $X^2(1)=3.2608$, $p > .05$.

3.2.8 Summary Representation Effects

I did not find any main effects of representation on performance, on language, or on the latent task. Participants used more simultaneous relationships in the numeric condition. However, examining the language patterns within each representation provided some evidence of different language patterns within each representation. Rather than a straightforward relationship between representation and performance, it is the combination of language and representational format that predicts performance.

3.3 General Language Findings

Apart from the influence of representation, the data permit the evaluation of two additional language related phenomena.

3.3.1 Discourse as Context for Production

In the comprehension study, I had predicted that discourse order would interact with iconicity, such that the difficulty associated with an order reversal would be smaller in the context of sentences that observed the Given-New discourse principle. Although I did observe an interaction between discourse order and iconicity in the comprehension study, it was further complicated by semantic relationship. Additionally, the predicted relationship between discourse order and iconicity did not appear to account for this three-way interaction. However, I did want to examine the relationship between discourse order and iconicity in the context of production—the hypothesis here being that most of the sentences reversing chronological order would be observing the Given-New principle.

The issue became how to operationalize givenness in the context of my transcripts. Could an event be assumed to be given only if it occurred in the immediately preceding sentence, or if it was mentioned up to 10 minutes, 20 minutes, or an hour earlier than the sentence in question? A sure indication in discourse that an object or event is given, or mutually understood, is the use of pronouns. In an effort to examine if the participants generally observed the Given-New principle, I therefore did a count on the frequency of use of '*that*' (and '*it*', '*this*', '*those*', '*these*', of these though, '*that*' was by far the most frequent) within the different sentences constructions.

Again, I was most interested in the two sentence constructions that are used most frequently, *beforemc1st* and *aftermc1st*. B*eforemc1st* does not reverse chronological order, *aftermc1st* does. For comparison purposes, I also counted the sentences in which event names (not pronouns) were used as the referent. These will serve as the baseline comparison, since those instances will both include events that are given and new ones as well. When participants use the name to refer to an event, it is possible that they are introducing it for the first time, i.e., it is new.

Figure 17 illustrates the proportions of before/after sentences using event name or a pronoun to refer to the object in the main clause. Again, I expect the *after* sentences with main clause first to have pronouns more frequently than *beforemc1st* sentences. That is, *aftermc1st* sentences will be used to refer to given events more often than *beforemc1st* sentences:

Before Main Clause First, Event Name:
(*'you pour the foundation before you build the frame')*

Before Main Clause First, Relative Pronoun:
('you do that before you build the frame')

After Main Clause First, Event Name:
('you build the frame after you pour the foundation')

After Main Clause First, Relative Pronoun:
('you do that after you pour the foundation')

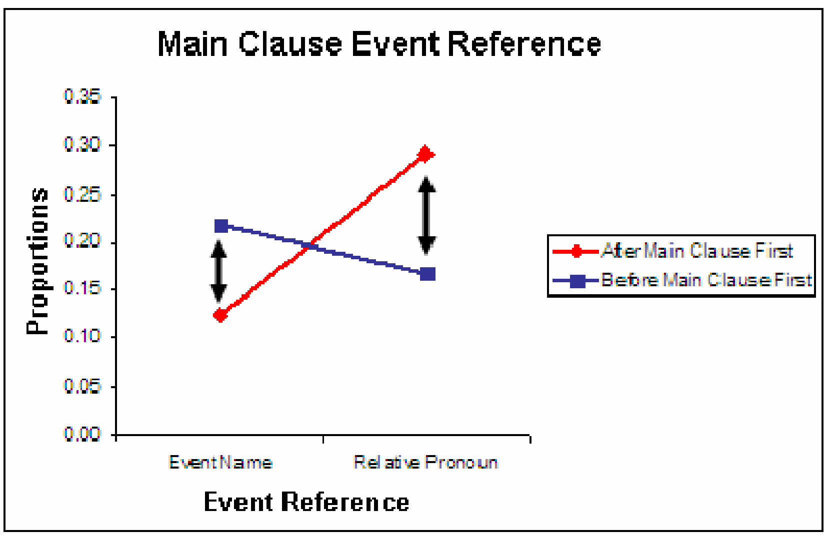

Figure 17. Main clause referent as a function of clause position.

The predicted pattern appears to be supported. I did identify a significant overall effect of event reference, $F(1,93)=9.37$, $p < .0001$. On closer inspection, *after* sentences did use relative pronouns significantly more often than the *before* sentences, *F(*1,31)=24.83, $P < .0001$. Conversely, the *before* sentences used event name references significantly more often than the *after* sentences, *F(*1,31)=8.56, $p = .0064$. There was no difference between the number of *before* sentences (MC first, in blue squares) that use event names versus relative pronouns, *F(*1,31)=2.08, $p > .05$. However, there was a difference between the number of *after* sentences (MC first, in red diamonds) that use event names versus relative pronouns, *F(*1,31)=40.86, $p < .0001$.

I also used this notion of pronoun use as an indicator of Givenness to examine the effect of representation. My hypothesis regarding the representation was that the graphical representation would provide better common ground than the numeric. This was not supported using a frequency of references to simultaneity; however, it was possible that the graphical representation allowed participants to use pronouns more often—as a function of having a better shared workspace. There was no main effect of representation on event referencing. There were no differences between the frequencies with which participants in the two conditions used pronouns to refer to events, *F(*1,31)= -0.8039, $p > .05$.

Overall, these results do support the idea that temporal order ambiguity is less problematic when the given-new principle is observed. Overall, the results indicate functionally different patterns of usage of the *before* and *after* main clause first constructions.

3.3.2 Comprehension versus Production

I predicted that sentence constructions with higher response times in the comprehension study would occur fewer times in the production study than sentence constructions with shorter response times. In other words, the pattern of difficulty should be comparable across comprehension and production. In comparing our production and comprehension results, I focused mainly on the frequencies of iconicity and clause position within the production data since it could readily be compared to the interaction obtained in the comprehension data. An ANOVA on the relative frequencies (Arcsine transformed proportions) of sentences in the transcripts that observed/reversed chronological order and placed the main clause first or last also revealed that the frequencies of main clause first or last depended on iconicity, $F(1,30)=5.170$, $p < .0300$ (see Figure 18).

This pattern does support the notion that main clause first is easier. However, the pattern of difference within the production results did not mirror those of the comprehension results. Figure 18 illustrates the production results overlayed with the comprehension results. Figure 18 juxtaposes the iconicity by clause position interaction in the context of both the production and comprehension experiments. The production results, in arcsine transformed proportions, are indicated using the unfilled symbols and are plotted against the left hand side y-axis. The comprehension results, measured in response time (least squared means), are indicated using the filled symbols and are plotted against the right hand side y-axis. This graph shows clearly that the chronological pattern (on the right) is largely the same for production and comprehension. The main clause first constructions are both produced more often and are responded to faster. However, this does not hold for non-chronological order. Here there is no difference between main clause first and main clause last constructions for the comprehension data, but there is a significant difference for the production data. Again, main clause first constructions are produced significantly more often.

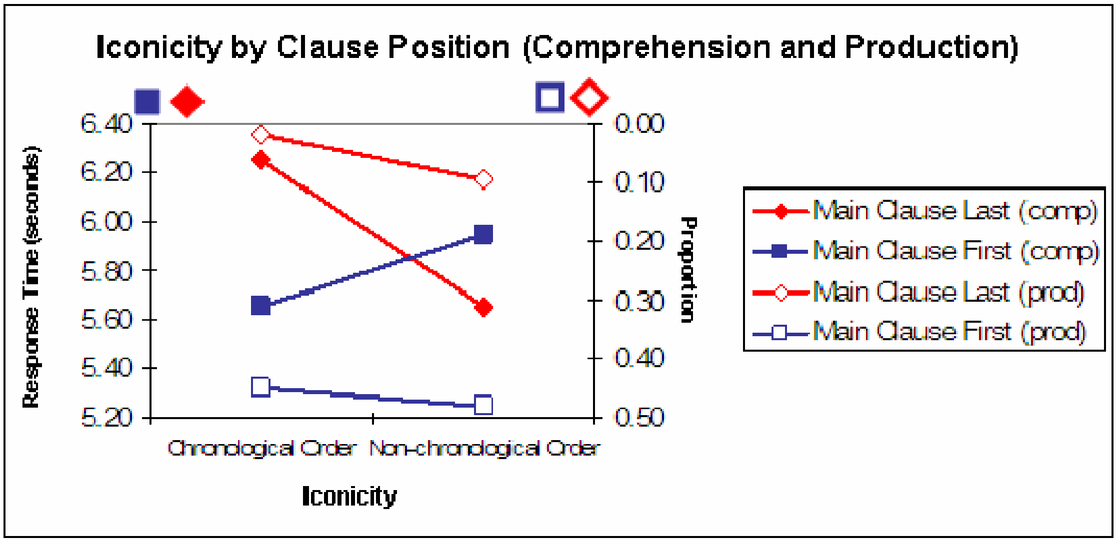

Figure 18. Iconicity by clause, comprehension and production results.[19]

[19] To enable direct comparison with response times the lowest proportions are at the top of the y-axis, while the highest proportions are at the bottom. Filled-in symbols denote comprehension data and are using the y-axis on the left, unfilled symbols denote production data and are using the y-axis on the right.

IV. Discussion

The following sections will discuss the ways in which my results address the syntactic, semantic, and contextual influences, i.e., discourse principles and representation on measures of language complexity, and by inference cognitive complexity. Syntactic influences include clause position and iconicity, semantic influences address semantic relationship/psychological distance, and contextual influences address role of discourse principles and representation—in all these sections I combine results from both comprehension and production.

The present set of experiments provide evidence to suggest that the context in which language is situated has an important influence on the cognitive complexity associated with that language—perhaps a more important influence than variables identified independently of the context (like lexical marking, clause position, and iconicity). The two aspects of the context examined in this study include 1) discourse principles, especially those related to the prior introduction of a topic, and 2) the nature of the representation.

4.1 Methodological Differences

Before I discuss findings from either study, it is worth mentioning some of the differences between the current comprehension study, study I, and previous research on comprehension. First, the present study uses meaningful stimuli: stimuli that have real inherent constraints and temporal relationships. Second, and more importantly, participants in the current comprehension study had been grounded in thinking about temporal relationships in the production study before they started verifying the comprehension sentences. This means that they are not fresh off the street, as is often the case, and they have actively been thinking about temporal relationships rather than merely reading about them, which is sometimes used as a way to provide content for the subsequent reasoning task (Foss, & Bower, 1986). That means that not only have they reasoned about the contents of the comprehension task, the events and their relationships, some of their strategies for thinking about time could carry over. Or, at the very least, they had some practice resolving temporal order in language before they went into the comprehension task.

These differences alone, however, do not account for the difference between the response times seen in the present study, and response times seen in previous comprehension research. The response times are much longer in my study (on the average about 5.7 seconds) than in previous studies. This increase could be a result of using meaningful stimuli or of the participants having reasoned about some of the relationships before (see Anderson and Bower's fan effect, 1973). The most obvious difference, though, between this study and previous studies is that I am using a sentence verification paradigm. Mandler (1986) used simple reading time—the response times in her study were on the order of about 2.2 seconds. It is therefore plausible that on the average, my participants used that amount of time to read the sentence, and perhaps resolve any temporal ambiguity associated with it. But, this does not even account for half the total time spent on the stimuli by participants in my study.

Mandler (1986) asked her participants to indicate that they had comprehended the sentence. In the present study participants were asked to indicate comprehension by responding true or false. This difference in paradigm alone, though, does not account for the magnitude of the difference between the present and Mandler's response times either. Foss and Bower (1986), in one of their experiments, also used a sentence verification task. In that study, participants we asked to verify an action sequence based on a manual they read immediately preceding the sentence verification task. The mean verification time in that experiment was about 2.5 seconds. This means, the nature of the experimental paradigm alone does not account for the long response times. Instead, I believe the reasoning processes involved in producing the response is responsible for the added response time. I will discuss these reasoning processes in the context of my results.

4.2 Contextual Influences on Complexity

The contextual influences on comprehension included aspects of discourse and representational format. First I will discuss the results I obtained with respect to the effects of including a discourse context on subsequent comprehension, as well as compare these comprehension results to the patterns of language actually produced in real discourse in my production study.

4.2.1 Discourse as a Context for Comprehension

I had predicted an interaction between iconicity and discourse order, such that the effect of an order reversal should be magnified in the context of a violation of discourse order, i.e., New-Given. An interaction in which the effect of iconicity, or chronological order reversal, was magnified by a violation of discourse principles would have important theoretical implications. Such a finding would call into question any theory concerning linguistic and/or cognitive complexity derived from experimental tasks that do not take into consideration the larger communicative context, be it produced or comprehended language. The previous literature suggested an interaction between semantic relationship and iconicity, such that the effect of an order reversal should be magnified in the context of arbitrary relationships. Neither of these two-way interactions were significant, however the three-way interaction involving all three variables was significant. The presence of *any* interaction involving discourse order provides initial evidence that the communicative context plays a role in determining cognitive complexity.

Generally, sentences with socially related events were more difficult than sentences with physically related events. This difference appeared to be magnified for certain combinations of chronological order and discourse order—namely for sentence in non-chronological order in Given-New, and for chronological order in New-Given. In order to provide an account of this pattern of differences, I have developed a model that assumes that the bulk of the response time variation in the present study is due to the inference processes involved in verifying the stimuli, as opposed to reading time.

In Clark et al.'s (1971) study, participants were comparing the contents of the sentence to the contents of a picture. In producing a response in the sentence-verification task, participants did not have to generate a reason, or an explanation, for their answer—the picture provided ground truth. That is, '*star is above plus'* would unequivocally be false if the picture depicted a plus above a star. In Foss and Bower's study, the manual, or long-term working memory, provided the ground truth. In the present study, it was necessary to infer the connections between the events in question in order to generate an explanation that could support one's answer. In other words, ground truth had to be constructed ad hoc. For example, in order to falsify the sentence *'you pour the* *foundation before you dig the hole'* you have to generate the explanation that *'you have to have a hole to pour the foundation into'*.

Sometimes the explanations, or reasons needed to justify an answer are simple, like the one above. This was an example of a physical relationship—one event is a necessary precondition for another. In the case of the social relationships, one event may be related to another, but one does not act as a precondition for the other. For example, *'you prime the walls before you install the carpet'* is true by social convention because *'if you install the carpet first then you have to cover it up so that you do not spill primer on it'*. This can account for my finding that social relationships appear to be associated with longer response times on the average.

Figure ***19*** summarizes the proposed explanation-based verification model. First, the sentence order is translated into a baseline order. When the sentence order matches chronological order, sentence event 1 becomes baseline event 1, and sentence event 2 becomes baseline event 2. When the sentence order does not match chronological order, sentence event1 becomes baseline event2, and vice versa.

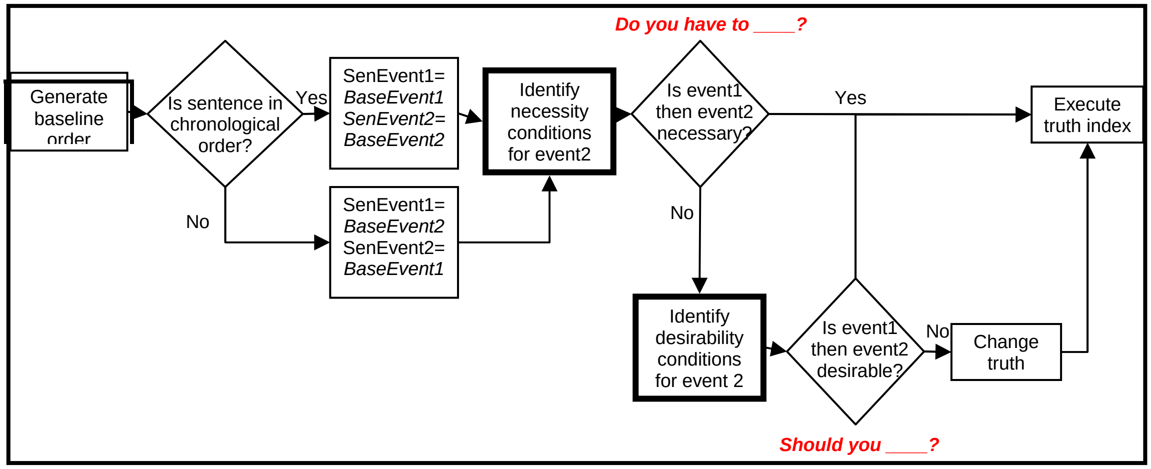

Figure 19. An explanation-based model of sentence verification.

Then, in order to verify the relationship, an explanation for the baseline order is generated. First, a necessary explanation for the relationship is generated and evaluated —"do you have to___?" In order to do this evaluation, the participant must determine whether event1 is a pre-condition for event2. If it is, then the relationship is necessary, and the truth index is executed. If it is not, then a desirability explanation is generated and evaluated—"would you___?" If executing the baseline order does not result in undesirable outcomes, then the relationship is desirable, and the truth index is executed (default truth index is True). If it is not, which can happen both in the case of a false physical relationship, and a false social relationship, then the truth index is changed to false, and then executed. Evaluating whether an order of events is desirable requires a different kind of explanation than is required for evaluating whether it is necessary. See Table 21 for the additional types of explanations generated to evaluate necessary versus desirable relationships.

Table 21

Necessary versus desirable explanations.

	SENTENCE ORDER	BASELINE ORDER	NECESSARY EXPLANATION
	You <u>SenEvent1</u> after SenEvent2	***Event1 then <u>Event2</u>***	***You have to event1 in order to <u>event2</u>.***
Physical Example *(False)*	***You dig the hole after you pour the foundation***	***Pour the foundation then dig the hole***	***You have to dig the hole in order to pour the foundation.***
	SENTENCE ORDER	**BASELINE ORDER**	**DESIRABLE EXPLANATION**
	You <u>SenEvent1</u> after SenEvent2	***Event1 then <u>Event2</u>***	***If you don't event1 then <u>event2</u> then event3***
Social Example *(True)*	***You attach the drywall after you install the exterior doors***	***Install exterior doors then attach drywall***	***If you don't install exterior doors then attach drywall then drywall might get wet.***

It is also possible that in order to examine desirability conditions, participants use a falsification strategy (Johnson-Laird, 1970). Instead of verifying that event1 is a desirable pre-condition for event2, participants might examine whether event2 can indeed occur without event1 having occurred first. In doing so, participants might imagine what would happen if event2 occurred first, i.e., event2 then event1. If this order is undesirable, then the opposite relationship must be true. This strategy may only be necessary for the social relationships because the events do not impose direct constraints on each other. The physical relationships do, and therefore imagining them in the opposite order is unnecessary.

A falsification strategy could also account for the slow responses when social relationships are presented in chronological order in the context of Given-Given and New-Given. The falsification process carried out on the social relationships might result in a mental representation that is in reverse chronological order. This means that when the sentence on the screen presents events in non-chronological order, the reversal generates the easily remembered chronological order for evaluation. However, when the sentence on the screen presents events in chronological order, the reversal generates the less accessible non-chronological order for evaluation. This model does not account for the odd, slow verification of physical relationships presented in chronological order in the context of observing the Given-New principle (Given-New). Because physical relationships should not require reversals for explanation, there is no reason for the chronological sentences to be slow.

This falsification account goes part of the way towards explaining my finding that the relative difficulties involved in verifying physical and social relationships interact with whether or not the Given-New principle is observed. Haviland and Clark's (1974) process account of the Given-New effect, concluded that presenting Given information first provides the reader with a mental scaffold onto which New information can be attached. If New information is presented first, the readers must keep New information in memory while they wait for the antecedent for this information.

Within the spirit of this process account, though, it makes sense that it would then be particularly advantageous, when you are reasoning about a social relationship, to have thought about the events in question previously. That is, because constructing social explanations is more difficult than constructing physical explanations, consistent with

Mandler's (1986) model-building account, having reasoned about events previously ensures that they are easier to sustain in working memory. This is particularly helpful in the case of social relationships, which require additional working memory resources. Because a Given event exists in long term working memory, when it is in the first position, it provides a better anchor for the baseline relationship. When a New event is in the first position, there is no such anchor and the baseline relationship must be rehearsed more often, interfering with the inference processes involved in generating an explanation.

Most theoretical accounts of comprehension (e.g., Johnson-Laird, 1983; Zwaan, & Radvansky, 1998) assume that a reader interprets a sentence by constructing a discourse model that is a mental representation of people, objects and events described. An important question in psycholinguistic research is whether processing decisions at one level of representation (e.g., the discourse model) can influence lower-level processing decisions (e.g., decisions about syntactic structure). At the very least, the present study demonstrates that lower level processing decisions, such as whether or not the sentence presents events in chronological order, are influenced by discourse level decisions—such as, have I heard about an event or object before. This means in particular, that absolute statements about what is difficult, or cognitively complex, are misguided. My results demonstrate that complexity depends on the whole set of things that have to be reasoned about. Therefore, if you must constrain the context so much in order to get the results observed in previous research, this may indicate that these low level variables do not provide a useful account of how people reason about language in the real world.

Results obtained in the production study corroborate my claim that low level language dimensions (marking (before/after), syntax (clause position), and iconicity) cannot be thought of as absolute influences on complexity. These production results show that certain low-level dimensions are associated with specific pragmatic purposes. That is it appears that after, main-clause-first constructions are specifically used to produce events in an order that is consistent with the previous discourse. This may call into question any claimed cognitive complexity associated with them that may have been observed in individual cognition studies that did not consider this functional dimension of language. My results support the notion that it is not meaningful to study language separately from its role as a tool for social coordination.

4.2.2 Discourse as Context for Production

In the production study, I examined the extent to which participants observed discourse order by focusing on their usage of pronouns in sentences relating temporal information, i.e., chronological order. Pronouns can be regarded as markers of Givenness as they are used to refer to an object or event that has been previously mentioned. If an event had not been mentioned before, a pronoun would be a very unlikely referent to use.

Participants produced sentences with the main clause first significantly more often. When they produced sentences that violated chronological order they used the preposition after, and they were more likely to use relative pronouns in place of the object in the main clause (see Figure 20).

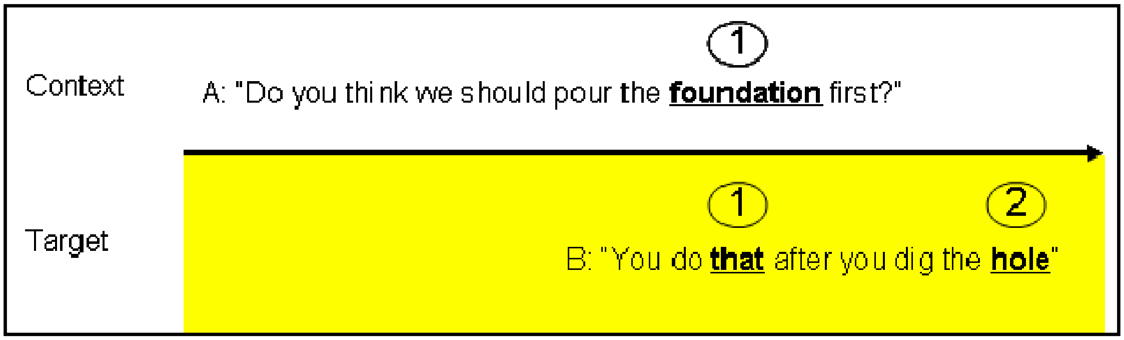

Figure 20. Temporality of discourse. Event referencing using pronoun.

When participants produced sentences that did not violate chronological order they used the preposition before, and they were more likely to use the name of the event to refer to it (see Figure 21).

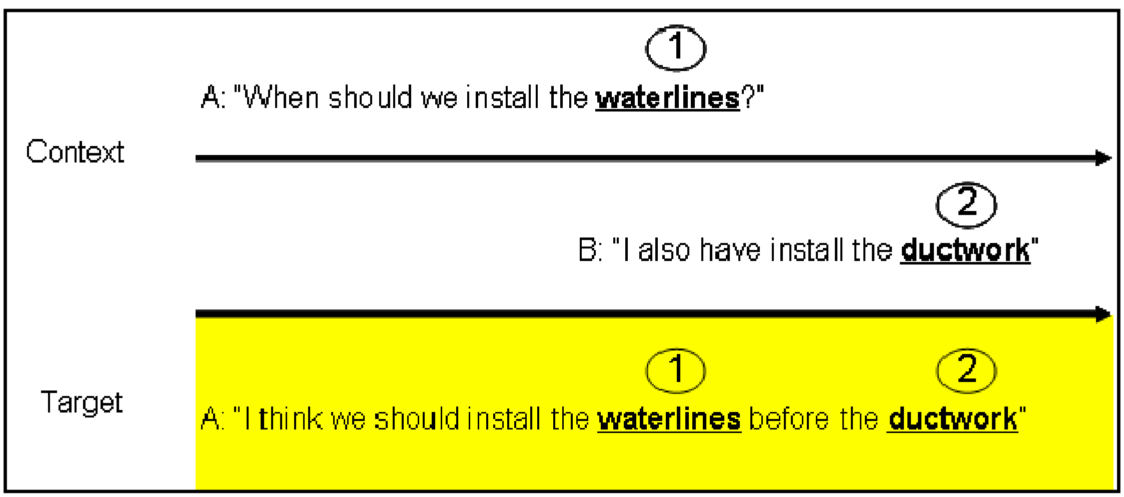

Figure 21. Temporality of discourse. Event referencing using event name.

These results demonstrate that people use syntax that reflects the temporality of the discourse itself and in this way utilize word-choice and syntax deliberately in order to ‘cooperate’. These findings provide initial evidence that the preposition after, and syntax that violates chronological order, is used functionally to present events in an order that is consistent with the previous discourse. In Figure 20, speaker B intends for the order *‘dig the hole before you pour the foundation’*. However, instead of saying that, they use the after, main clause first construction to present events in an order that is consistent with the order they have been talked about in the discourse.

This suggests that, in the context of discourse, the comprehension of language violating chronological order may be facilitated by the local context of the discourse itself. That is, the discourse itself provides a temporal context which can serve to disambiguate the temporality of the content of the conversation. The discourse example in Figure 21 demonstrates that this is not merely a matter of observing the Given-New principle. In this example, both *waterlines* and *ductwork* have been mentioned in the immediately preceding discourse, and should both be assumed to be Given. The choice of a sentence construction that places the 'oldest' information first shows that the speaker is using temporality from the discourse situation to guide production. Just like speakers can violate discourse maxims to imply meaning (implicature; Grice, 1981), speakers can present information out of chronological order, using more 'complex' syntax in order to make their language coherent within a larger meaning system. Fittingly, Schegloff (1991) notes that conversational language is not precise and unambiguous, exactly because the entire interactive and situational context, not just a speaker's words, is available for establishing shared understanding among participants.

My results demonstrate then, that in discourse, coordination of communicative actions trumps ordering of content. This means that the discourse itself provides a context for comprehension that may efface low level influences on cognitive complexity, i.e., the local context overrides general rules about difficulty. In this case, context appears to reduce complexity rather than to increase it. Results such as these suggest that our understanding of the relationship between language and cognition is better enhanced by studying language in use, when it is produced for someone.

4.3 Semantic Influences on Complexity

Prior research suggests that objects and events that are logically related are easier to reason about than objects and events which are arbitrarily related. This suggests that the nature of the relationship between two events should influence cognitive processing. I had predicted that socially related events would be more difficult to reason about than physically related events. I did indeed find that socially related events were more difficult to reason about than physically related events, but only when events were closer together in time (see Table 22). There was no difference between physical and social events when the events were far apart in time. I therefore have partial support for the claim that physical laws and social convention pose different constraints on reasoning, which is consistent with previous research. This is also consistent with my earlier suggestion that social relationships require a different, and more involved verification process.

Table 22

Sample Sentences from Psychological Distance by Semantic Relationship. The Difficult Near/Social Case is Highlighted.

	Near	Far
Physical	You pour the foundation before you build the frame	You deliver the lumber before you run the rough wiring
Social	You install the exterior doors before you attach the drywall	You build the floor frame before you pour the concrete driveway

The question that remains, however, is why the processes involved in reasoning about different types of relationships are influenced by the perceived distance between the events? The absence of an overall distance effect was somewhat surprising. This result is in contradiction with the literature suggesting that it is more difficult to reason about actions and goals that are further apart conceptually and temporally (Foss, & Bower, 1986).

Franklin, Smith, and Jonides (2007), however, provide some evidence that the psychological distance effect may depend on familiarity with the material. In a similar study to Foss and Bower (1986), Franklin et al. used different task domains, half of which participants had rated high familiarity with and half that they had rated that they were unfamiliar with. Franklin et al. found a reverse-distance effect, i.e., they were faster when events were closer together, in the context of familiar task domains, such as going to a restaurant. In the context of an unfamiliar task domain such as making new clothes, they found a distance effect, i.e., they were faster when events were further apart. Franklin et al. propose a hybrid model of temporal codes, such that events are coded both in terms of their exact position within a routine and terms of their coarse position—early, middle, and late. In the case of low familiarity, participants are more likely to have a coarse coding which can be used to estimate position within the routine and produce fast responses for events that are far apart. A coarse coding, however, makes it more difficult to discern fine distinctions. Low familiarity therefore results in slower responses when events are close in time. When participants have high familiarity, events are more likely to be represented with specific position information, which takes longer to scan—the closer events are, the less time it should take to scan position information.

My results provide support for a partial distance effect. It can certainly be argued that my participants have low familiarity with the material (their self-ratings indicated this). This distance effect, however, only appeared for socially related events. This could suggest that my participants are indeed using some form of estimation process due to their low familiarity. The absence of a distance effect in the context of the physically related events suggests that the estimation process is somehow influenced by the semantics of the relationship, though. The social conventions for temporal order of activities in house construction are more likely to be unfamiliar to participants than physical laws constraining the same activities. It makes sense then, as found by Franklin et al. (2007), that the less familiar relationships are influenced more by psychological distance. It is possible that in the case of the social relationships, the explanations are more difficult to construct, and participants are resorting to coarse estimation making the temporally close events more difficult to discern.

4.4 Syntactic Influences on Complexity

The present research examined the effects of syntax, or sentence construction, on comprehension by varying the positions of the main and subordinate clauses in the production experiment. Similarly, frequency counts of sentences with main clause first and main clause last sentence constructions in comprehension experiment provide information about syntactic production patterns, which provides a basis for a comparison of comprehension and production.

4.4.1 Linguistic Order

The two main findings related to the Iconicity and Clause Position interaction, which speak to the influences of linguistic order on cognitive complexity, concern the preference for main clause first and for the preposition *before*. I will relate these two findings to the potential role of discourse context in the comprehension and production of linguistic order.

4.4.1.1 Main-clause-first advantage.

In the present study, participants comprehended sentence constructions with main-clause-first, *before* sentences more easily than main-clause-last, *after* sentences.[20] Similarly, participants produced sentence constructions with the main clause first significantly more often than sentence constructions with main clause last, regardless of the preposition. Although these production results are not similar to the comprehension results established in the previous literature, they are comparable to the results obtained from the analysis of the mission control production data. The presence of a similar pattern of production in these two different task contexts and populations lends credibility to the results.

Clark and Clark (1968) put forth that the position of the main clause is the most important cognitive feature of a sentence. That is, in computational terms, the position of the main clause is the feature of the sentence that is evaluated first. If the main clause is positioned first, the sentence is considered unmarked for clause position; if it positioned last, it is considered marked.

One could interpret my results as supporting Clark and Chase's original cognitive marking notion, predicting that main clause first is easier than main clause last, and that *before* is easier than *after*. However an alternative explanation is that Clark and Clark's participants simply produced the main clause first, *before* sentences more often because

[20] There were no differences between comprehending main clause first, *after* and main clause last, *before* sentences.

the main clause first, *after* sentences have a functionally different significance when used in the context of real discourse (see earlier discussion of the functional significance of after). Because their experiment was devoid of such a context, it was also devoid of a reason to use that particular sentence construction.

4.4.1.2 'Before' advantage.

Surprisingly, main clause last, *before* sentences appeared to be just as easy to comprehend as main clause first, *before* sentences. Within the cognitive marking framework, main clause last, *before* sentences should be the most difficult sentence construction to comprehend. This was consistently the finding in all the research presented earlier by Clark and his colleagues as well as in most of the developmental literature. This particular sentence construction should be difficult because it presents events non-chronologically and it places the main clause last.

Given the numerous methodological differences between the present study and the studies which have examined the marking phenomenon, though, it is not surprising that I should obtain a somewhat different pattern of results. The fact that the cognitive marking framework does not provide an adequate account of the present findings suggests that the data cannot be explained simply by appealing to the low level linguistic aspects of the sentences. Instead, the pragmatic context for the stimuli provided in this experiment likely has contributed to the pattern of results. As discussed earlier, it appears that the low level aspects of language can be utilized in discourse to attain functionally different ends. In particular, *after* sentences that reversed chronological order appeared to be used to communicate events in correspondence with the temporal order of the discourse, i.e., to preserve Given-New, or to follow up on a partner's previous comment.

Because my participants had recently participated in a discourse in which before and after were associated with different pragmatic purposes, it is possible that they had these purposes in mind when resolving the temporal ambiguity of the comprehension stimuli. Only, in the context of the sentence verification task, there was no real pragmatic purpose associated with the sentences, and expecting such a purpose could serve to distract, or somehow disrupt the comprehension of the *after* sentences in particular.

Therefore, rather than concluding that after is uniformly marked, or uniformly cognitively more complex, I lean towards the conclusion that *after* is used differently within real discourse. Because it has a different purpose, it behaves differently within artificial comprehension tasks in which the purpose of the language changes as a function of the experimental task.

4.4.2 Comprehension versus Production

Another important prediction in the present study was that production patterns should mirror comprehension patterns. If speakers take ease of comprehension into consideration in their choice of 'words' and syntax then the words and syntax used most often in discourse should be the ones that have the least complexity associated with them. Grice's conversational principles provide evidence to support the above premise.

I did observe an interaction between Iconicity by Clause Position within both my comprehension and my production studies. However, not only were the patterns of the interactions not the same, neither patterns resembled the pattern of differences reported in the previous literature. I had reasoned that if comprehension and production patterns did not converge, then either Grice’s principles do not always hold; we do not always produce that which is comprehensible, or, consistent with Grice’s concept of implicature, we produce language that is deliberately more complicated to call special attention to the content. The last alternative, which is not necessarily disjunctive with the first two, is that predictions from comprehension literature about what is comprehensible in real discourse are wrong.

Even though my data does not allow me to choose one of these options definitively, it does allow me to speculate about a fourth option which I had not anticipated. The fourth option being that the discourse itself can provide a pragmatic context which can serve to disambiguate complexity.

4.5 Representational Format and Cooperation

The other contextual factor which can have important influences on cognitive complexity examined in the present study concerns the format of the external representations available to support, or provide reference for the content of language. I hypothesized that representational format would influence the online production of language in the context of a cooperative task. I further predicted that representational format would have an effect on later comprehension of information which had been reasoned about in the context of a specific external representation. This latter prediction was not supported by the data, and will therefore be discussed first.

4.5.1 Representations as Contexts for Comprehension

I was interested in determining whether the representation would have persisting influences on the patterns of cognitive complexities associated with the language variables. The absence of a main effect or interactions involving representational format indicates that the nature of the representation used to create the schedules did not appear to have a differential effect on the ease with which participants resolved chronological ambiguity in the later comprehension study. This means that the present study did not succeed in uncovering persisting influences of representational format on the manner in which temporal information is stored and retrieved.

Similarly, the finding that participants did not appear to systematically reply Monday or Wednesday to the temporal metaphor question indicated that there was no effect of representation on the propensity to adopt a time-moving or an ego-moving metaphor.

4.5.2 Representations as Contexts for Cooperation

Even though the present study did not demonstrate differential lasting effects of representational format on language comprehension, it did demonstrate modest effects of representation on performance and reliable effects on language production.

4.5.2.1 Effect of representation on performance.

The main predicted effect of representation on performance was that participants experiencing the graphical condition would complete the schedules faster and more efficiently (using fewer words) than participants in the numeric condition. There were no differences between the groups on the amount of time they spent on the task or the number of words they used. Although I did not have specific predictions about the quality or the appearance of the schedules, I did examine these dimensions.

In terms of the appearance of the schedules, the question here was whether or not the format of the schedule somehow influenced participants to use a different strategy for creating their schedules—resulting in different types of schedules. It did appear that participants in the numeric condition used more simultaneous relationships. There was no difference between the groups in the number of successive relationships used. The reason using different types of relationships did not affect the quality scores (no differences) is that the quality measure only evaluated the order of the physical relationships—which, per definition, had to be ordered successively. It is possible that the participants in the graphical condition felt less pressured to use simultaneous relationships because the graphical representation gave them a more clear idea of how much time was left of the three month time limit. Or, conversely, it is possible that the participants used simultaneous relationships, or overlapped days, due to inattention.

There were no differences for quality as indicated by the performance measure. Attempts to decrease performance variance with language and ability variables did not reveal an effect of representation. This result is relevant to Human Factors. My data indicates that, in the context of distributed, cooperative work, there are dimensions of the task that are more important to performance than the representation—in this case it is language. So even if I did identify a combination of covariates that revealed a main effect of representation on a performance dimension, I would likely conclude that the representation effect was minute in comparison to the other variables. This suggests that representational format is not as important a constraint on distributed cognition as it has been demonstrated to be on individual cognition.

4.5.2.2 Main effect of representation on language.

The exploratory hypothesis I posed in regards to the relationship between representational format and language production, queried whether the differences in individual reasoning strategies afforded by different representational formats affect the cooperative exchange in a distributed work situation. The main dimension of interest was the relationship between how easily a relationship is determined in a graphical representation, such as duration, and how much it is talked about. That is, would the relationship be talked about more because it is explicit? Or, is the converse true, relationships that were explicit in the representation would be talked about less.

There were no differences between the frequencies with which participants discussed simultaneous relationships in the graphical versus numeric conditions. (Note that the numeric condition did use more simultaneous events in their schedules). Also, there were no differences in the number of times participants used pronouns to refer to events. The idea here was that participants could use pronouns much in the way participants working in a collocated fashion might use body language to physically point to a shared representation. Because the graphical representation represented objects spatially, it should have been easier to 'point' to these objects with language.

This means that the language measures used in this study did not establish differences between how different representational formats may provide better or worse common ground in the context of non-collocated, distributed work. Nevertheless, I do not believe that this experiment has provided definitive support for the alternative hypothesis, that graphical and numeric representations provide common ground equally well. The limitation of the current study in this regard is that in this experimental task, the schedule was the output of the cognitive work. This means that the cognitive operations were not necessarily carried out on the schedule itself—i.e., participants would be most likely to talk about a temporal relationship before they had entered it into the schedule. That is, they talked about a relationship before they had a lasting, physical representation of that relationship in front of them. An alternative manipulation might have the participants place in order a set of events which have already been entered on the computer—i.e., objects already exist in the representation, and the cognitive work would therefore take place on these objects.

The finding that participants in the graphical condition asked more questions of each other, i.e., cooperated more, suggests that the representation may have had an effect on the work process. I therefore went go on to examine whether representation and language might jointly have an effect on performance.

4.5.2.3 Interaction between representation and language.

An interaction between representation and language in the context of the production study would manifest itself in differences between how well the language measures predicted performance within the two representations. Because I did not have enough power to distinguish between the R^2 values, I was not able to determine whether the same combinations of language measures provided better models of performance within on representation or the other. However, I did have enough power to make claims about which models worked better to account for performance within each of the two representations.

Apart from the pronoun *that*, which is common to both representations, a different set of language variables is correlated with the performance measures for graphical and numeric representations. In particular, *overlap* is correlated with time/accuracy for graphical representations while sentences relating successive temporal order with main clause first (*chronomc1st* and *nchronomc1st*) are correlated with time/accuracy for numeric representations. Further, the slopes on *that* are different. These findings suggest that language is used differently to accomplish the task in the context of the numeric representation, than in the context of the graphical.

The preceding discussion suggests that there are two ways that language can be related to representational format. The first is that language is compensatory (Beun, & Cremers, 1998). That is, language can make up for deficiencies in the representation. For example, if something is not explicit, it is discussed more. The present experiment did not find support for this idea. The second way that language can be related to representational format is that language is synergistic. Within this view, language picks up on features of the representation, i.e., if something is explicit, it is discussed more. The finding that *overlap* has a different relationship with time to completion in the graphical representation than in the numeric representation seems to support a synergistic account of the language/representation relationship.

4.6 Limitations

4.6.1 Comprehension

Although I did obtain an effect of discourse order in the comprehension study, it is possible that I did not operationalize the discourse order variable in a manner that compares to how it manifests itself in produced language. In produced discourse, Given information is information that has been grounded in previous discourse and that can be assumed to be shared among the discourse participants. This notion of sharedness is difficult to reproduce in a sentence verification paradigm—where there is only one 'discourse participant'. Therefore, in the comprehension study, Given events were events that participants had reasoned about in the earlier production study; New events were ones that they had not. This means that some time had passed in between the point at which participants first saw and reasoned about the Given events and the point in the comprehension study when they were asked to verify a sentence containing that event. It is possible therefore that my discourse order manipulation really relates to short term memory; i.e., do the events exist in memory (Given) or are they encoded for the first time (New).

One could also argue, however, that this difference, between existence in memory versus encoded for the first time, is merely a description of the Given-New phenomenon at the level of individual cognition. The question does remain as to how to operationalize Givenness and Newness at the individual level—i.e., how much time can pass until a Given event is no longer given, or how much interceding information (discourse) can come between the time when the event is first mentioned and the time when it if referenced? These bounds should be defined within the context of production. Participants in discourse know implicitly, for the most part, when an event can no longer be assumed to be common knowledge. A much more interesting question for psychology instead of the temporal and informational bounds on memory, might be 'how do people know when an event can no longer be assumed to be common knowledge?'. The answer to this question, rather than focusing on absolute dimensions of memory, concerns instead people's understanding of the phenomenon of memory itself, i.e., our knowledge of what other people can be expected to remember. Our folk understanding of memory may place a just as important constraint on 'what people say' as low level process-oriented variables.

4.6.2 Production

It is possible that the absence of solid representation effects on performance is an artifact of the experimental constraints imposed on the task. The fact that I allowed participants to work to criterion, that is, until they finished the schedules, may have eradicated potential effects of the representation on performance. The decision to let them work to criterion, however, was made to ensure that all participants would have experienced all the experimental stimuli—and so that these could be assumed to be Given in the subsequent comprehension study.

4.7 Future Research

I plan to further examine the hypothesis that sentences violating chronological order, but observing the given-new principle are just as easy to comprehend as sentences that do not violate chronological order using my production dataset. Within this dataset I can examine ease of comprehension by looking at the ‘time to produce a response’ associated with the sentences that violate chronological order, but observe the discourse principle (use pronoun) versus sentences that violate chronological order but in which the discourse principle may not apply (do not use pronoun). Response time in the production context means the time in between the utterance of a sentence until the recipient initiates a response. I expect it will take longer to respond to sentences that violate chronological order for which the discourse principle does not apply. This would provide further evidence to suggest that the discourse context influences comprehension.

4.8 Summary

The present study offers preliminary evidence that cognition-in-the-lab and cognition-in-the-world diverge. In and of itself, this is not a surprising revelation: cognitive anthropologists have long known this, and to a certain extent Human Factors psychologists as well. What the present study has uncovered that is novel, is that linguistic variables that have previously been established to be associated with cognitive complexity, do not appear to be complex when they are examined in a communicative context. That is, discourse can provide a context for the production and comprehension of language which resolves or effaces (some of) the low level influences on cognitive complexity which have been established in more traditional experimental paradigms (language isolated from context).

In terms of what we should be studying in the laboratory, the more general idea, that what may look like complexity does not straightforwardly equate to complexity once you provide a context, is a problem for psychological research in general. Context is a problem for psychology because it is potentially an unbounded variable—how much context is enough, and what are the right aspects of context to include? The present study suggests that a good place to start, in the spirit of pragmatics, is with purpose. When the purpose of language in the experimental situation (scheduling) is the same as the purpose of language when it is used to accomplish a real task, such as the mission control task, the results are more likely to transfer.

In terms of how we should be studying language in the laboratory, the present study took the comprehension paradigm, put it in context, and the results did not replicate. Furthermore, the results obtained in this comprehension paradigm did not predict the production results collected—on the same participants. This indicates that response time and reading time measures may provide very precise information about the kinds of influences on cognitive complexity that can exist in a very controlled, context-free situation, but these findings do not hold up when we try to add more context to the comprehension task, nor do they help us predict how people will use language to cooperate with each other.

The fundamental assumption underlying leading theories of cognitive linguistics is that language and linguistic organization is an expression of conceptual organization (Talmy, 2000; Langacker, 1991; Jackendoff, 1983). That is, there is a ‘real’ world and a conceptualized world, and language provides insight into the organization of the latter conceptualized realm. My findings suggest that the discourse context is an important aspect of what cognitive linguistics considers the ‘real’ world because it imposes constraints on linguistic complexity. Or, at the very least, my results suggest that we need to expand our notion of which parts of the ‘real’ world are conceptualized.

Even though the present study has not uncovered a specific principle which can aid in the design of external support for reasoning, it has demonstrated some general points about the differences between individual and collaborative work. The present study has demonstrated that, in the context of collaborative work tasks, representational format may have as strong an influence on performance as it does in the context of individual work. When people are collaborating to accomplish the task, they tend to use language, as a form of representation in itself, to coordinate aspects of the task that can lead to good performance. This means that in the context of collaborative work, language may provide us with important insight into the dynamics of poor and good team performance as well as poor and good persisting representations. The idea of using language as a dependent measure is at the forefront of Human Factors research. At the same time, the Human Factors community, in recognition of the fact that more and more work domains require division of labor, and therefore collaboration has been seeking to develop ways to improve work conditions for teams. This requires, however, that we have a way of distinguishing poor team performance from good team performance.

Recent research has successfully employed semantic language variables to assess team cognition (Kiekel, Cooke, Foltz, & Shope, 2001). The present study suggests that pragmatic language variables may offer additional information to assist in the development of reliable metrics of team performance.

V. REFERENCES

Anderson, J. R., & Bower, G. H. (1973). *Human Associative Memory.* New York, NY: J. Wiley & Sons.

Bennett, K. B., & Flach, J. M. (1992). Graphical displays: Implications for divided attention, focused attention, and problem solving. *Human Factors, 34*, (5), 513-533.

Beun, R. J., & Cremers, H. M. (1998). Object reference in a shared domain of conversation. *Pragmatics & Cognition, 6*(1/2), 121-152.

Boroditsky, L., & Rasmcar, M. (2002). The roles of body and mind in abstract thought. *Psychological Science, 13*(2), 185-189.

Brown, P. & Levinson, S. (1987). *Politeness: Some universals in language usage.* Cambridge, MA: Cambridge University Press.

Carswell, C. M., & Wickens, C. D. (1990). The perceptual interaction of graphical attributes: Configurality, stimulus homogeneity, and object integration. *Perception & Psychophysics, 47*, 157-168.

Chafe, W. L. (1972). Discourse structure and human knowledge. In: *Language comprehension and the acquisition of knowledge,* J. B. Carroll and R. O. Freedle (Eds.). Washington, D. C.: V. H. Winston.

Clark, E. V. (1971). On the acquisition of the meaning of ‘before’ and ‘after’. *Journal of Verbal Learning and Verbal Behavior, 10*, 266-275.

Clark, H. H., & Card, S. K. (1969). Role of semantics in remembering comparative sentences. *Journal of Experimental Psychology, 82*(3), 545-553.

Clark, H. H., & Chase, W. G. (1972). On the process of comparing sentences against pictures. *Cognitive Psychology, 3*(3), 472-517.

Clark, H. H., & Clark, E. V. (1968). Semantic distinctions and memory for complex sentences. Quarterly *Journal of Experimental Psychology, 20,* 129-138.

Daneman, M. & Carpenter, P.A. (1983). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behaviour,* 19, 450-466.

Dowling, P. R., DiIulio, J. L., & Shalin, V. L. (In preparation). Verb use in an instructional context.

Ehrlich, K., & Johnson-Laird, P. N. (1982). Spatial descriptions and referential continuity. *Journal of Verbal Learning and Verbal Behavior, 21*, 296-306.

Ekstrom, R. B., French, J. W. & Harman, H. H. (1976). *Kit of factor-referenced cognitive tests.* Educational Testing Service, Princeton.

Franklin, M. S., Smith, E. E., & Jonides, J. (2007). Distance effects in memory for sequences: Evidence for estimation and scanning processes. *Memory, 15*(1), 104-116.

Foss, C. L., & Bower, G. H. (1986). Understanding actions in relation to goals. In: *Advances in cognitive science 1*, N. E. Sharkey (Ed.). Chichester: Ellis Horwood.

French, L. A., & Brown, A. L. (1977). Comprehension of before and after in logical and arbitrary sentences. *Journal of Child Language, 4*(2), 247-256.

Garrod, S. C., & Sanford, A. J. (1994). Resolving sentences in a discourse context: How discourse representation affects language understanding. In: *Handbook of psycholinguistics,* Gernsbacher, M. A. (Ed.). San Diego, CA: Academic Press

Gentner, D., Mutsumi, I., & Boroditsky, L. (2002). As time goes by: Evidence for two systems in processing space time metaphors. *Language & Cognitive Processes, 17*(5), 537-565.

Goldvarg, E., & Johnson-Laird P.N. (2001). Naive causality: a mental model theory of causal meaning and reasoning. *Cognitive Science, 25,* 565–610

Goodwin, C. (2002). Time in action. *Current Anthropology, 43*, 19-35.

Greeno, J. (1983). Conceptual entities. In: *Mental models*, Dedre Gentner and Albert L. Stevens (Eds.) Hillsdale, NJ: L. Erlbaum Associates.

Grice, H. P. (1975). Logic and conversation. In: *The Logic of Grammar*, Donald Davidson and Gilbert Harman (Eds.). Encino, CA.: Dickenson.

Grice, H. P. (1981). Presupposition and conversational implicature. In: *Radical pragmatics*, P. Cole (Ed.). New York, NY: Academic Press.

Hartley, H.O. (1950). The maximum F-ratio as a shortcut for heterogeneity of variance. *Biometrika, 37,* 308–312.

Haviland, S. E., & Clark, H. H. (1974). What's new? Acquiring new information as a process in comprehension. *Journal of Verbal Learning and Verbal Behavior, 13,* 512-521.

Horton, W. S., & Gerrig, R. J. (2005). Conversational common ground and memory processes in language production. *Discourse Processes, 40*(1), 1-35.

Hutchins, E. (1995). How a cockpit remembers its speeds. *Cognitive Science, 19*(3), 265-288.

Jackendoff, R. (1983). *Semantics and Cognition*. MIT Press.

Johnson-Laird, P. N. (1970). A theoretical analysis of insight into a reasoning task. *Cognitive Psychology, 1*(2). 134-148.

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

Kavanaugh, R. D. (1979). Observations on the role of logically constrained sentences in the comprehension of “before” and “after”. *Journal of Child Language, 6*(2), 353-357.

Keenan, J. M, & MacWhinney, B. (1987). Understanding the relationship between comprehension and production. In: *Psycholinguistic models of production,* Hans W. Dechert, Manfred Raupach (Eds.). Westport, CT: Ablex.

Keppel, G., & Wickens, T. D. (2004). *Design and analysis: A researcher’s handbook.* Prentice Hall.

Kiekel, P. A., Cooke, N. J., Foltz, P. W., & Shope, S. M. (2001). Automating measurement of team cognition through analysis of communication data. In: *Usability Evaluation and Interface Design*, M. J. Smith, G. Salvendy, D. Harris, and R. J. Koubek (Eds*.).* Mahwah, NJ: Lawrence Erlbaum Associates.

Kintsch, W. (2001). Predication. *Cognitive Science, 25*, 173–202.

Kintsch, W., and van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review, 85*(5), 363-394.

Kirk, R. E. (1995). *Experimental design: Procedures for behavioral sciences*. Wadsworth Publishing.

Lakoff, G. (1993). The contemporary theory of metaphor. In: Ortony, Andrew (ed.) *Metaphor and thought (2nd edition),* Cambridge, MA: Cambridge University Press.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. University of Chicago Press.

Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: the embodied mind and its challenge to western thought*. Basic Books.

Langacker, R.W. (1991). *Concept, image and symbol*, Berlin/N.Y.: Mouton de Gruyter.

Larkin, J. H., & Simon, H. A. (1987). Why a diagram is (sometimes) worth ten thousand words. *Cognitive Science, 11*(1), 65-100.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* New York, NY: Cambridge University Press.

MacDonald, M. C., Just, M. A., & Carpenter, P. A. (1992). Working memory constraints on the processing of syntactic ambiguity. *Cognitive Psychology, 24*(1), 56-98.

Mandler, J. M. (1986). On the comprehension of temporal order. *Language and Cognitive Processes, 1*(4), 309-320.

Myers, J. L., & O'Brien, E. J. (1998). Accessing the discourse representation during reading. *Discourse Processes, 26*, 131–157.

Myers, J. L., Shinjo, M., & Duffy, S. A. (1987). Degree of causal relatedness and memory. *Journal of Memory and Language, 26*, 453–465.

Newell, A. (1990). *Unified theories of cognition.* Cambridge, Massachusetts/London, England: Harvard University Press,

Norman, D. (1987). Design principles for human-computer interfaces. In: *Applications of cognitive psychology: Problem solving, education, and computing,* Berger, Dale E., & Pezdek, Kathy, (Eds.). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

O'Brien, E. J., & Myers, J. L. (1999). Text comprehension: A view from the bottom up. In: *Narrative comprehension, causality, and coherence: Essays in honor of Tom Trabasso,* S. R. Goldman, A. C. Graesser, & P. van den Broek (Eds.). Mahwah, NJ: Lawrence Erlbaum Associates.

Palmer, S. E. (1977). Hierarchical structure in perceptual representation. *Cognitive Psychology, 9*(4), 441-474.

Rasmussen, J., & Vicente, K. J. (1989). Coping with human errors through system design: Implications for ecological interface design. *International Journal of Man-Machine Studies, 31*, 517-534.

Rasmussen, L., & Shalin V.L. (in preparation). Lexical influences on the process of reasoning with graphical and numeric representations.

Schegloff, E. A. (1991). Conversation analysis and socially shared cognition. In: *Perspectives on socially shared cognition,* Resnick, Lauren B., (Ed); Levine, John M., (Ed); Teasley, Stephanie D., (Ed) p. 150-171.

Schraagen, J.M., Chipman, S.F., & Shalin, V.L. (2000). *Cognitive task analysis.* Mahwah, NJ: Lawrence Erlbaum Associates.

Searle, J. R. (1969). *Speech acts: An essay in the philosophy of language.* Cambridge, England: Cambridge University Press, Suchman, L. A. (1987). *Plans and situated actions : the problem of human-machine communication*. Cambridge/NY: Cambridge University Press.

Talmy, L. (2000). *Toward a cognitive semantics—Vol 1.* The MIT Press.

Trosborg, A. (1982). Children's comprehension of "before" and "after" reinvestigated. *Journal of Child Language, 9*(2), 381-402.

Tversky, B. (2004). Narratives of space, time, and life. *Mind & Language, 19*(4), 380-392.

van de Kopple, W. J. (1982). The Given-New strategy of comprehension and some natural expository paragraphs. *Journal of Psycholinguistic Research, 11*(5), 501-520.

Vicente, K.J. (1999). *Cognitive work analysis: Toward safe, productive, and healthy computer-based work.* Mahwah, NJ: Lawrence Erlbaum Associates.

Vicente, K. J., & Rasmussen, J. (1990). The ecology of human-machine systems II: Mediating "direct perception" in complex work domains. *Ecological Psychology, 2*, (3), 207-249.

Wickens, C. D., & Andre, A. D. (1990). Proximity compatibility and information display: effects of color, space, and objectness on Information Integration. *Human Factors, 32,* (1), 61-77.

Wilson, M. D. (1984). *Leibniz' doctrine of necessary truth.* Cambridge, MA: Harvard University Press.

Woods, D. D. (1991). The cognitive engineering of problem representations. In: *Human-Computer Interaction and Complex Systems*, G. R. S. Weir and J. L. Alty (Eds.). London: Academic Press.

Zacks, J., & Tversky, B. (1999). Bars and lines: A study of graphic communication. *Memory & Cognition, 27*(6), 1073-1079.

Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin, 123*(2), 162-185).

Zwaan, R. A., & Yaxley, R. H. (2003a). Spatial iconicity affects semantic relatedness judgments. *Psychonomic Bulletin & Review, 10*(4), 954-958.

Zwaan, R. A., & Yaxley, R. H. (2003b). Hemispheric differences in semantic-relatedness judgments. *Cognition*, *87*, B79-B86.

APPENDIX A

Variable Naming Key.

			Name	Name
Before	Main Clause First	Chronological	*chronomc1st*	*beforemc1st*
After	Main Clause First	Non-chronological	*nchronomc1st*	*aftermc1st*
After	Main Clause Last	Chronological	*chronomc2nd*	*aftermc2nd*
Before	Main Clause Last	Non-chronological	*nchronomc2nd*	*beforemc2nd*

APPENDIX B

Instructions for Production Phase.

HOUSE CONSTRUCTION EXPERIMENT
[Production Phase]

You two are now a team. In this experiment you will work together to create the best possible schedule for building a house. You will be supplied with a list of tasks that have to take place when one is constructing a house, such as ‘pouring the foundation’, ‘building the frame’, etc. The list also tells you how long each task normally takes to complete when an average sized construction crew is building a house. You will only see a small selection of all the tasks that must be carried out to complete a house. Your list will contain 19 tasks and your partner’s list will also contain 19 tasks for a total of 38 tasks that you have to put in order.

It is your job to place the 38 house construction tasks in the best possible order, such that you can complete all the tasks in a three-month time period. This part of the experiment will be completed when you have met this goal. In order to meet this requirement you will have to decide which tasks must be carried out successively, and which can take place at the same time. You will have to carry out some of the tasks simultaneously to fit all the tasks in the three-month time period.

You and your partner will be placed in two different rooms. You will each have access to a computer with software that will help you each create a house construction plan. You will be able to communicate with your partner through a speaker-phone. You are encouraged to decide the order of your own events before you start communicating with your partner.

Even though the software is made for creating schedules it is a little difficult to add an event to the middle of an existing list of events, so you are encouraged to be extra careful that you are sure about the order before you enter an event into the schedule.

You should end up with identical schedules on each of your computers. Approximately 40 teams will participate in this experiment and the team that performs the best will receive a $150 reward of which you will be notified via email. You will be evaluated on the degree to which you and your partner’s schedules agree with each other, and a professional contractor will grade your schedules based on how closely they resemble a real construction schedule.

You will now watch a video that instructs you in how to use the scheduling software.

APPENDIX C

Instructions for Comprehension Phase.

HOUSE CONSTRUCTION EXPERIMENT
[Comprehension Phase]

You will now see (on a computer) a set of sentences describing some of the tasks that must be carried out to construct a house. These sentences are written by other participants, like yourself, but in a slightly different version of this experiment. These participants were asked to write down instructions for constructing a house. I would like you to rate whether or not you think they have done a good job. That is, I will show you 48 sentences, one at the time, and I want you indicate Yes or No for each sentence whether or not you would be likely to follow the instruction it gives if you were about to build a house.

For example, would be likely to follow this instruction:

You excavate the basement before you build the frame

The participants who wrote these instructions may have seen events that were not part of the schedule you just created. You should indicate whether this is a good instruction in general. For example, would you be likely to follow this instruction Yes/No:

After you install the floor joists you purchase the lot

There is no reward for being fast; however, a professional contractor has already rated whether or not he would be likely to follow these instructions. The team member whose answers agree the most with the ratings of the professional contractor will receive a small gift from the university bookstore.

APPENDIX D

Comprehensive List of Sentences for Comprehension Phase.

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Match (1. pour the foundation)			
Causal	Near	Given - Given	First	You	pour the foundation	before you	build the frame
			Last	After you	pour the foundation	you	build the frame
		Given - New	First	You	pour the foundation	before you	backfill around the foundation
			Last	After you	pour the foundation	you	backfill around the foundation
		New - Given	First	You	clear the trees	before you	pour the foundation
			Last	After you	clear the trees	you	pour the foundation
	Far	Given - Given	First	You	pour the foundation	before you	install the fireplace
			Last	After you	pour the foundation	you	install the fireplace
		Given - New	First	You	pour the foundation	before you	install the mirrors
			Last	After you	pour the foundation	you	install the mirrors
		New - Given	First	You	schedule the excavation	before you	pour the foundation
			Last	After you	schedule the excavation	you	pour the foundation
Social	Near	Given - Given	First	You	pour the foundation	before you	deliver the windows
			Last	After you	pour the foundation	you	deliver the windows
		Given - New	First	You	pour the foundation	before you	grade for the lawn
			Last	After you	pour the foundation	you	grade for the lawn
		New - Given	First	You	build access road	before you	pour the foundation
			Last	After you	build access road	you	pour the foundation
	Far	Given - Given	First	You	pour the foundation	before you	deliver interior trim
			Last	After you	pour the foundation	you	deliver interior trim
		Given - New	First	You	pour the foundation	before you	pour the concrete driveway
			Last	After you	pour the foundation	you	pour the concrete driveway
		New - Given	First	You	obtain the permits	before you	pour the foundation
			Last	After you	obtain the permits	you	pour the foundation

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Mismatch (1. pour the foundation)			
Causal	Near	Given - Given	First	You	build the frame	after you	pour the foundation
			Last	Before you	build the frame	you	pour the foundation
		Given - New	First	You	pour the foundation	after you	clear the trees
			Last	Before you	pour the foundation	you	clear the trees
		New - Given	First	You	backfill around the foundation	after you	pour the foundation
			Last	Before you	backfill around the foundation	you	pour the foundation
	Far	Given - Given	First	You	install the fireplace	after you	pour the foundation
			Last	Before you	install the fireplace	you	pour the foundation
		Given - New	First	You	pour the foundation	after you	schedule the excavation
			Last	Before you	pour the foundation	you	schedule the excavation
		New - Given	First	You	install the mirrors	after you	pour the foundation
			Last	Before you	install the mirrors	you	pour the foundation
Social	Near	Given - Given	First	You	deliver the windows	after you	pour the foundation
			Last	Before you	deliver the windows	you	pour the foundation
		Given - New	First	You	pour the foundation	after you	build access road
			Last	Before you	pour the foundation	you	build access road
		New - Given	First	You	grade for the lawn	after you	pour the foundation
			Last	Before you	grade for the lawn	you	pour the foundation
	Far	Given - Given	First	You	deliver interior trim	after you	pour the foundation
			Last	Before you	deliver interior trim	you	pour the foundation
		Given - New	First	You	pour the foundation	after you	obtain the permits
			Last	Before you	pour the foundation	you	obtain the permits
		New - Given	First	You	pour the concrete driveway	after you	pour the foundation
			Last	Before you	pour the concrete driveway	you	pour the foundation

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Match (2. build the frame)			
Causal	Near	Given - Given	First	You	build the frame	before you	install the windows
			Last	After you	build the frame	you	install the windows
		Given - New	First	You	build the frame	before you	apply the roof felt
			Last	After you	build the frame	you	apply the roof felt
		New - Given	First	You	deliver the lumber	before you	build the frame
			Last	After you	deliver the lumber	you	build the frame
	Far	Given - Given	First	You	build the frame	before you	connect the switches
			Last	After you	build the frame	you	connect the switches
		Given - New	First	You	build the frame	before you	apply the wallpaper
			Last	After you	build the frame	you	apply the wallpaper
		New - Given	First	You	order the lumber	before you	build the frame
			Last	After you	order the lumber	you	build the frame
Social	Near	Given - Given	First	You	build the frame	before you	install the ductwork
			Last	After you	build the frame	you	install the ductwork
		Given - New	First	You	build the frame	before you	grade for the lawn
			Last	After you	build the frame	you	grade for the lawn
		New - Given	First	You	waterproof the foundation	before you	build the frame
			Last	After you	waterproof the foundation	you	build the frame
	Far	Given - Given	First	You	build the frame	before you	remove the dumpsters
			Last	After you	build the frame	you	remove the dumpsters
		Given - New	First	You	build the frame	before you	install the garbage disposal
			Last	After you	build the frame	you	install the garbage disposal
		New - Given	First	You	order dumpster	before you	build the frame
			Last	After you	order dumpster	you	build the frame

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Mismatch (2. build the frame)			
Causal	Near	Given - Given	First	You	install the windows	after you	build the frame
			Last	Before you	install the windows	you	build the frame
		Given - New	First	You	build the frame	after you	deliver the lumber
			Last	Before you	build the frame	you	deliver the lumber
		New - Given	First	You	apply the roof felt	after you	build the frame
			Last	Before you	apply the roof felt	you	build the frame
	Far	Given - Given	First	You	connect the switches	after you	build the frame
			Last	Before you	connect the switches	you	build the frame
		Given - New	First	You	build the frame	after you	order the lumber
			Last	Before you	build the frame	you	order the lumber
		New - Given	First	You	apply the wallpaper	after you	build the frame
			Last	Before you	apply the wallpaper	you	build the frame
Social	Near	Given - Given	First	You	install the ductwork	after you	build the frame
			Last	Before you	install the ductwork	you	build the frame
		Given - New	First	You	build the frame	after you	waterproof the foundation
			Last	Before you	build the frame	you	waterproof the foundation
		New - Given	First	You	grade for the lawn	after you	build the frame
			Last	Before you	grade for the lawn	you	build the frame
	Far	Given - Given	First	You	remove the dumpsters	after you	build the frame
			Last	Before you	remove the dumpsters	you	build the frame
		Given - New	First	You	build the frame	after you	order dumpster
			Last	Before you	build the frame	you	order dumpster
		New - Given	First	You	install the garbage disposal	after you	build the frame
			Last	Before you	install the garbage disposal	you	build the frame

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Match (3. attach the exterior siding)			
Causal	Near	Given - Given	First	You	attach the exterior siding	before you	attach the drywall
			Last	After you	attach the exterior siding	you	attach the drywall
		Given - New	First	You	attach the exterior siding	before you	install exterior trim
			Last	After you	attach the exterior siding	you	install exterior trim
		New - Given	First	You	place the foundation forms	before you	attach the exterior siding
			Last	After you	place the foundation forms	you	attach the exterior siding
	Far	Given - Given	First	You	attach the exterior siding	before you	install the downspouts
			Last	After you	attach the exterior siding	you	install the downspouts
		Given - New	First	You	attach the exterior siding	before you	attach the shutters
			Last	After you	attach the exterior siding	you	attach the shutters
		New - Given	First	You	backfill around the foundation	before you	attach the exterior siding
			Last	After you	backfill around the foundation	you	attach the exterior siding
Social	Near	Given - Given	First	You	attach the exterior siding	before you	install the vinyl floor
			Last	After you	attach the exterior siding	you	install the vinyl floor
		Given - New	First	You	attach the exterior siding	before you	build the deck
			Last	After you	attach the exterior siding	you	build the deck
		New - Given	First	You	hook up the sewer	before you	attach the exterior siding
			Last	After you	hook up the sewer	you	attach the exterior siding
	Far	Given - Given	First	You	attach the exterior siding	before you	install the baseboards
			Last	After you	attach the exterior siding	you	install the baseboards
		Given - New	First	You	attach the exterior siding	before you	apply the wallpaper
			Last	After you	attach the exterior siding	you	apply the wallpaper
		New - Given	First	You	purchase the lot	before you	attach the exterior siding
			Last	After you	purchase the lot	you	attach the exterior siding

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Mismatch (3. attach the exterior siding)			
Causal	Near	Given - Given	First	You	attach the drywall	after you	attach the exterior siding
			Last	Before you	attach the drywall	you	attach the exterior siding
		Given - New	First	You	attach the exterior siding	after you	place the foundation forms
			Last	Before you	attach the exterior siding	you	place the foundation forms
		New - Given	First	You	install exterior trim	after you	attach the exterior siding
			Last	Before you	install exterior trim	you	attach the exterior siding
	Far	Given - Given	First	You	install the downspouts	after you	attach the exterior siding
			Last	Before you	install the downspouts	you	attach the exterior siding
		Given - New	First	You	attach the exterior siding	after you	backfill around the foundation
			Last	Before you	attach the exterior siding	you	backfill around the foundation
		New - Given	First	You	install the downspouts	after you	attach the exterior siding
			Last	Before you	attach the shutters	you	attach the exterior siding
Social	Near	Given - Given	First	You	install the vinyl floor	after you	attach the exterior siding
			Last	Before you	install the vinyl floor	you	attach the exterior siding
		Given - New	First	You	attach the exterior siding	after you	hook up the sewer
			Last	Before you	attach the exterior siding	you	hook up the sewer
		New - Given	First	You	build the deck	after you	attach the exterior siding
			Last	Before you	build the deck	you	attach the exterior siding
	Far	Given - Given	First	You	install the baseboards	after you	attach the exterior siding
			Last	Before you	install the baseboards	you	attach the exterior siding
		Given - New	First	You	attach the exterior siding	after you	purchase the lot
			Last	Before you	attach the exterior siding	you	purchase the lot
		New - Given	First	You	apply the wallpaper	after you	attach the exterior siding
			Last	Before you	apply the wallpaper	you	attach the exterior siding

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Match (4. install the floor joists)			
Causal	Near	Given - Given	First	You	install the floor joists	before you	frame the interior walls
			Last	After you	install the floor joists	you	frame the interior walls
		Given - New	First	You	install the floor joists	before you	install the exterior doors
			Last	After you	install the floor joists	you	install the exterior doors
		New - Given	First	You	schedule the excavation	before you	install the floor joists
			Last	After you	schedule the excavation	you	install the floor joists
	Far	Given - Given	First	You	install the floor joists	before you	install the carpet
			Last	After you	install the floor joists	you	install the carpet
		Given - New	First	You	install the floor joists	before you	install the interior doors
			Last	After you	install the floor joists	you	install the interior doors
		New - Given	First	You	stake the homesite	before you	install the floor joists
			Last	After you	stake the homesite	you	install the floor joists
Social	Near	Given - Given	First	You	install the floor joists	before you	deliver the roofing material
			Last	After you	install the floor joists	you	deliver the roofing material
		Given - New	First	You	install the floor joists	before you	deliver the windows
			Last	After you	install the floor joists	you	deliver the windows
		New - Given	First	You	order dumpster	before you	install the floor joists
			Last	After you	order dumpster	you	install the floor joists
	Far	Given - Given	First	You	install the floor joists	before you	order the tile
			Last	After you	install the floor joists	you	order the tile
		Given - New	First	You	install the floor joists	before you	pour the concrete driveway
			Last	After you	install the floor joists	you	pour the concrete driveway
		New - Given	First	You	hook up the sewer	before you	install the floor joists
			Last	After you	hook up the sewer	you	install the floor joists

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Mismatch (4. install the floor joists)			
Causal	Near	Given - Given	First	You	frame the interior walls	after you	install the floor joists
			Last	Before you	frame the interior walls	you	install the floor joists
		Given - New	First	You	install the floor joists	after you	schedule the excavation
			Last	Before you	install the floor joists	you	schedule the excavation
		New - Given	First	You	install the exterior doors	after you	install the floor joists
			Last	Before you	install the exterior doors	you	install the floor joists
	Far	Given - Given	First	You	install the carpet	after you	install the floor joists
			Last	Before you	install the carpet	you	install the floor joists
		Given - New	First	You	install the floor joists	after you	stake the homesite
			Last	Before you	install the floor joists	you	stake the homesite
		New - Given	First	You	install the interior doors	after you	install the floor joists
			Last	Before you	install the interior doors	you	install the floor joists
Social	Near	Given - Given	First	You	deliver the roofing material	after you	install the floor joists
			Last	Before you	deliver the roofing material	you	install the floor joists
		Given - New	First	You	install the floor joists	after you	order dumpster
			Last	Before you	install the floor joists	you	order dumpster
		New - Given	First	You	deliver the windows	after you	install the floor joists
			Last	Before you	deliver the windows	you	install the floor joists
	Far	Given - Given	First	You	order the tile	after you	install the floor joists
			Last	Before you	order the tile	you	install the floor joists
		Given - New	First	You	install the floor joists	after you	hook up the sewer
			Last	Before you	install the floor joists	you	hook up the sewer
		New - Given	First	You	pour the concrete driveway	after you	install the floor joists
			Last	Before you	pour the concrete driveway	you	install the floor joists

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Match (5. construct the roof)			
Causal	Near	Given - Given	First	You	construct the roof	before you	install the shingles
			Last	After you	construct the roof	you	install the shingles
		Given - New	First	You	construct the roof	before you	install the attic vents
			Last	After you	construct the roof	you	install the attic vents
		New - Given	First	You	deliver the lumber	before you	construct the roof
			Last	After you	deliver the lumber	you	construct the roof
	Far	Given - Given	First	You	construct the roof	before you	install the gutters
			Last	After you	construct the roof	you	install the gutters
		Given - New	First	You	construct the roof	before you	plaster the ceilings
			Last	After you	construct the roof	you	plaster the ceilings
		New - Given	First	You	clear the trees	before you	construct the roof
			Last	After you	clear the trees	you	construct the roof
Social	Near	Given - Given	First	You	construct the roof	before you	install the windows
			Last	After you	construct the roof	you	install the windows
		Given - New	First	You	construct the roof	before you	deliver the furnace
			Last	After you	construct the roof	you	deliver the furnace
		New - Given	First	You	backfill around the foundation	before you	construct the roof
			Last	After you	backfill around the foundation	you	construct the roof
	Far	Given - Given	First	You	construct the roof	before you	plant the shrubs
			Last	After you	construct the roof	you	plant the shrubs
		Given - New	First	You	construct the roof	before you	install the water softener
			Last	After you	construct the roof	you	install the water softener
		New - Given	First	You	build access road	before you	construct the roof
			Last	After you	build access road	you	construct the roof

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Mismatch (5. construct the roof)			
Causal	Near	Given - Given	First	You	install the shingles	after you	construct the roof
			Last	Before you	install the shingles	you	construct the roof
		Given - New	First	You	construct the roof	after you	deliver the lumber
			Last	Before you	construct the roof	you	deliver the lumber
		New - Given	First	You	install the attic vents	after you	construct the roof
			Last	Before you	install the attic vents	you	construct the roof
	Far	Given - Given	First	You	install the gutters	after you	construct the roof
			Last	Before you	install the gutters	you	construct the roof
		Given - New	First	You	construct the roof	after you	clear the trees
			Last	Before you	construct the roof	you	clear the trees
		New - Given	First	You	plaster the ceilings	after you	construct the roof
			Last	Before you	plaster the ceilings	you	construct the roof
Social	Near	Given - Given	First	You	install the windows	after you	construct the roof
			Last	Before you	install the windows	you	construct the roof
		Given - New	First	You	construct the roof	after you	backfill around the foundation
			Last	Before you	construct the roof	you	backfill around the foundation
		New - Given	First	You	deliver the furnace	after you	construct the roof
			Last	Before you	deliver the furnace	you	construct the roof
	Far	Given - Given	First	You	plant the shrubs	after you	construct the roof
			Last	Before you	plant the shrubs	you	construct the roof
		Given - New	First	You	construct the roof	after you	build access road
			Last	Before you	construct the roof	you	build access road
		New - Given	First	You	install the water softener	after you	construct the roof
			Last	Before you	install the water softener	you	construct the roof

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Match (6. attach the drywall)			
Causal	Near	Given - Given	First	You	attach the drywall	before you	prime the walls
			Last	After you	attach the drywall	you	prime the walls
		Given - New	First	You	attach the drywall	before you	plaster the ceilings
			Last	After you	attach the drywall	you	plaster the ceilings
		New - Given	First	You	install wall insulation	before you	attach the drywall
			Last	After you	install wall insulation	you	attach the drywall
	Far	Given - Given	First	You	attach the drywall	before you	install the baseboards
			Last	After you	attach the drywall	you	install the baseboards
		Given - New	First	You	attach the drywall	before you	install the light fixtures
			Last	After you	attach the drywall	you	install the light fixtures
		New - Given	First	You	pour the foundation	before you	attach the drywall
			Last	After you	pour the foundation	you	attach the drywall
Social	Near	Given - Given	First	You	attach the drywall	before you	deliver interior trim
			Last	After you	attach the drywall	you	deliver interior trim
		Given - New	First	You	attach the drywall	before you	install the interior doors
			Last	After you	attach the drywall	you	install the interior doors
		New - Given	First	You	install the exterior doors	before you	attach the drywall
			Last	After you	install the exterior doors	you	attach the drywall
	Far	Given - Given	First	You	attach the drywall	before you	install the faucets
			Last	After you	attach the drywall	you	install the faucets
		Given - New	First	You	attach the drywall	before you	install the carpet
			Last	After you	attach the drywall	you	install the carpet
		New - Given	First	You	waterproof the foundation	before you	attach the drywall
			Last	After you	waterproof the foundation	you	attach the drywall

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Mismatch (6. attach the drywall)			
Causal	Near	Given - Given	First	You	prime the walls	after you	attach the drywall
			Last	Before you	prime the walls	you	attach the drywall
		Given - New	First	You	attach the drywall	after you	install wall insulation
			Last	Before you	attach the drywall	you	install wall insulation
		New - Given	First	You	plaster the ceilings	after you	attach the drywall
			Last	Before you	plaster the ceilings	you	attach the drywall
	Far	Given - Given	First	You	install the baseboards	after you	attach the drywall
			Last	Before you	install the baseboards	you	attach the drywall
		Given - New	First	You	attach the drywall	after you	pour the foundation
			Last	Before you	attach the drywall	you	pour the foundation
		New - Given	First	You	install the light fixtures	after you	attach the drywall
			Last	Before you	install the light fixtures	you	attach the drywall
Social	Near	Given - Given	First	You	deliver interior trim	after you	attach the drywall
			Last	Before you	deliver interior trim	you	attach the drywall
		Given - New	First	You	attach the drywall	after you	install the exterior doors
			Last	Before you	attach the drywall	you	install the exterior doors
		New - Given	First	You	install the interior doors	after you	attach the drywall
			Last	Before you	install the interior doors	you	attach the drywall
	Far	Given - Given	First	You	install the faucets	after you	attach the drywall
			Last	Before you	install the faucets	you	attach the drywall
		Given - New	First	You	attach the drywall	after you	waterproof the foundation
			Last	Before you	attach the drywall	you	waterproof the foundation
		New - Given	First	You	install the carpet	after you	attach the drywall
			Last	Before you	install the carpet	you	attach the drywall

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Match (7. run the rough wiring)			
Causal	Near	Given - Given	First	You	run the rough wiring	before you	connect the switches
			Last	After you	run the rough wiring	you	connect the switches
		Given - New	First	You	run the rough wiring	before you	connect the electrical outlets
			Last	After you	run the rough wiring	you	connect the electrical outlets
		New - Given	First	You	frame the interior walls	before you	run the rough wiring
			Last	After you	frame the interior walls	you	run the rough wiring
	Far	Given - Given	First	You	run the rough wiring	before you	install the light fixtures
			Last	After you	run the rough wiring	you	install the light fixtures
		Given - New	First	You	run the rough wiring	before you	install the dishwasher
			Last	After you	run the rough wiring	you	install the dishwasher
		New - Given	First	You	deliver the lumber	before you	run the rough wiring
			Last	After you	deliver the lumber	you	run the rough wiring
Social	Near	Given - Given	First	You	run the rough wiring	before you	attach the exterior siding
			Last	After you	run the rough wiring	you	attach the exterior siding
		Given - New	First	You	run the rough wiring	before you	install wall insulation
			Last	After you	run the rough wiring	you	install wall insulation
		New - Given	First	You	install the furnace	before you	run the rough wiring
			Last	After you	install the furnace	you	run the rough wiring
	Far	Given - Given	First	You	run the rough wiring	before you	install the vinyl floor
			Last	After you	run the rough wiring	you	install the vinyl floor
		Given - New	First	You	run the rough wiring	before you	lay the sod
			Last	After you	run the rough wiring	you	lay the sod
		New - Given	First	You	connect temporary electric	before you	run the rough wiring
			Last	After you	connect temporary electric	you	run the rough wiring

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Mismatch (7. run the rough wiring)			
Causal	Near	Given - Given	First	You	connect the switches	after you	run the rough wiring
			Last	Before you	connect the switches	you	run the rough wiring
		Given - New	First	You	run the rough wiring	after you	frame the interior walls
			Last	Before you	run the rough wiring	you	frame the interior walls
		New - Given	First	You	connect the electrical outlets	after you	run the rough wiring
			Last	Before you	connect the electrical outlets	you	run the rough wiring
	Far	Given - Given	First	You	install the light fixtures	after you	run the rough wiring
			Last	Before you	install the light fixtures	you	run the rough wiring
		Given - New	First	You	run the rough wiring	after you	deliver the lumber
			Last	Before you	run the rough wiring	you	deliver the lumber
		New - Given	First	You	install the dishwasher	after you	run the rough wiring
			Last	Before you	install the dishwasher	you	run the rough wiring
Social	Near	Given - Given	First	You	attach the exterior siding	after you	run the rough wiring
			Last	Before you	attach the exterior siding	you	run the rough wiring
		Given - New	First	You	run the rough wiring	after you	install the furnace
			Last	Before you	run the rough wiring	you	install the furnace
		New - Given	First	You	install wall insulation	after you	run the rough wiring
			Last	Before you	install wall insulation	you	run the rough wiring
	Far	Given - Given	First	You	install the vinyl floor	after you	run the rough wiring
			Last	Before you	install the vinyl floor	you	run the rough wiring
		Given - New	First	You	run the rough wiring	after you	connect temporary electric
			Last	Before you	run the rough wiring	you	connect temporary electric
		New - Given	First	You	lay the sod	after you	run the rough wiring
			Last	Before you	lay the sod	you	run the rough wiring

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Match (8. install the ductwork)			
Causal	Near	Given - Given	First	You	install the ductwork	before you	test the heating system
			Last	After you	install the ductwork	you	test the heating system
		Given - New	First	You	install the ductwork	before you	apply the wallpaper
			Last	After you	install the ductwork	you	apply the wallpaper
		New - Given	First	You	deliver ductwork	before you	install the ductwork
			Last	After you	deliver ductwork	you	install the ductwork
	Far	Given - Given	First	You	install the ductwork	before you	install the cabinets
			Last	After you	install the ductwork	you	install the cabinets
		Given - New	First	You	install the ductwork	before you	blow in the attic insulation
			Last	After you	install the ductwork	you	blow in the attic insulation
		New - Given	First	You	place the foundation forms	before you	install the ductwork
			Last	After you	place the foundation forms	you	install the ductwork
Social	Near	Given - Given	First	You	install the ductwork	before you	run the rough wiring
			Last	After you	install the ductwork	you	run the rough wiring
		Given - New	First	You	install the ductwork	before you	install the hardwood floor
			Last	After you	install the ductwork	you	install the hardwood floor
		New - Given	First	You	apply the roof felt	before you	install the ductwork
			Last	After you	apply the roof felt	you	install the ductwork
	Far	Given - Given	First	You	install the ductwork	before you	build the bookshelves
			Last	After you	install the ductwork	you	build the bookshelves
		Given - New	First	You	install the ductwork	before you	install the range
			Last	After you	install the ductwork	you	install the range
		New - Given	First	You	backfill around the foundation	before you	install the ductwork
			Last	After you	backfill around the foundation	you	install the ductwork

Semantic Constraint	Psychological Distance	Discourse Order	Main Clause	Absolute Time Mismatch (8. install the ductwork)			
Causal	Near	Given - Given	First	You	test the heating system	after you	install the ductwork
			Last	Before you	test the heating system	you	install the ductwork
		Given - New	First	You	install the ductwork	after you	deliver ductwork
			Last	Before you	install the ductwork	you	deliver ductwork
		New - Given	First	You	apply the wallpaper	after you	install the ductwork
			Last	Before you	apply the wallpaper	you	install the ductwork
	Far	Given - Given	First	You	install the cabinets	after you	install the ductwork
			Last	Before you	install the cabinets	you	install the ductwork
		Given - New	First	You	install the ductwork	after you	place the foundation forms
			Last	Before you	install the ductwork	you	place the foundation forms
		New - Given	First	You	blow in the attic insulation	after you	install the ductwork
			Last	Before you	blow in the attic insulation	you	install the ductwork
Social	Near	Given - Given	First	You	run the rough wiring	after you	install the ductwork
			Last	Before you	run the rough wiring	you	install the ductwork
		Given - New	First	You	install the ductwork	after you	apply the roof felt
			Last	Before you	install the ductwork	you	apply the roof felt
		New - Given	First	You	install the hardwood floor	after you	install the ductwork
			Last	Before you	install the hardwood floor	you	install the ductwork
	Far	Given - Given	First	You	build the bookshelves	after you	install the ductwork
			Last	Before you	build the bookshelves	you	install the ductwork
		Given - New	First	You	install the ductwork	after you	backfill around the foundation
			Last	Before you	install the ductwork	you	backfill around the foundation
		New - Given	First	You	install the range	after you	install the ductwork
			Last	Before you	install the range	you	install the ductwork

APPENDIX E

Omnibus ANOVA Using Raw Scores: Subject Means (Missing Scores Replaced with Subject Means).

Source	DF	SS	MS	F	Pr > F
REP	1	76.92	76.92	0.72	0.3994
Error	62	6624.32	106.84		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO	2	137.11	68.56	8.35	0.0004	0.0008	0.0006	**
DISCO*REP	2	7.60	3.80	0.46	0.6308	0.6040	0.6121	
Error(DISCO)	124	1018.31	8.21					

Source	DF	SS	MS	F	Pr > F
ICON	1	13.17	13.17	1.91	0.1716
ICON*REP	1	14.11	14.11	2.05	0.1572
Error(ICON)	62	426.80	6.88		

Source	DF	SS	MS	F	Pr > F
DIS	1	14.13	14.13	1.54	0.2198
DIS*REP	1	4.59	4.59	0.50	0.4826
Error(DIS)	62	570.13	9.20		

Source	DF	SS	MS	F	Pr > F
CLAUSE	1	15.56	15.56	2.07	0.1554
CLAUSE*REP	1	8.87	8.87	1.18	0.2817
Error(CLAUSE)	62	466.39	7.52		

Source	DF	SS	MS	F	Pr > F	
SEMREL	1	197.10	197.10	24.27	<.0001	**
SEMREL*REP	1	0.12	0.12	0.01	0.9051	
Error(SEMREL)	62	503.45	8.12			

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON	2	4.96	2.48	0.39	0.6782	0.6719	0.6782
DISCO*ICON*REP	2	12.66	6.33	1.00	0.3726	0.3707	0.3726
Error(DISCO*ICON)	124	788.87	6.36				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS	2	21.41	10.71	1.22	0.2998	0.2993	0.2998
DISCO*DIS*REP	2	22.40	11.20	1.27	0.2838	0.2835	0.2838
Error(DISCO*DIS)	124	1091.58	8.80				

Source	DF	SS	MS	F	Pr > F
ICON*DIS	1	1.97	1.97	0.28	0.5994
ICON*DIS*REP	1	5.84	5.84	0.82	0.3673
Error(ICON*DIS)	62	439.14	7.08		

Source	DF	SS	MS	F	Pr > F	G - G	H - F

DISCO*CLAUSE	2	39.54	19.77	2.41	0.0942	0.0945	0.0942
DISCO*CLAUSE*REP	2	5.37	2.68	0.33	0.7219	0.7208	0.7219
Error(DISCO*CLAUSE)	124	1018.07	8.21				

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE	1	101.48	101.48	12.73	0.0007	**
ICON*CLAUSE*REP	1	0.21	0.21	0.03	0.8703	
Error(ICON*CLAUSE)	62	494.10	7.97			

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE	1	3.23	3.23	0.31	0.5788
DIS*CLAUSE*REP	1	33.40	33.40	3.22	0.0775
Error(DIS*CLAUSE)	62	642.48	10.36		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*SEMREL	2	25.03	12.51	1.78	0.1731	0.1732	0.1731
DISCO*SEMREL*REP	2	33.27	16.64	2.37	0.0981	0.0983	0.0981
Error(DISCO*SEMREL)	124	872.20	7.03				

Source	DF	SS	MS	F	Pr > F
ICON*SEMREL	1	1.31	1.31	0.23	0.6337
ICON*SEMREL*REP	1	5.31	5.31	0.93	0.3391
Error(ICON*SEMREL)	62	354.56	5.72		

Source	DF	SS	MS	F	Pr > F	
DIS*SEMREL	1	36.27	36.27	6.75	0.0117	*
DIS*SEMREL*REP	1	1.69	1.69	0.32	0.5766	
Error(DIS*SEMREL)	62	333.25	5.38			

Source	DF	SS	MS	F	Pr > F	
CLAUSE*SEMREL	1	2.14	2.14	0.58	0.4475	
CLAUSE*SEMREL*REP	1	17.97	17.97	4.90	0.0306	*
Error(CLAUSE*SEMREL)	62	227.54	3.67			

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*DIS	2	13.18	6.59	0.64	0.5267	0.4996	0.5055
DISCO*ICON*DIS*REP	2	9.57	4.78	0.47	0.6275	0.5925	0.6002
Error(DISCO*ICON*DIS)	124	1268.14	10.23				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*CLAUSE	2	16.41	8.21	1.35	0.2637	0.2620	0.2625
DISCO*ICON*CLAUSE*REP	2	0.10	0.05	0.01	0.9917	0.9812	0.9836
Error(DISCO*ICON*CLAUSE)	124	755.16	6.09				

Source	DF	SS	MS	F	Pr > F
DISCO*DIS*CLAUSE	2	18.61	9.31	1.08	0.3434
DISCO*DIS*CLAUSE*REP	2	20.61	10.31	1.19	0.3065
Error(DISCO*DIS*CLAUSE)	124	1070.45	8.63		

Source	DF	SS	MS	F	Pr > F

ICON*DIS*CLAUSE	1	0.01	0.01	0.00	0.9802
ICON*DIS*CLAUSE*REP	1	5.69	5.69	0.50	0.4808
Error(ICON*DIS*CLAUSE)	62	701.34	11.31		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*ICON*SEMREL	2	119.97	59.99	11.89	<.0001	<.0001	<.0001	**
DISCO*ICON*SEMREL*REP	2	4.09	2.04	0.40	0.6679	0.6675	0.6679	
Error(DISCO*ICON*SEMREL)	124	625.66	5.05					

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS*SEMREL	2	18.80	9.40	1.43	0.2426	0.2426	0.2426
DISCO*DIS*SEMREL*REP	2	0.99	0.49	0.08	0.9274	0.9271	0.9274
Error(DISCO*DIS*SEMREL)	124	813.49	6.56				

Source	DF	SS	MS	F	Pr > F
ICON*DIS*SEMREL	1	2.34	2.34	0.52	0.4737
ICON*DIS*SEMREL*REP	1	0.00	0.00	0.00	0.9880
Error(ICON*DIS*SEMREL)	62	279.08	4.50		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*CLAUSE*SEMREL	2	78.11	39.05	5.02	0.0080	0.0081	0.0080	**
DISCO*CLAUSE*SEMREL*REP	2	10.39	5.20	0.67	0.5145	0.5136	0.5145	
Error(DISCO*CLAUSE*SEMREL)	124	964.51	7.78					

Source	DF	SS	MS	F	Pr > F
ICON*CLAUSE*SEMREL	1	0.38	0.38	0.05	0.8266
ICON*CLAUSE*SEMREL*REP	1	6.77	6.77	0.87	0.3552
Error(ICON*CLAUSE*SEMREL)	62	483.59	7.80		

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE*SEMREL	1	0.05	0.05	0.01	0.9361
DIS*CLAUSE*SEMREL*REP	1	0.41	0.41	0.05	0.8154
Error(DIS*CLAUSE*SEMREL)	62	459.12	7.41		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ICON*DIS*CLAU	2	1.04	0.52	0.06	0.9461	0.9222	0.9285
DISC*ICON*DIS*CLAU*REP	2	5.14	2.57	0.27	0.7605	0.7233	0.7325
Error(DISC*ICON*DIS*CLAU)	124	1162.27	9.37				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ICON*DIS*SEMR	2	22.67	11.33	1.62	0.2026	0.2031	0.2026
DISC*ICON*DIS*SEMR*REP	2	31.81	15.90	2.27	0.1077	0.1087	0.1077
Error(DISC*ICON*DIS*SEMR)	124	869.08	7.01				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ICON*CLAU*SEMR	2	18.31	9.15	1.34	0.2661	0.2660	0.2661
DISC*ICON*CLAU*SEMR*REP	2	5.61	2.80	0.41	0.6645	0.6639	0.6645
Error(ICON*ORDC*CLAU*SEMR)	124	848.16	6.84				

Source	DF	SS	MS	F	Pr > F	G - G	H - F

DISC*DIS*CLAU*SEMR	2	38.51	19.25	2.18	0.1170	0.1184	0.1170
DISC*DIS*CLAU*SEMR*REP	2	0.49	0.24	0.03	0.9727	0.9705	0.9727
Error(DISC*DIS*CLAU*SEMR)	124	1093.45	8.82				

Source	DF	SS	MS	F	Pr > F
ICON*DIS*CLAU*SEMR	1	0.16	0.16	0.02	0.8777
ICON*DIS*CLAU*SEMR*REP	1	6.67	6.67	0.98	0.3268
Error(ICON*DIS*CLAU*SEMR)	62	423.44	6.83		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DIS*ICO*DIS*CLA*SEM	2	13.29	6.65	0.66	0.5200	0.5004	0.5065
DIS*ICO*DIS*CLA*SEM*REP	2	5.76	2.88	0.28	0.7526	0.7226	0.7320
Error(DIS*ICO*DIS*CLA*SEM)	124	1253.49	10.11				

APPENDIX F

Omnibus ANOVA Using Raw Scores: Condition Means (Missing Scores Replaced with Condition Means).

Source	DF	SS	MS	F	Pr > F
REP	1	59.27	59.27	0.69	0.4105
Error	62	5351.66	86.32		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO	2	187.09	93.55	10.33	<.0001	0.0002	0.0002	**
DISCO*REP	2	4.88	2.44	0.27	0.7640	0.7238	0.7328	
Error(DISCO)	124	1122.41	9.05					

Source	DF	SS	MS	F	Pr > F
ICON	1	17.52	17.52	2.56	0.1145
ICON*REP	1	10.54	10.54	1.54	0.2191
Error(ICON)	62	423.84	6.84		

Source	DF	SS	MS	F	Pr > F
DIS	1	11.59	11.59	1.20	0.2781
DIS*REP	1	4.70	4.70	0.49	0.4884
Error(DIS)	62	599.93	9.68		

Source	DF	SS	MS	F	Pr > F
CLAUSE	1	12.73	12.73	1.77	0.1886
CLAUSE*REP	1	5.73	5.73	0.79	0.3761
Error(CLAUSE)	62	446.63	7.20		

Source	DF	SS	MS	F	Pr > F	
SEMREL	1	205.96	205.96	20.16	<.0001	**
SEMREL*REP	1	2.98	2.98	0.29	0.5909	
Error(SEMREL)	62	633.35	10.22			

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON	2	3.58	1.79	0.26	0.7726	0.7689	0.7726
DISCO*ICON*REP	2	12.08	6.04	0.87	0.4204	0.4188	0.4204
Error(DISCO*ICON)	124	858.07	6.92				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS	2	26.15	13.07	1.42	0.2460	0.2462	0.2460
DISCO*DIS*REP	2	30.96	15.48	1.68	0.1906	0.1917	0.1906
Error(DISCO*DIS)	124	1142.90	9.22				

Source	DF	SS	MS	F	Pr > F
ICON*DIS	1	5.01	5.01	0.66	0.4205
ICON*DIS*REP	1	4.30	4.30	0.57	0.4550
Error(ICON*DIS)	62	472.28	7.62		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*CLAUSE	2	43.63	21.81	2.48	0.0875	0.0876	0.0875	
DISCO*CLAUSE*REP	2	4.17	2.08	0.24	0.7891	0.7885	0.7891	
Error(DISCO*CLAUSE)	124	1088.54	8.78					

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE	1	145.73	145.73	17.23	0.0001	**
ICON*CLAUSE*REP	1	0.02	0.02	0.00	0.9598	
Error(ICON*CLAUSE)	62	524.54	8.46			

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE	1	3.59	3.59	0.35	0.5590
DIS*CLAUSE*REP	1	34.38	34.38	3.30	0.0741
Error(DIS*CLAUSE)	62	645.63	10.41		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*SEMREL	2	41.70	20.85	3.12	0.0475	0.0479	0.0475	*
DISCO*SEMREL*REP	2	33.85	16.93	2.54	0.0833	0.0837	0.0833	
Error(DISCO*SEMREL)	124	827.77	6.68					

Source	DF	SS	MS	F	Pr > F
ICON*SEMREL	1	5.33	5.33	0.83	0.3656
ICON*SEMREL*REP	1	6.14	6.14	0.96	0.3315
Error(ICON*SEMREL)	62	397.57	6.41		

Source	DF	SS	MS	F	Pr > F	
DIS*SEMREL	1	54.27	54.27	9.87	0.0026	**
DIS*SEMREL*REP	1	3.41	3.41	0.62	0.4339	
Error(DIS*SEMREL)	62	340.97	5.50			

Source	DF	SS	MS	F	Pr > F	
CLAUSE*SEMREL	1	2.30	2.30	0.52	0.4715	
CLAUSE*SEMREL*REP	1	25.85	25.85	5.90	0.0180	*
Error(CLAUSE*SEMREL)	62	271.57	4.38			

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*DIS	2	21.19	10.60	1.08	0.3434	0.3347	0.3368
DISCO*ICON*DIS*REP	2	9.27	4.64	0.47	0.6250	0.5916	0.5993
Error(DISCO*ICON*DIS)	124	1218.79	9.83				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*CLAUSE	2	22.71	11.36	1.86	0.1596	0.1645	0.1628
DISCO*ICON*CLAUSE*REP	2	0.36	0.18	0.03	0.9713	0.9598	0.9643
Error(DISCO*ICON*CLAUSE)	124	756.13	6.10				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS*CLAUSE	2	19.77	9.88	1.18	0.3097	0.3078	0.3092
DISCO*DIS*CLAUSE*REP	2	18.55	9.28	1.11	0.3326	0.3300	0.3319
Error(DISCO*DIS*CLAUSE)	124	1035.80	8.35				

Source	DF	SS	MS	F	Pr > F
ICON*DIS*CLAUSE	1	0.95	0.95	0.08	0.7767
ICON*DIS*CLAUSE*REP	1	2.78	2.78	0.24	0.6288
Error(ICON*DIS*CLAUSE)	62	729.02	11.76		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*ICON*SEMREL	2	141.03	70.52	12.58	<.0001	<.0001	<.0001	**
DISCO*ICON*SEMREL*REP	2	5.15	2.58	0.46	0.6325	0.6308	0.6325	
Error(DISCO*ICON*SEMREL)	124	694.83	5.60					

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS*SEMREL	2	16.45	8.22	1.15	0.3190	0.3189	0.3190
DISCO*DIS*SEMREL*REP	2	1.01	0.51	0.07	0.9316	0.9308	0.9316
Error(DISCO*DIS*SEMREL)	124	884.36	7.13				

Source	DF	SS	MS	F	Pr > F
ICON*DIS*SEMREL	1	2.21	2.21	0.51	0.4789
ICON*DIS*SEMREL*REP	1	0.05	0.05	0.01	0.9124
Error(ICON*DIS*SEMREL)	62	269.48	4.35		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*CLAUSE*SEMREL	2	76.37	38.18	5.25	0.0065	0.0068	0.0065	**
DISCO*CLAUSE*SEMREL*REP	2	10.78	5.39	0.74	0.4785	0.4761	0.4785	
Error(DISCO*CLAUSE*SEMREL)	124	901.30	7.27					

Source	DF	SS	MS	F	Pr > F
ICON*CLAUSE*SEMREL	1	4.07	4.07	0.45	0.5067
ICON*CLAUSE*SEMREL*REP	1	7.22	7.22	0.79	0.3775
Error(ICON*CLAUSE*SEMREL)	62	566.48	9.14		

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE*SEMREL	1	0.00	0.00	0.00	0.9799
DIS*CLAUSE*SEMREL*REP	1	0.32	0.32	0.05	0.8320
Error(DIS*CLAUSE*SEMREL)	62	434.83	7.01		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ICON*DIS*CLAU	2	1.57	0.78	0.08	0.9196	0.8924	0.8998
DISC*ICON*DIS*CLAU*REP	2	8.25	4.13	0.44	0.6436	0.6123	0.6203
Error(DISC*ICON*DIS*CLAU)	124	1156.94	9.33				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ICON*DIS*SEMR	2	30.16	15.08	2.16	0.1191	0.1198	0.1191
DISC*ICON*DIS*SEMR*REP	2	33.45	16.72	2.40	0.0948	0.0956	0.0948
Error(DISC*ICON*DIS*SEMR)	124	863.74	6.97				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ICON*CLAU*SEMR	2	23.71	11.86	1.72	0.1828	0.1828	0.1828
DISC*ICON*CLAU*SEMR*REP	2	9.80	4.90	0.71	0.4925	0.4924	0.4925
Error(DISC*ICON*CLAU*SEMR)	124	853.19	6.88				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*DIS*CLAU*SEMR	2	40.76	20.38	2.32	0.1026	0.1044	0.1026
DISC*DIS*CLAU*SEMR*REP	2	0.52	0.26	0.03	0.9711	0.9685	0.9711
Error(DISC*DIS*CLAU*SEMR)	124	1089.85	8.79				

Source	DF	SS	MS	F	Pr > F
ICON*DIS*CLAU*SEMR	1	1.49	1.49	0.22	0.6417
ICON*DIS*CLAU*SEMR*REP	1	4.85	4.85	0.71	0.4020
Error(ICON*DIS*CLAU*SEMR)	62	422.65	6.82		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DIS*ICO*DIS*CLA*SEM	2	12.15	6.08	0.63	0.5330	0.5131	0.5194
DIS*ICO*DIS*CLA*SEM*REP	2	14.22	7.11	0.74	0.4791	0.4627	0.4680
Error(DIS*ICO*DIS*CLA*SEM)	124	1191.34	9.61				

APPENDIX G

Omnibus ANOVA Raw Scores. (Regressed Means. Missing Scores Replaced through Regression Procedure).

Source	DF	SS	MS	F	Pr > F
REP	1	96.60	96.60	1.09	0.3010
Error	62	5506.63	88.82		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO	2	200.45	100.23	11.13	<.0001	0.0001	<.0001	**
DISCO*REP	2	4.71	2.36	0.26	0.7702	0.7311	0.7402	
Error(DISCO)	124	1116.43	9.00					

Source	DF	SS	MS	F	Pr > F
ICON	1	23.96	23.96	3.35	0.0720
ICON*REP	1	25.77	25.77	3.60	0.0623
Error(ICON)	62	443.32	7.15		

Source	DF	SS	MS	F	Pr > F
DIS	1	7.51	7.51	0.81	0.3728
DIS*REP	1	5.52	5.52	0.59	0.4446
Error(DIS)	62	577.84	9.32		

Source	DF	SS	MS	F	Pr > F
CLAUSE	1	18.32	18.32	2.62	0.1105
CLAUSE*REP	1	9.75	9.75	1.40	0.2419
Error(CLAUSE)	62	433.10	6.99		

Source	DF	SS	MS	F	Pr > F	
SEMREL	1	174.34	174.34	16.99	0.0001	**
SEMREL*REP	1	0.69	0.69	0.07	0.7957	
Error(SEMREL)	62	636.37	10.26			

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON	2	2.72	1.36	0.20	0.8219	0.8201	0.8219
DISCO*ICON*REP	2	16.85	8.43	1.22	0.2992	0.2990	0.2992
Error(DISCO*ICON)	124	857.59	6.92				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS	2	25.98	12.99	1.32	0.2704	0.2702	0.2704
DISCO*DIS*REP	2	35.26	17.63	1.79	0.1706	0.1720	0.1706
Error(DISCO*DIS)	124	1218.76	9.83				

Source	DF	SS	MS	F	Pr > F
ICON*DIS	1	4.84	4.84	0.64	0.4271
ICON*DIS*REP	1	3.04	3.04	0.40	0.5289
Error(ICON*DIS)	62	469.89	7.58		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*CLAUSE	2	33.46	16.73	1.91	0.1519	0.1521	0.1519	
DISCO*CLAUSE*REP	2	10.68	5.34	0.61	0.5444	0.5439	0.5444	
Error(DISCO*CLAUSE)	124	1084.19	8.74					

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE	1	190.59	190.59	22.18	<.0001	**
ICON*CLAUSE*REP	1	1.09	1.09	0.13	0.7224	
Error(ICON*CLAUSE)	62	532.75	8.59			

Source	DF	SS	MS	F	Pr > F	
DIS*CLAUSE	1	6.27	6.27	0.62	0.4334	
DIS*CLAUSE*REP	1	59.89	59.89	5.94	0.0177	*
Error(DIS*CLAUSE)	62	625.34	10.09			

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*SEMREL	2	37.29	18.65	2.79	0.0654	0.0657	0.0654	
DISCO*SEMREL*REP	2	53.78	26.89	4.02	0.0203	0.0205	0.0203	*
Error(DISCO*SEMREL)	124	829.23	6.69					

Source	DF	SS	MS	F	Pr > F
ICON*SEMREL	1	6.41	6.41	1.02	0.3157
ICON*SEMREL*REP	1	8.80	8.80	1.41	0.2403
Error(ICON*SEMREL)	62	388.24	6.26		

Source	DF	SS	MS	F	Pr > F	
DIS*SEMREL	1	69.01	69.01	11.96	0.0010	**
DIS*SEMREL*REP	1	0.69	0.69	0.12	0.7308	
Error(DIS*SEMREL)	62	357.71	5.77			

Source	DF	SS	MS	F	Pr > F
CLAUSE*SEMREL	1	0.70	0.70	0.15	0.6964
CLAUSE*SEMREL*REP	1	12.90	12.90	2.84	0.0968
Error(CLAUSE*SEMREL)	62	281.35	4.54		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*DIS	2	23.91	11.95	1.14	0.3221	0.3174	0.3191
DISCO*ICON*DIS*REP	2	17.34	8.67	0.83	0.4388	0.4260	0.4303
Error(DISCO*ICON*DIS)	124	1296.28	10.45				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*CLAUSE	2	21.00	10.50	1.71	0.1853	0.1884	0.1871
DISCO*ICON*CLAUSE*REP	2	0.47	0.23	0.04	0.9626	0.9519	0.9570
Error(DISCO*ICON*CLAUSE)	124	761.86	6.14				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS*CLAUSE	2	20.43	10.22	1.21	0.3011	0.2997	0.3008
DISCO*DIS*CLAUSE*REP	2	17.67	8.83	1.05	0.3538	0.3507	0.3532
Error(DISCO*DIS*CLAUSE)	124	1045.22	8.43				

Source	DF	SS	MS	F	Pr > F
ICON*DIS*CLAUSE	1	3.68	3.68	0.29	0.5909
ICON*DIS*CLAUSE*REP	1	15.84	15.84	1.26	0.2667
Error(ICON*DIS*CLAUSE)	62	781.85	12.61		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*ICON*SEMREL	2	149.80	74.90	12.60	<.0001	<.0001	<.0001	**
DISCO*ICON*SEMREL*REP	2	12.40	6.20	1.04	0.3555	0.3548	0.3555	
Error(DISCO*ICON*SEMREL)	124	737.32	5.95					

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS*SEMREL	2	15.38	7.69	1.09	0.3391	0.3389	0.3391
DISCO*DIS*SEMREL*REP	2	1.44	0.72	0.10	0.9029	0.9022	0.9029
Error(DISCO*DIS*SEMREL)	124	874.15	7.05				

Source	DF	SS	MS	F	Pr > F
ICON*DIS*SEMREL	1	3.54	3.54	0.77	0.3832
ICON*DIS*SEMREL*REP	1	2.03	2.03	0.44	0.5082
Error(ICON*DIS*SEMREL)	62	284.48	4.59		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*CLAUSE*SEMREL	2	85.91	42.96	6.07	0.0031	0.0033	0.0031	**
DISCO*CLAUSE*SEMREL*REP	2	19.71	9.85	1.39	0.2525	0.2526	0.2525	
Error(DISCO*CLAUSE*SEMREL)	124	878.00	7.08					

Source	DF	SS	MS	F	Pr > F
ICON*CLAUSE*SEMREL	1	8.92	8.92	0.98	0.3252
ICON*CLAUSE*SEMREL*REP	1	19.72	19.72	2.18	0.1452
Error(ICON*CLAUSE*SEMREL)	62	561.99	9.06		

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE*SEMREL	1	1.11	1.11	0.16	0.6950
DIS*CLAUSE*SEMREL*REP	1	0.00	0.00	0.00	0.9950
Error(DIS*CLAUSE*SEMREL)	62	442.82	7.14		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ORDC*DIS*CLAU	2	1.22	0.61	0.07	0.9363	0.9108	0.9176
DISC*ORDC*DIS*CLAU*REP	2	15.21	7.61	0.82	0.4432	0.4259	0.4302
Error(DISC*ORDC*DIS*CLAU)	124	1151.51	9.29				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ORDC*DIS*SEMR	2	26.24	13.12	1.88	0.1564	0.1569	0.1564
DISC*ORDC*DIS*SEMR*REP	2	38.94	19.47	2.79	0.0650	0.0656	0.0650
Error(DISC*ORDC*DIS*SEMR)	124	863.98	6.97				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ORDC*CLAU*SEMR	2	17.44	8.72	1.25	0.2908	0.2908	0.2908
DISC*ORDC*CLAU*SEMR*REP	2	15.07	7.53	1.08	0.3434	0.3434	0.3434
Error(DISC*ORDC*CLAU*SEMR)	124	866.51	6.99				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*DIS*CLAU*SEMR	2	39.10	19.55	2.29	0.1055	0.1066	0.1055
DISC*DIS*CLAU*SEMR*REP	2	3.92	1.96	0.23	0.7954	0.7915	0.7954
Error(DISC*DIS*CLAU*SEMR)	124	1058.65	8.54				

Source	DF	SS	MS	F	Pr > F
ORDC*DIS*CLAU*SEMR	1	7.19	7.19	1.06	0.3078
ORDC*DIS*CLAU*SEMR*REP	1	15.50	15.50	2.28	0.1362
Error(ORDC*DIS*CLAU*SEMR)	62	421.67	6.80		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DIS*ORD*DIS*CLA*SEM	2	10.79	5.40	0.58	0.5634	0.5400	0.5469
DIS*ORD*DIS*CLA*SEM*REP	2	16.82	8.41	0.90	0.4099	0.3977	0.4014
Error(DIS*ORD*DIS*CLA*SEM)	124	1160.92	9.36				

APPENDIX H

ANOVA Log scores: Subject Means (Missing Scores Replaced with Subject Means).

Source	DF	SS	MS	F	Pr > F
REP	1	1.39	1.39	0.61	0.4396
Error	62	141.91	2.29		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO	2	4.15	2.08	9.70	0.0001	0.0001	0.0001	**
DISCO*REP	2	0.31	0.15	0.71	0.4924	0.4914	0.4924	
Error(DISCO)	124	26.55	0.21					

Source	DF	SS	MS	F	Pr > F	
ICON	1	0.20	0.20	1.01	0.3182	
ICON*REP	1	0.79	0.79	4.01	0.0496	*
Error(ICON)	62	12.15	0.20			

Source	DF	SS	MS	F	Pr > F
DIS	1	0.54	0.54	2.43	0.1242
DIS*REP	1	0.01	0.01	0.04	0.8374
Error(DIS)	62	13.90	0.22		

Source	DF	SS	MS	F	Pr > F
CLAUSE	1	0.07	0.07	0.32	0.5741
CLAUSE*REP	1	0.03	0.03	0.13	0.7176
Error(CLAUSE)	62	12.86	0.21		

Source	DF	SS	MS	F	Pr > F	
SEMREL	1	2.60	2.60	13.05	0.0006	**
SEMREL*REP	1	0.02	0.02	0.12	0.7279	
Error(SEMREL)	62	12.34	0.20			

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON	2	0.09	0.05	0.24	0.7835	0.7613	0.7710
DISCO*ICON*REP	2	0.28	0.14	0.75	0.4763	0.4640	0.4693
Error(DISCO*ICON)	124	22.93	0.18				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS	2	1.00	0.50	2.41	0.0936	0.0959	0.0936
DISCO*DIS*REP	2	0.72	0.36	1.72	0.1827	0.1840	0.1827
Error(DISCO*DIS)	124	25.74	0.21				

Source	DF	SS	MS	F	Pr > F
ICON*DIS	1	0.15	0.15	0.67	0.4164
ICON*DIS*REP	1	0.47	0.47	2.16	0.1466
Error(ICON*DIS)	62	13.46	0.22		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*CLAUSE	2	1.24	0.62	2.98	0.0544	0.0557	0.0544

DISCO*CLAUSE*REP	2	0.01	0.00	0.02	0.9797	0.9781	0.9797
Error(DISCO*CLAUSE)	124	25.69	0.21				

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE	1	3.25	3.25	12.72	0.0007	**
ICON*CLAUSE*REP	1	0.04	0.04	0.16	0.6915	
Error(ICON*CLAUSE)	62	15.82	0.26			

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE	1	0.12	0.12	0.41	0.5233
DIS*CLAUSE*REP	1	0.27	0.27	0.93	0.3391
Error(DIS*CLAUSE)	62	17.76	0.29		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*SEMREL	2	0.48	0.24	1.14	0.3234	0.3233	0.3234
DISCO*SEMREL*REP	2	1.05	0.52	2.51	0.0852	0.0854	0.0852
Error(DISCO*SEMREL)	124	25.88	0.21				

Source	DF	SS	MS	F	Pr > F
ICON*SEMREL	1	0.22	0.22	1.19	0.2793
ICON*SEMREL*REP	1	0.00	0.00	0.00	0.9934
Error(ICON*SEMREL)	62	11.38	0.18		

Source	DF	SS	MS	F	Pr > F	
DIS*SEMREL	1	1.18	1.18	9.34	0.0033	**
DIS*SEMREL*REP	1	0.06	0.06	0.46	0.4985	
Error(DIS*SEMREL)	62	7.86	0.13			

Source	DF	SS	MS	F	Pr > F
CLAUSE*SEMREL	1	0.01	0.01	0.04	0.8417
CLAUSE*SEMREL*REP	1	0.36	0.36	2.73	0.1032
Error(CLAUSE*SEMREL)	62	8.22	0.13		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*DIS	2	0.08	0.04	0.17	0.8437	0.8221	0.8314
DISCO*ICON*DIS*REP	2	0.06	0.03	0.12	0.8854	0.8657	0.8743
Error(DISCO*ICON*DIS)	124	28.63	0.23				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*CLAUSE	2	0.29	0.14	0.71	0.4941	0.4716	0.4770
DISCO*ICON*CLAUSE*REP	2	0.00	0.00	0.01	0.9887	0.9790	0.9817
Error(DISCO*ICON*CLAUSE)	124	24.92	0.20				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS*CLAUSE	2	0.41	0.20	0.79	0.4557	0.4510	0.4557
DISCO*DIS*CLAUSE*REP	2	0.29	0.14	0.56	0.5736	0.5665	0.5736
Error(DISCO*DIS*CLAUSE)	124	31.79	0.26				

Source	DF	SS	MS	F	Pr > F
ICON*DIS*CLAUSE	1	0.09	0.09	0.32	0.5763

ICON*DIS*CLAUSE*REP	1	0.00	0.00	0.01	0.9254			
Error(ICON*DIS*CLAUSE)	62	17.99	0.29					

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*ICON*SEMREL	2	3.53	1.76	11.02	<.0001	<.0001	<.0001	**
DISCO*ICON*SEMREL*REP	2	0.05	0.03	0.17	0.8445	0.8381	0.8445	
Error(DISCO*ICON*SEMREL)	124	19.85	0.16					

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*DIS*SEMREL	2	1.33	0.66	3.92	0.0223	0.0224	0.0223	*
DISCO*DIS*SEMREL*REP	2	0.37	0.18	1.08	0.3426	0.3425	0.3426	
Error(DISCO*DIS*SEMREL)	124	20.98	0.17					

Source	DF	SS	MS	F	Pr > F
ICON*DIS*SEMREL	1	0.02	0.02	0.17	0.6807
ICON*DIS*SEMREL*REP	1	0.00	0.00	0.01	0.9048
Error(ICON*DIS*SEMREL)	62	8.46	0.14		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*CLAUSE*SEMREL	2	1.94	0.97	5.55	0.0049	0.0050	0.0049	**
DISCO*CLAUSE*SEMREL*REP	2	0.13	0.07	0.37	0.6887	0.6879	0.6887	
Error(DISCO*CLAUSE*SEMREL)	124	21.71	0.18					

Source	DF	SS	MS	F	Pr > F
ICON*CLAUSE*SEMREL	1	0.10	0.10	0.51	0.4798
ICON*CLAUSE*SEMREL*REP	1	0.10	0.10	0.50	0.4806
Error(ICON*CLAUSE*SEMREL)	62	12.64	0.20		

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE*SEMREL	1	0.05	0.05	0.28	0.5989
DIS*CLAUSE*SEMREL*REP	1	0.02	0.02	0.12	0.7253
Error(DIS*CLAUSE*SEMREL)	62	10.76	0.17		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ORDC*DIS*CLAU	2	0.03	0.01	0.06	0.9434	0.9309	0.9373
DISC*ORDC*DIS*CLAU*REP	2	0.42	0.21	0.90	0.4094	0.4018	0.4056
Error(DISC*ORDC*DIS*CLAU)	124	29.02	0.23				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ORDC*DIS*SEMR	2	0.63	0.32	1.44	0.2399	0.2407	0.2405
DISC*ORDC*DIS*SEMR*REP	2	0.57	0.29	1.31	0.2741	0.2726	0.2732
Error(DISC*ORDC*DIS*SEMR)	124	27.09	0.22				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ORDC*CLAU*SEMR	2	0.64	0.32	1.44	0.2408	0.2410	0.2408
DISC*ORDC*CLAU*SEMR*REP	2	0.24	0.12	0.54	0.5840	0.5808	0.5840
Error(DISC*ORDC*CLAU*SEMR)	124	27.64	0.22				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*DIS*CLAU*SEMR	2	1.13	0.56	2.45	0.0909	0.0912	0.0909

DISC*DIS*CLAU*SEMR*REP	2	0.28	0.14	0.62	0.5420	0.5411	0.5420
Error(DISC*DIS*CLAU*SEMR)	124	28.58	0.23				

Source	DF	SS	MS	F	Pr > F
ORDC*DIS*CLAU*SEMR	1	0.06	0.06	0.23	0.6325
ORDC*DIS*CLAU*SEMR*REP	1	0.28	0.28	1.11	0.2970
Error(ORDC*DIS*CLAU*SEMR)	62	15.48	0.25		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DIS*ORD*DIS*CLA*SEM	2	0.33	0.17	0.65	0.5217	0.5103	0.5169
DIS*ORD*DIS*CLA*SEM*REP	2	0.05	0.02	0.10	0.9077	0.8941	0.9021
Error(DIS*ORD*DIS*CLA*SEM)	124	31.29	0.25				

APPENDIX I

Omnibus ANOVA LOG scores: Condition Means (Missing Scores Replaced with Condition Means).

Source	DF	SS	MS	F	Pr > F
REP	1	0.72	0.72	0.40	0.5276
Error	61	108.87	1.78		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO	2	5.56	2.78	12.25	<.0001	<.0001	<.0001	**
DISCO*REP	2	0.17	0.09	0.38	0.6842	0.6812	0.6842	
Error(DISCO)	122	27.71	0.23					

Source	DF	SS	MS	F	Pr > F
ICON	1	0.28	0.28	1.39	0.2427
ICON*REP	1	0.58	0.58	2.86	0.0962
Error(ICON)	61	12.41	0.20		

Source	DF	SS	MS	F	Pr > F
DIS	1	0.55	0.55	2.31	0.1339
DIS*REP	1	0.02	0.02	0.07	0.7954
Error(DIS)	61	14.42	0.24		

Source	DF	SS	MS	F	Pr > F
CLAUSE	1	0.09	0.09	0.47	0.4957
CLAUSE*REP	1	0.05	0.05	0.26	0.6104
Error(CLAUSE)	61	11.80	0.19		

Source	DF	SS	MS	F	Pr > F	
SEMREL	1	2.42	2.42	10.61	0.0018	**
SEMREL*REP	1	0.15	0.15	0.64	0.4253	
Error(SEMREL)	61	13.93	0.23			

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON	2	0.08	0.04	0.21	0.8077	0.7936	0.8038
DISCO*ICON*REP	2	0.41	0.21	1.12	0.3300	0.3274	0.3292
Error(DISCO*ICON)	122	22.56	0.18				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS	2	1.09	0.55	2.50	0.0867	0.0903	0.0875
DISCO*DIS*REP	2	1.10	0.55	2.51	0.0851	0.0887	0.0860
Error(DISCO*DIS)	122	26.70	0.22				

Source	DF	SS	MS	F	Pr > F
ICON*DIS	1	0.23	0.23	1.02	0.3172
ICON*DIS*REP	1	0.45	0.45	1.98	0.1641
Error(ICON*DIS)	61	13.79	0.23		

Source	DF	SS	MS	F	Pr > F	G - G	H - F

DISCO*CLAUSE	2	1.21	0.60	2.80	0.0646	0.0670	0.0646
DISCO*CLAUSE*REP	2	0.01	0.00	0.02	0.9848	0.9823	0.9848
Error(DISCO*CLAUSE)	122	26.33	0.22				

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE	1	4.88	4.88	17.38	<.0001	**
ICON*CLAUSE*REP	1	0.07	0.07	0.24	0.6274	
Error(ICON*CLAUSE)	61	17.13	0.28			

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE	1	0.11	0.11	0.37	0.5428
DIS*CLAUSE*REP	1	0.30	0.30	1.08	0.3024
Error(DIS*CLAUSE)	61	17.18	0.28		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*SEMREL	2	0.81	0.40	1.92	0.1512	0.1514	0.1512
DISCO*SEMREL*REP	2	1.16	0.58	2.75	0.0679	0.0680	0.0679
Error(DISCO*SEMREL)	122	25.66	0.21				

Source	DF	SS	MS	F	Pr > F
ICON*SEMREL	1	0.36	0.36	1.83	0.1813
ICON*SEMREL*REP	1	0.00	0.00	0.01	0.9346
Error(ICON*SEMREL)	61	12.03	0.20		

Source	DF	SS	MS	F	Pr > F	
DIS*SEMREL	1	1.83	1.83	13.38	0.0005	**
DIS*SEMREL*REP	1	0.02	0.02	0.12	0.7313	
Error(DIS*SEMREL)	61	8.34	0.14			

Source	DF	SS	MS	F	Pr > F
CLAUSE*SEMREL	1	0.01	0.01	0.05	0.8194
CLAUSE*SEMREL*REP	1	0.55	0.55	3.66	0.0605
Error(CLAUSE*SEMREL)	61	9.19	0.15		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*DIS	2	0.26	0.13	0.55	0.5778	0.5616	0.5693
DISCO*ICON*DIS*REP	2	0.04	0.02	0.08	0.9189	0.9032	0.9108
Error(DISCO*ICON*DIS)	122	28.74	0.24				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*CLAUSE	2	0.37	0.18	0.89	0.4140	0.4049	0.4088
DISCO*ICON*CLAUSE*REP	2	0.03	0.02	0.07	0.9291	0.9130	0.9202
Error(DISCO*ICON*CLAUSE)	122	25.18	0.21				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS*CLAUSE	2	0.42	0.21	0.83	0.4395	0.4345	0.4393
DISCO*DIS*CLAUSE*REP	2	0.21	0.10	0.41	0.6646	0.6547	0.6643
Error(DISCO*DIS*CLAUSE)	122	30.77	0.25				

Source	DF	SS	MS	F	Pr > F
ICON*DIS*CLAUSE	1	0.23	0.23	0.74	0.3916
ICON*DIS*CLAUSE*REP	1	0.01	0.01	0.02	0.8897
Error(ICON*DIS*CLAUSE)	61	19.24	0.32		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*ICON*SEMREL	2	4.10	2.05	11.53	<.0001	<.0001	<.0001	**
DISCO*ICON*SEMREL*REP	2	0.08	0.04	0.22	0.8014	0.7941	0.8014	
Error(DISCO*ICON*SEMREL)	122	21.68	0.18					

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*DIS*SEMREL	2	1.50	0.75	4.22	0.0169	0.0172	0.0169	*
DISCO*DIS*SEMREL*REP	2	0.26	0.13	0.72	0.4867	0.4856	0.4867	
Error(DISCO*DIS*SEMREL)	122	21.61	0.18					

Source	DF	SS	MS	F	Pr > F
ICON*DIS*SEMREL	1	0.06	0.06	0.48	0.4895
ICON*DIS*SEMREL*REP	1	0.00	0.00	0.00	0.9656
Error(ICON*DIS*SEMREL)	61	8.03	0.13		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*CLAUSE*SEMREL	2	1.97	0.99	5.62	0.0046	0.0048	0.0046	**
DISCO*CLAUSE*SEMREL*REP	2	0.13	0.07	0.38	0.6817	0.6790	0.6817	
Error(DISCO*CLAUSE*SEMREL)	122	21.41	0.18					

Source	DF	SS	MS	F	Pr > F
ICON*CLAUSE*SEMREL	1	0.35	0.35	1.56	0.2160
ICON*CLAUSE*SEMREL*REP	1	0.13	0.13	0.61	0.4384
Error(ICON*CLAUSE*SEMREL)	61	13.53	0.22		

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE*SEMREL	1	0.05	0.05	0.28	0.5968
DIS*CLAUSE*SEMREL*REP	1	0.04	0.04	0.21	0.6451
Error(DIS*CLAUSE*SEMREL)	61	10.09	0.17		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ICON*DIS*CLAU	2	0.01	0.00	0.02	0.9798	0.9723	0.9759
DISC*ICON*DIS*CLAU*REP	2	0.53	0.26	1.12	0.3281	0.3241	0.3259
Error(DISC*ICON*DIS*CLAU)	122	28.70	0.24				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ICON*DIS*SEMR	2	0.74	0.37	1.68	0.1904	0.1938	0.1926
DISC*ICON*DIS*SEMR*REP	2	0.76	0.38	1.73	0.1811	0.1850	0.1836
Error(DISC*ICON*DIS*SEMR)	122	26.84	0.22				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ICON*CLAU*SEMR	2	0.89	0.44	1.90	0.1541	0.1545	0.1541

DISC*ICON*CLAU*SEMR*REP	2	0.51	0.25	1.09	0.3398	0.3393	0.3398
Error(DISC*ICON*CLAU*SEMR)	122	28.54	0.23				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*DIS*CLAU*SEMR	2	1.20	0.60	2.60	0.0782	0.0786	0.0782
DISC*DIS*CLAU*SEMR*REP	2	0.39	0.19	0.84	0.4327	0.4321	0.4327
Error(DISC*DIS*CLAU*SEMR)	122	28.18	0.23				

APPENDIX J

Omnibus ANOVA Log scores: Regressed Means (Missing Scores Replaced through Regression Procedure).

Source	DF	SS	MS	F	Pr > F
REP	1	1.78	1.78	0.96	0.3314
Error	62	114.88	1.85		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO	2	5.86	2.93	12.76	<.0001	<.0001	<.0001	**
DISCO*REP	2	0.14	0.07	0.30	0.7378	0.7347	0.7378	
Error(DISCO)	124	28.46	0.23					

Source	DF	SS	MS	F	Pr > F	
ICON	1	0.36	0.36	1.78	0.1866	
ICON*REP	1	1.05	1.05	5.18	0.0263	*
Error(ICON)	62	12.59	0.20			

Source	DF	SS	MS	F	Pr > F
DIS	1	0.38	0.38	1.69	0.1987
DIS*REP	1	0.01	0.01	0.05	0.8279
Error(DIS)	62	14.13	0.23		

Source	DF	SS	MS	F	Pr > F
CLAUSE	1	0.07	0.07	0.33	0.5693
CLAUSE*REP	1	0.03	0.03	0.13	0.7211
Error(CLAUSE)	62	12.83	0.21		

Source	DF	SS	MS	F	Pr > F	
SEMREL	1	2.09	2.09	9.44	0.0031	**
SEMREL*REP	1	0.09	0.09	0.41	0.5240	
Error(SEMREL)	62	13.75	0.22			

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON	2	0.03	0.02	0.08	0.9260	0.9130	0.9202
DISCO*ICON*REP	2	0.34	0.17	0.86	0.4236	0.4159	0.4201
Error(DISCO*ICON)	124	24.65	0.20				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS	2	0.98	0.49	2.11	0.1259	0.1290	0.1266
DISCO*DIS*REP	2	1.00	0.50	2.14	0.1216	0.1247	0.1223
Error(DISCO*DIS)	124	28.90	0.23				

Source	DF	SS	MS	F	Pr > F
ICON*DIS	1	0.22	0.22	0.97	0.3285
ICON*DIS*REP	1	0.45	0.45	2.00	0.1621
Error(ICON*DIS)	62	13.86	0.22		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*CLAUSE	2	1.23	0.62	2.86	0.0613	0.0638	0.0613
DISCO*CLAUSE*REP	2	0.03	0.02	0.08	0.9244	0.9175	0.9244
Error(DISCO*CLAUSE)	124	26.71	0.22				

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE	1	6.10	6.10	22.26	<.0001	**
ICON*CLAUSE*REP	1	0.16	0.16	0.58	0.4481	
Error(ICON*CLAUSE)	62	17.00	0.27			

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE	1	0.14	0.14	0.50	0.4804
DIS*CLAUSE*REP	1	0.68	0.68	2.38	0.1278
Error(DIS*CLAUSE)	62	17.65	0.28		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*SEMREL	2	0.80	0.40	1.92	0.1503	0.1504	0.1503	
DISCO*SEMREL*REP	2	1.62	0.81	3.91	0.0225	0.0226	0.0225	*
Error(DISCO*SEMREL)	124	25.66	0.21					

Source	DF	SS	MS	F	Pr > F
ICON*SEMREL	1	0.39	0.39	2.07	0.1555
ICON*SEMREL*REP	1	0.00	0.00	0.01	0.9069
Error(ICON*SEMREL)	62	11.65	0.19		

Source	DF	SS	MS	F	Pr > F	
DIS*SEMREL	1	2.11	2.11	15.51	0.0002	*
DIS*SEMREL*REP	1	0.06	0.06	0.47	0.4967	
Error(DIS*SEMREL)	62	8.45	0.14			

Source	DF	SS	MS	F	Pr > F
CLAUSE*SEMREL	1	0.00	0.00	0.01	0.9349
CLAUSE*SEMREL*REP	1	0.30	0.30	2.07	0.1548
Error(CLAUSE*SEMREL)	62	8.92	0.14		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*DIS	2	0.23	0.11	0.45	0.6381	0.6267	0.6356
DISCO*ICON*DIS*REP	2	0.04	0.02	0.07	0.9282	0.9192	0.9263
Error(DISCO*ICON*DIS)	124	31.08	0.25				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*ICON*CLAUSE	2	0.31	0.16	0.75	0.4752	0.4644	0.4698
DISCO*ICON*CLAUSE*REP	2	0.05	0.02	0.11	0.8944	0.8779	0.8863
Error(DISCO*ICON*CLAUSE)	124	25.83	0.21				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISCO*DIS*CLAUSE	2	0.39	0.19	0.79	0.4582	0.4531	0.4582

DISCO*DIS*CLAUSE*REP	2	0.22	0.11	0.45	0.6375	0.6286	0.6375	
Error(DISCO*DIS*CLAUSE)	124	30.45	0.25					

Source	DF	SS	MS	F	Pr > F
ICON*DIS*CLAUSE	1	0.34	0.34	1.05	0.3093
ICON*DIS*CLAUSE*REP	1	0.09	0.09	0.26	0.6089
Error(ICON*DIS*CLAUSE)	62	20.24	0.33		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*ICON*SEMREL	2	3.96	1.98	10.54	<.0001	<.0001	<.0001	**
DISCO*ICON*SEMREL*REP	2	0.11	0.06	0.30	0.7418	0.7374	0.7418	
Error(DISCO*ICON*SEMREL)	124	23.32	0.19					

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*DIS*SEMREL	2	1.41	0.70	3.88	0.0232	0.0234	0.0232	*
DISCO*DIS*SEMREL*REP	2	0.32	0.16	0.89	0.4145	0.4141	0.4145	
Error(DISCO*DIS*SEMREL)	124	22.51	0.18					

Source	DF	SS	MS	F	Pr > F
ICON*DIS*SEMREL	1	0.04	0.04	0.29	0.5945
ICON*DIS*SEMREL*REP	1	0.05	0.05	0.34	0.5606
Error(ICON*DIS*SEMREL)	62	8.18	0.13		

Source	DF	SS	MS	F	Pr > F	G - G	H - F	
DISCO*CLAUSE*SEMREL	2	2.15	1.08	6.44	0.0022	0.0023	0.0022	**
DISCO*CLAUSE*SEMREL*REP	2	0.30	0.15	0.91	0.4063	0.4054	0.4063	
Error(DISCO*CLAUSE*SEMREL)	124	20.73	0.17					

Source	DF	SS	MS	F	Pr > F
ICON*CLAUSE*SEMREL	1	0.47	0.47	2.12	0.1505
ICON*CLAUSE*SEMREL*REP	1	0.40	0.40	1.79	0.1853
Error(ICON*CLAUSE*SEMREL)	62	13.77	0.22		

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE*SEMREL	1	0.01	0.01	0.05	0.8215
DIS*CLAUSE*SEMREL*REP	1	0.03	0.03	0.18	0.6704
Error(DIS*CLAUSE*SEMREL)	62	10.49	0.17		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ORDC*DIS*CLAU	2	0.04	0.02	0.09	0.9168	0.9009	0.9086
DISC*ORDC*DIS*CLAU*REP	2	0.91	0.46	1.97	0.1432	0.1477	0.1457
Error(DISC*ORDC*DIS*CLAU)	124	28.61	0.23				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ORDC*DIS*SEMR	2	0.78	0.39	1.79	0.1717	0.1755	0.1740
DISC*ORDC*DIS*SEMR*REP	2	0.82	0.41	1.87	0.1584	0.1627	0.1609
Error(DISC*ORDC*DIS*SEMR)	124	27.19	0.22				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*ORDC*CLAU*SEMR	2	0.63	0.31	1.32	0.2713	0.2712	0.2713

DISC*ORDC*CLAU*SEMR*REP	2	0.72	0.36	1.52	0.2231	0.2232	0.2231
Error(DISC*ORDC*CLAU*SEMR)	124	29.41	0.24				

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DISC*DIS*CLAU*SEMR	2	0.95	0.48	2.09	0.1284	0.1295	0.1284
DISC*DIS*CLAU*SEMR*REP	2	0.57	0.29	1.26	0.2886	0.2883	0.2886
Error(DISC*DIS*CLAU*SEMR)	124	28.27	0.23				

Source	DF	SS	MS	F	Pr > F
ORDC*DIS*CLAU*SEMR	1	0.01	0.01	0.05	0.8189
ORDC*DIS*CLAU*SEMR*REP	1	0.56	0.56	2.22	0.1415
Error(ORDC*DIS*CLAU*SEMR)	62	15.69	0.25		

Source	DF	SS	MS	F	Pr > F	G - G	H - F
DIS*ORD*DIS*CLA*SEM	2	0.37	0.19	0.79	0.4571	0.4486	0.4537
DIS*ORD*DIS*CLA*SEM*REP	2	0.24	0.12	0.52	0.5985	0.5848	0.5929
Error(DIS*ORD*DIS*CLA*SEM)	124	29.18	0.24				

APPENDIX K

Means, Subject Residuals (Grand Mean Added).

Discourse Order by Iconicity by Semantic Relationship

	Physical Chrono	Social Chrono	Physical Nchrono	Social Nchrono
GivenGiven	5.025	5.958	5.159	5.606
GivenNew	6.263	5.857	5.460	6.411
NewGiven	5.463	6.474	5.498	5.988

Iconicity by Clause

	Main Clause First	Main Clause Last
Chronological	5.546	6.134
Non-Chronological	5.827	5.547

Semantic Relationship by Psychological Distance

	Physical	Social
Near	5.428	6.247
Far	5.528	5.851

Discourse Order

GG	5.437
GN	5.998
NG	5.856

APPENDIX L

Omnibus ANOVA Subject Residuals (Tested Against an Aggregated Error Term. Missing Scores not Replaced).

Source	DF	SS	MS	F	Pr > F
Model	95	1397.07	14.71	1.71	<.0001
Error	2582	22170.28	8.59		
Corrected	2677	23567.34			

Source	DF	SS	MS	F	Pr > F	
REP	1	0.07	0.07	0.01	0.9263	
DISCO	2	147.35	73.67	8.58	0.0002	**
REP*DISCO	2	9.70	4.85	0.56	0.5686	
ICON	1	15.43	15.43	1.80	0.1801	
REP*ICON	1	17.67	17.67	2.06	0.1515	
DIS	1	14.45	14.45	1.68	0.1947	
REP*DIS	1	3.91	3.91	0.46	0.5000	
CLAUSE	1	15.71	15.71	1.83	0.1763	
REP*CLAUSE	1	7.86	7.86	0.92	0.3387	
SEMREL	1	214.87	214.87	25.02	<.0001	*
REP*SEMREL	1	0.16	0.16	0.02	0.8910	
DISCO*ICON	2	1.76	0.88	0.10	0.9026	
REP*DISCO*ICON	2	15.58	7.79	0.91	0.4037	
DISCO*DIS	2	23.92	11.96	1.39	0.2485	
REP*DISCO*DIS	2	25.40	12.70	1.48	0.2280	
ICON*DIS	1	3.62	3.62	0.42	0.5164	
REP*ICON*DIS	1	6.24	6.24	0.73	0.3940	
DISCO*CLAUSE	2	30.05	15.03	1.75	0.1740	
REP*DISCO*CLAUSE	2	7.08	3.54	0.41	0.6621	
ICON*CLAUSE	1	124.16	124.16	14.46	0.0001	**
REP*ICON*CLAUSE	1	0.18	0.18	0.02	0.8851	
DIS*CLAUSE	1	0.70	0.70	0.08	0.7760	
REP*DIS*CLAUSE	1	20.87	20.87	2.43	0.1191	
DISCO*SEMREL	2	29.92	14.96	1.74	0.1753	
REP*DISCO*SEMREL	2	41.67	20.84	2.43	0.0885	
ICON*SEMREL	1	2.24	2.24	0.26	0.6093	
REP*ICON*SEMREL	1	7.23	7.23	0.84	0.3590	
DIS*SEMREL	1	40.31	40.31	4.69	0.0304	*
REP*DIS*SEMREL	1	3.00	3.00	0.35	0.5547	
CLAUSE*SEMREL	1	1.11	1.11	0.13	0.7188	
REP*CLAUSE*SEMREL	1	21.11	21.11	2.46	0.1170	
DISCO*ICON*DIS	2	23.79	11.89	1.39	0.2504	
REP*DISCO*ICON*DIS	2	8.31	4.15	0.48	0.6165	
DISCO*ICON*CLAUSE	2	15.28	7.64	0.89	0.4110	
REP*DISC*ICON*CLAUS	2	1.30	0.65	0.08	0.9270	
DISCO*DIS*CLAUSE	2	19.45	9.73	1.13	0.3223	
REP*DISCO*DIS*CLAUSE	2	24.34	12.17	1.42	0.2426	
ICON*DIS*CLAUSE	1	0.28	0.28	0.03	0.8564	
REP*ICON*DIS*CLAUSE	1	10.17	10.17	1.18	0.2765	

DISCO*ICON*SEMREL	2	126.75	63.38	7.38	0.0006	**
REP*DISC*ICON*SEMRE	2	8.55	4.28	0.50	0.6078	
DISCO*DIS*SEMREL	2	13.09	6.55	0.76	0.4666	
REP*DISCO*DIS*SEMREL	2	1.74	0.87	0.10	0.9039	
ICON*DIS*SEMREL	1	3.96	3.96	0.46	0.4970	
REP*ICON*DIS*SEMREL	1	0.01	0.01	0.00	0.9719	
DISCO*CLAUSE*SEMREL	2	76.78	38.39	4.47	0.0115	*
REP*DISCO*CLAUSE*SEMREL	2	7.82	3.91	0.46	0.6343	
ICON*CLAUSE*SEMREL	1	4.17	4.17	0.49	0.4858	
REP*ICON*CLAUSE*SEMREL	1	8.78	8.78	1.02	0.3121	
DIS*CLAUSE*SEMREL	1	0.10	0.10	0.01	0.9130	
REP*DIS*CLAUSE*SEMREL	1	0.44	0.44	0.05	0.8213	
DISCO*ICON*DIS*CLAUS	2	0.27	0.13	0.02	0.9844	
REP*DISCO*ICON*DIS*CLAUSE	2	3.80	1.90	0.22	0.8014	
DISCO*ICON*DIS*SEMREL	2	25.47	12.74	1.48	0.2271	
REP*DIS*ICON*DIS*SEMREL	2	32.83	16.42	1.91	0.1480	
DISCO*ICON*CLAUSE*SEMREL	2	15.61	7.81	0.91	0.4030	
REP*DIS*ICON*CLAUSE*SEMREL	2	5.84	2.92	0.34	0.7116	
DISCO*DIS*CLAUSE*SEMREL	2	27.56	13.78	1.60	0.2012	
REP*DISCO*DIS*CLAUSE*SEMREL	2	0.40	0.20	0.02	0.9770	
DISCO*ICON*DIS*CLAUSE*SEMREL	3	20.33	6.78	0.79	0.4998	
REP*DISCO*ICON*DIS*CLAUSE*SEMREL	3	19.57	6.52	0.76	0.5166	

APPENDIX M

Omnibus ANOVA Covariate Residuals (Cube Comparisons Test. Tested Against an Aggregated Error Term. Missing Scores not Replaced).

Source	DF	SS	MS	F	Pr > F
Model	95	1430.69	15.06	1.38	0.0093
Error	2582	28114.81	10.89		
Corrected	Total	2677.00	29545.50		

Source	DF	SS	MS	F	Pr > F	
REP	1	51.08	51.08	4.69	0.0304	*
DISCO	2	161.66	80.83	7.42	0.0006	**
REP*DISCO	2	7.43	3.71	0.34	0.7110	
ICON	1	12.81	12.81	1.18	0.2782	
REP*ICON	1	13.79	13.79	1.27	0.2606	
DIS	1	9.68	9.68	0.89	0.3458	
REP*DIS	1	3.53	3.53	0.32	0.5692	
CLAUSE	1	11.60	11.60	1.06	0.3022	
REP*CLAUSE	1	4.34	4.34	0.40	0.5279	
SEMREL	1	179.32	179.32	16.47	<.0001	**
REP*SEMREL	1	0.73	0.73	0.07	0.7962	
DISCO*ICON	2	2.42	1.21	0.11	0.8950	
REP*DISCO*ICON	2	16.52	8.26	0.76	0.4684	
DISCO*DIS	2	25.83	12.91	1.19	0.3056	
REP*DISCO*DIS	2	37.56	18.78	1.72	0.1784	
ICON*DIS	1	4.08	4.08	0.38	0.5403	
REP*ICON*DIS	1	4.14	4.14	0.38	0.5376	
DISCO*CLAUSE	2	37.59	18.80	1.73	0.1782	
REP*DISCO*CLAUSE	2	5.41	2.70	0.25	0.7802	
ICON*CLAUSE	1	133.78	133.78	12.29	0.0005	**
REP*ICON*CLAUSE	1	0.97	0.97	0.09	0.7648	
DIS*CLAUSE	1	0.53	0.53	0.05	0.8250	
REP*DIS*CLAUSE	1	20.79	20.79	1.91	0.1672	
DISCO*SEMREL	2	31.49	15.74	1.45	0.2358	
REP*DISCO*SEMREL	2	41.41	20.70	1.90	0.1496	
ICON*SEMREL	1	2.85	2.85	0.26	0.6091	
REP*ICON*SEMREL	1	7.46	7.46	0.68	0.4080	
DIS*SEMREL	1	49.27	49.27	4.52	0.0335	*
REP*DIS*SEMREL	1	3.09	3.09	0.28	0.5945	
CLAUSE*SEMREL	1	1.12	1.12	0.10	0.7482	
REP*CLAUSE*SEMREL	1	26.88	26.88	2.47	0.1163	
DISCO*ICON*DIS	2	21.30	10.65	0.98	0.3762	
REP*DISCO*ICON*DIS	2	7.59	3.80	0.35	0.7057	
DISCO*ICON*CLAUSE	2	19.56	9.78	0.90	0.4075	
REP*DISC*ICON*CLAUS	2	1.35	0.67	0.06	0.9399	
DISCO*DIS*CLAUSE	2	18.01	9.01	0.83	0.4374	
REP*DISCO*DIS*CLAUSE	2	19.76	9.88	0.91	0.4037	
ICON*DIS*CLAUSE	1	1.87	1.87	0.17	0.6788	
REP*ICON*DIS*CLAUSE	1	9.53	9.53	0.87	0.3497	

DISCO*ICON*SEMREL	2	114.99	57.49	5.28	0.0051	**
REP*DISC*ICON*SEMRE	2	10.04	5.02	0.46	0.6308	
DISCO*DIS*SEMREL	2	10.79	5.39	0.50	0.6095	
REP*DISCO*DIS*SEMREL	2	1.53	0.76	0.07	0.9322	
ICON*DIS*SEMREL	1	2.72	2.72	0.25	0.6171	
REP*ICON*DIS*SEMREL	1	0.02	0.02	0.00	0.9663	
DISCO*CLAUSE*SEMREL	2	57.45	28.73	2.64	0.0717	
REP*DISCO*CLAUSE*SEMREL	2	6.72	3.36	0.31	0.7344	
ICON*CLAUSE*SEMREL	1	7.76	7.76	0.71	0.3988	
REP*ICON*CLAUSE*SEMREL	1	11.61	11.61	1.07	0.3019	
DIS*CLAUSE*SEMREL	1	1.24	1.24	0.11	0.7360	
REP*DIS*CLAUSE*SEMREL	1	1.09	1.09	0.10	0.7515	
DISCO*ICON*DIS*CLAUS	2	0.42	0.21	0.02	0.9810	
REP*DIS*ICON*DIS*CLAUSE	2	6.47	3.23	0.30	0.7430	
DISC*ICON*DIS*SEMREL	2	26.82	13.41	1.23	0.2921	
REP*DIS*ICON*DIS*SEMREL	2	33.62	16.81	1.54	0.2138	
DISC*ICON*CLAUSE*SEMREL	2	15.27	7.64	0.70	0.4960	
REP*DIS*ICON*CLAUSE*SEMREL	2	12.77	6.39	0.59	0.5563	
DISC*DIS*CLAUSE*SEMREL	2	21.39	10.69	0.98	0.3746	
REP*DISCO*DIS*CLAUSE*SEMREL	2	0.02	0.01	0.00	0.9989	
DIS*ICON*DIS*CLAUSE*SEMREL	3	17.73	5.91	0.54	0.6530	
REP*DISCO*ICON*DIS*CLAUSE*SEMREL	3	29.91	9.97	0.92	0.4325	

APPENDIX N

Omnibus ANOVA Covariate Residuals (Card Rotation Test. Tested Against an Aggregated Error Term. Missing Scores not Replaced).

Source	DF	SS	MS	F	Pr > F
Model	95	1449.24	15.26	1.40	0.0071
Error	2582	28120.15	10.89		
Corrected	Total	2677.00	29569.39		

Source	DF	SS	MS	F	Pr > F
REP	1	70.02	70.02	6.43	0.0113*
DISCO	2	160.16	80.08	7.35	0.0007**
REP*DISCO	2	6.98	3.49	0.32	0.7258
ICON	1	13.25	13.25	1.22	0.2700
REP*ICON	1	14.36	14.36	1.32	0.2510
DIS	1	9.37	9.37	0.86	0.3537
REP*DIS	1	3.66	3.66	0.34	0.5621
CLAUSE	1	10.99	10.99	1.01	0.3152
REP*CLAUSE	1	4.32	4.32	0.40	0.5287
SEMREL	1	181.22	181.22	16.64	<.0001**
REP*SEMREL	1	0.80	0.80	0.07	0.7863
DISCO*ICON	2	2.49	1.25	0.11	0.8919
REP*DISCO*ICON	2	16.15	8.07	0.74	0.4765
DISCO*DIS	2	24.99	12.49	1.15	0.3177
REP*DISCO*DIS	2	37.57	18.79	1.72	0.1784
ICON*DIS	1	4.17	4.17	0.38	0.5360
REP*ICON*DIS	1	4.16	4.16	0.38	0.5365
DISCO*CLAUSE	2	38.00	19.00	1.74	0.1749
REP*DISCO*CLAUSE	2	5.27	2.63	0.24	0.7852
ICON*CLAUSE	1	133.48	133.48	12.26	0.0005**
REP*ICON*CLAUSE	1	0.74	0.74	0.07	0.7937
DIS*CLAUSE	1	0.56	0.56	0.05	0.8203
REP*DIS*CLAUSE	1	21.12	21.12	1.94	0.1638
DISCO*SEMREL	2	30.68	15.34	1.41	0.2447
REP*DISCO*SEMREL	2	40.43	20.22	1.86	0.1565
ICON*SEMREL	1	2.95	2.95	0.27	0.6029
REP*ICON*SEMREL	1	7.83	7.83	0.72	0.3966
DIS*SEMREL	1	49.01	49.01	4.50	0.0340*
REP*DIS*SEMREL	1	3.25	3.25	0.30	0.5849
CLAUSE*SEMREL	1	1.46	1.46	0.13	0.7142
REP*CLAUSE*SEMREL	1	27.44	27.44	2.52	0.1126
DISCO*ICON*DIS	2	20.79	10.40	0.95	0.3851
REP*DISCO*ICON*DIS	2	7.39	3.69	0.34	0.7124
DISCO*ICON*CLAUSE	2	19.08	9.54	0.88	0.4165
REP*DISC*ICON*CLAUS	2	1.39	0.70	0.06	0.9380
DISCO*DIS*CLAUSE	2	18.08	9.04	0.83	0.4360
REP*DISCO*DIS*CLAUSE	2	19.34	9.67	0.89	0.4116
ICON*DIS*CLAUSE	1	2.16	2.16	0.20	0.6561
REP*ICON*DIS*CLAUSE	1	9.63	9.63	0.88	0.3472

DISCO*ICON*SEMREL	2	116.15	58.07	5.33	0.0049**
REP*DISC*ICON*SEMRE	2	10.22	5.11	0.47	0.6255
DISCO*DIS*SEMREL	2	11.33	5.66	0.52	0.5946
REP*DISCO*DIS*SEMREL	2	1.33	0.66	0.06	0.9409
ICON*DIS*SEMREL	1	2.80	2.80	0.26	0.6124
REP*ICON*DIS*SEMREL	1	0.03	0.03	0.00	0.9565
DISCO*CLAUSE*SEMREL	2	57.86	28.93	2.66	0.0704
REP*DISCO*CLAUSE*SEMREL	2	6.95	3.48	0.32	0.7268
ICON*CLAUSE*SEMREL	1	7.62	7.62	0.70	0.4031
REP*ICON*CLAUSE*SEMREL	1	11.00	11.00	1.01	0.3150
DIS*CLAUSE*SEMREL	1	1.20	1.20	0.11	0.7403
REP*DIS*CLAUSE*SEMREL	1	1.05	1.05	0.10	0.7559
DISCO*ICON*DIS*CLAUS	2	0.35	0.17	0.02	0.9842
REP*DIS*ICON*DIS*CLAUSE	2	6.23	3.12	0.29	0.7512
DISC*ICON*DIS*SEMREL	2	26.61	13.31	1.22	0.2949
REP*DIS*ICON*DIS*SEMREL	2	33.36	16.68	1.53	0.2164
DISC*ICON*CLAUSE*SEMREL	2	15.78	7.89	0.72	0.4847
REP*DIS*ICON*CLAUSE*SEMREL	2	12.77	6.39	0.59	0.5564
DISC*DIS*CLAUSE*SEMREL	2	21.21	10.60	0.97	0.3778
REP*DISCO*DIS*CLAUSE*SEMREL	2	0.03	0.01	0.00	0.9988
DIS*ICON*DIS*CLAUSE*SEMREL	3	18.52	6.17	0.57	0.6369
REP*DISCO*ICON*DIS*CLAUSE*SEMREL	3	29.61	9.87	0.91	0.4372

APPENDIX O

Omnibus ANOVA Covariate Residuals (Sentence Span Test. Tested Against an Aggregated Error Term. Missing Scores not Replaced).

Source	DF	SS	MS	F	Pr > F
Model	95	1472.03	15.50	1.43	0.0047
Error	2582	28010.02	10.85		
Corrected	Total	2677.00	29482.06		

Source	DF	SS	MS	F	Pr > F
REP	1	91.83	91.83	8.46	0.0037**
DISCO	2	162.09	81.04	7.47	0.0006**
REP*DISCO	2	6.78	3.39	0.31	0.7317
ICON	1	14.25	14.25	1.31	0.2519
REP*ICON	1	14.36	14.36	1.32	0.2501
DIS	1	8.86	8.86	0.82	0.3662
REP*DIS	1	3.77	3.77	0.35	0.5556
CLAUSE	1	10.67	10.67	0.98	0.3215
REP*CLAUSE	1	4.94	4.94	0.45	0.5000
SEMREL	1	180.16	180.16	16.61	<.0001**
REP*SEMREL	1	0.85	0.85	0.08	0.7789
DISCO*ICON	2	2.76	1.38	0.13	0.8805
REP*DISCO*ICON	2	16.33	8.17	0.75	0.4712
DISCO*DIS	2	24.64	12.32	1.14	0.3214
REP*DISCO*DIS	2	38.01	19.00	1.75	0.1737
ICON*DIS	1	4.15	4.15	0.38	0.5361
REP*ICON*DIS	1	3.96	3.96	0.37	0.5456
DISCO*CLAUSE	2	39.26	19.63	1.81	0.1639
REP*DISCO*CLAUSE	2	5.73	2.87	0.26	0.7678
ICON*CLAUSE	1	134.65	134.65	12.41	0.0004**
REP*ICON*CLAUSE	1	0.48	0.48	0.04	0.8330
DIS*CLAUSE	1	0.56	0.56	0.05	0.8196
REP*DIS*CLAUSE	1	21.70	21.70	2.00	0.1574
DISCO*SEMREL	2	30.53	15.27	1.41	0.2450
REP*DISCO*SEMREL	2	39.72	19.86	1.83	0.1605
ICON*SEMREL	1	2.91	2.91	0.27	0.6046
REP*ICON*SEMREL	1	8.43	8.43	0.78	0.3780
DIS*SEMREL	1	50.28	50.28	4.63	0.0314*
REP*DIS*SEMREL	1	3.19	3.19	0.29	0.5877
CLAUSE*SEMREL	1	1.56	1.56	0.14	0.7043
REP*CLAUSE*SEMREL	1	26.98	26.98	2.49	0.1149
DISCO*ICON*DIS	2	20.11	10.05	0.93	0.3959
REP*DISCO*ICON*DIS	2	7.03	3.51	0.32	0.7233
DISCO*ICON*CLAUSE	2	19.41	9.71	0.89	0.4088
REP*DISC*ICON*CLAUS	2	1.85	0.92	0.09	0.9183
DISCO*DIS*CLAUSE	2	18.11	9.05	0.83	0.4342
REP*DISCO*DIS*CLAUSE	2	19.04	9.52	0.88	0.4160
ICON*DIS*CLAUSE	1	2.48	2.48	0.23	0.6324
REP*ICON*DIS*CLAUSE	1	8.80	8.80	0.81	0.3679

DISCO*ICON*SEMREL	2	116.28	58.14	5.36	0.0048**
REP*DISC*ICON*SEMRE	2	9.71	4.86	0.45	0.6391
DISCO*DIS*SEMREL	2	10.94	5.47	0.50	0.6041
REP*DISCO*DIS*SEMREL	2	1.21	0.60	0.06	0.9459
ICON*DIS*SEMREL	1	2.98	2.98	0.27	0.6004
REP*ICON*DIS*SEMREL	1	0.11	0.11	0.01	0.9214
DISCO*CLAUSE*SEMREL	2	56.56	28.28	2.61	0.0740
REP*DISCO*CLAUSE*SEMREL	2	7.45	3.72	0.34	0.7095
ICON*CLAUSE*SEMREL	1	7.91	7.91	0.73	0.3931
REP*ICON*CLAUSE*SEMREL	1	9.58	9.58	0.88	0.3473
DIS*CLAUSE*SEMREL	1	1.28	1.28	0.12	0.7309
REP*DIS*CLAUSE*SEMREL	1	1.00	1.00	0.09	0.7620
DISCO*ICON*DIS*CLAUS	2	0.28	0.14	0.01	0.9872
REP*DIS*ICON*DIS*CLAUSE	2	6.40	3.20	0.29	0.7446
DISC*ICON*DIS*SEMREL	2	25.50	12.75	1.18	0.3089
REP*DIS*ICON*DIS*SEMREL	2	33.27	16.64	1.53	0.2160
DISC*ICON*CLAUSE*SEMREL	2	16.44	8.22	0.76	0.4687
REP*DIS*ICON*CLAUSE*SEMREL	2	12.75	6.37	0.59	0.5558
DISC*DIS*CLAUSE*SEMREL	2	20.12	10.06	0.93	0.3957
REP*DISCO*DIS*CLAUSE*SEMREL	2	0.01	0.01	0.00	0.9995
DIS*ICON*DIS*CLAUSE*SEMREL	3	19.14	6.38	0.59	0.6227
REP*DISCO*ICON*DIS*CLAUSE*SEMREL	3	29.82	9.94	0.92	0.4321

APPENDIX P

Omnibus ANOVA Log Scores (Missing Scores not Replaced).

Source	DF	SS	MS	F	Pr > F	
REP	1	71.94	71.93	0.96	0.3732	
SUBJ(REP)	62	4741.24	76.51	.	.	

Source	DF	SS	MS	F	Pr > F	
DISCO	2	3.19	1.59	5.48	0.0053	**
REP*DISCO	2	0.02	0.01	0.04	0.9641	
SUBJ*DISCO(REP)	124	36.08	0.29	.	.	

Source	DF	SS	MS	F	Pr > F
ICON	1	0.34	0.34	1.68	0.1996
REP*ICON	1	0.66	0.66	3.28	0.0750
SUBJ*ICON(REP)	62	12.56	0.20	.	.

Source	DF	SS	MS	F	Pr > F
DIS	1	0.39	0.39	1.54	0.2191
REP*DIS	1	0.00	0.00	0.00	0.9711
SUBJ*DIS(REP)	62	15.83	0.26	.	.

Source	DF	SS	MS	F	Pr > F
CLAUSE	1	0.01	0.01	0.03	0.8653
REP*CLAUSE	1	0.15	0.15	0.69	0.4110
SUBJ*CLAUSE(REP)	62	13.84	0.22	.	.

Source	DF	SS	MS	F	Pr > F	
SEMREL	1	3.65	3.65	15.64	0.0002	**
REP*SEMREL	1	0.01	0.01	0.06	0.8123	
SUBJ*SEMREL(REP)	62	14.46	0.23	.	.	

Source	DF	SS	MS	F	Pr > F
DISCO*ICON	2	0.16	0.08	0.30	0.7407
REP*DISCO*ICON	2	0.21	0.10	0.38	0.6823
SUBJ*DISCO*ICON(REP)	124	33.95	0.27	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*DIS	2	0.85	0.43	1.60	0.2065
REP*DISCO*DIS	2	0.56	0.28	1.05	0.3545
SUBJ*DISCO*DIS(REP)	124	33.13	0.27	.	.

Source	DF	SS	MS	F	Pr > F
ICON*DIS	1	0.17	0.17	0.64	0.4269
REP*ICON*DIS	1	0.11	0.11	0.43	0.5130
SUBJ*ICON*DIS(REP)	62	16.09	0.26	.	.

Source	DF	SS	MS	F	Pr > F	
DISCO*CLAUSE	2	1.76	0.88	3.40	0.0364	*

Source	DF	SS	MS	F	Pr > F	
REP*DISCO*CLAUSE	2	0.04	0.02	0.08	0.9243	
SUBJ*DISCO*CLAUSE(REP)	124	31.97	0.26	.	.	

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE	1	2.57	2.57	10.68	0.0018	**
REP*ICON*CLAUSE	1	0.02	0.02	0.09	0.7669	
SUBJ*ICON*CLAUSE(REP)	62	14.93	0.24	.	.	

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE	1	0.54	0.54	2.57	0.1140
REP*DIS*CLAUSE	1	0.24	0.24	1.16	0.2855
SUBJ*DIS*CLAUSE(REP)	62	12.94	0.21	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*SEMREL	2	0.40	0.20	0.93	0.3959
REP*DISCO*SEMREL	2	0.95	0.48	2.21	0.1138
SUBJ*DISCO*SEMREL(REP)	124	26.72	0.22	.	.

Source	DF	SS	MS	F	Pr > F
ICON*SEMREL	1	0.04	0.04	0.20	0.6591
REP*ICON*SEMREL	1	0.01	0.01	0.06	0.8065
SUBJ*ICON*SEMREL(REP)	62	12.77	0.21	.	.

Source	DF	SS	MS	F	Pr > F	
DIS*SEMREL	1	1.00	1.00	4.95	0.0298	*
REP*DIS*SEMREL	1	0.00	0.00	0.02	0.8917	
SUBJ*DIS*SEMREL(REP)	62	12.49	0.20	.	.	

Source	DF	SS	MS	F	Pr > F
CLAUSE*SEMREL	1	0.05	0.05	0.24	0.6239
REP*CLAUSE*SEMREL	1	0.27	0.27	1.28	0.2625
SUBJ*CLAUSE*SEMREL(REP)	62	13.00	0.21	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*ICON*DIS	2	0.78	0.39	1.75	0.1775
REP*DISCO*ICON*DIS	2	0.49	0.25	1.11	0.3342
SUBJ*DISCO*ICON*DIS(REP)	122	27.20	0.22	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*ICON*CLAUSE	2	0.59	0.30	1.55	0.2159
REP*DISC*ORDCO*CLAUS	2	0.70	0.35	1.84	0.1638
SUBJ*DISCO*ICON*CLAUSE(REP)	124	23.59	0.19	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*DIS*CLAUSE	2	0.55	0.27	1.06	0.3482
REP*DISCO*DIS*CLAUSE	2	0.27	0.13	0.52	0.5945
SUBJ*DISCO*DIS*CLAUSE(REP)	122	31.44	0.26	.	.

Source	DF	SS	MS	F	Pr > F
ICON*DIS*CLAUSE	1	0.22	0.22	0.79	0.3784

REP*ORDCO*DIS*CLAUSE	1	0.00	0.00	0.01	0.9353	
SUBJ*ICON*DIS*CLAUSE(REP)	62	17.26	0.28	.	.	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON*SEMREL	2	4.45	2.22	10.98	<.0001	**
REP*DISC*ORDCO*SEMRE	2	0.10	0.05	0.25	0.7796	
SUBJ*DISCO*ICON*SEMREL(REP)	106	21.47	0.20	.	.	

Source	DF	SS	MS	F	Pr > F
DISCO*DIS*SEMREL	2	0.29	0.15	0.68	0.5091
REP*DISCO*DIS*SEMREL	2	0.40	0.20	0.93	0.3981
SUBJ*DISCO*DIS*SEMREL(REP)	120	25.87	0.22	.	.

Source	DF	SS	MS	F	Pr > F
ICON*DIS*SEMREL	1	0.10	0.10	0.43	0.5138
REP*ICON*DIS*SEMREL	1	0.38	0.38	1.59	0.2128
SUBJ*ICON*DIS*SEMREL(REP)	54	13.07	0.24	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*CLAUSE*SEMREL	2	0.43	0.21	1.08	0.3438
REP*DISCO*CLAUSE*SEMREL	2	0.05	0.03	0.13	0.8800
SUBJ*DISCO*CLAUSE*SEMREL(REP)	115	22.73	0.20	.	.

Source	DF	SS	MS	F	Pr > F
ICON*CLAUSE*SEMREL	1	0.00	0.00	0.00	0.9797
REP*ICON*CLAUSE*SEMREL	1	0.50	0.50	2.03	0.1602
SUBJ*ICON*CLAUSE*SEMREL(REP)	50	12.29	0.25	.	.

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE*SEMREL	1	0.10	0.10	0.30	0.5868
REP*DIS*CLAUSE*SEMREL	1	0.53	0.53	1.61	0.2103
SUBJ*DIS*CLAUSE*SEMREL(REP)	52	17.21	0.33	.	.

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON*DIS*CLAUSE	2	0.10	0.05	0.21	0.8120	
REP*DISCO*ICON*DIS*CLAUSE	2	1.63	0.82	3.29	0.0444	*
SUBJ*DISCO*ICON*DIS*CLAUSE(REP)	58	14.40	0.25	.	.	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON*DIS*SEMREL	2	2.93	1.46	3.95	0.0270	*
REP*DISCO*ICON*DIS*SEMREL	2	2.68	1.34	3.62	0.0355	*
SUBJ*DISCO*ICON*DIS*SEMREL(REP)	41	15.18	0.37	.	.	

Source	DF	SS	MS	F	Pr > F
DISCO*ICON*CLAUSE*SEMREL	2	0.81	0.40	0.85	0.4360
REP*DISCO*ICON*CLAUSE*SEMREL	2	0.34	0.17	0.36	0.7020
SUBJ*DISCO*ICON*CLAUSE*SEMREL(REP)	32	15.21	0.48	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*DIS*CLAUSE*SEMREL	2	0.01	0.00	0.01	0.9928

REP*DISCO*DIS*CLAUSE*SEMREL	2	1.14	0.57	1.53	0.2296
SUBJ*DISCO*DIS*CLAUSE*SEMREL(REP)	41	15.33	0.37	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*ICON*DIS*CLAUSE*SEMREL	2	1.23	0.61	2.12	0.1490
REP*DISCO*ICON*DIS*CLAUSE*SEMREL	2	0.63	0.31	1.08	0.3601
SUBJ*DISCO*ICON*DIS*CLAUSE*SEMREL(REP)	18	5.22	0.29	.	.

APPENDIX Q

Omnibus ANOVA Raw Scores (Six-way subtracted. ! Denotes the five-way interactions that were not subtracted due to significance or borderline significance. Missing scores not replaced).

Source	DF	SS	MS	F	Pr > F	
REP	1	70.11	70.11	0.91	0.3443	

Source	DF	SS	MS	F	Pr > F	
DISCO	2	106.98	53.49	5.00	0.0081	**
REP*DISCO	2	0.10	0.05	0.00	0.9954	

Source	DF	SS	MS	F	Pr > F	
ICON	1	21.85	21.85	3.11	0.0829	
REP*ICON	1	14.90	14.90	2.12	0.1506	

Source	DF	SS	MS	F	Pr > F	
DIS	1	7.70	7.70	0.79	0.3783	
REP*DIS	1	5.76	5.76	0.59	0.4459	

Source	DF	SS	MS	F	Pr > F	
CLAUSE	1	7.22	7.22	0.95	0.3334	
REP*CLAUSE	1	20.32	20.32	2.68	0.1069	

Source	DF	SS	MS	F	Pr > F	
SEMREL	1	173.56	173.56	18.04	<.0001	**
REP*SEMREL	1	0.21	0.21	0.02	0.8843	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON	2	0.22	0.11	0.01	0.9901	
REP*DISCO*ICON	2	8.28	4.14	0.37	0.6888	

Source	DF	SS	MS	F	Pr > F	
DISCO*DIS	2	32.76	16.38	1.59	0.2073	
REP*DISCO*DIS	2	17.93	8.96	0.87	0.4206	

Source	DF	SS	MS	F	Pr > F	
ICON*DIS	1	3.57	3.57	0.35	0.5556	
REP*ICON*DIS	1	4.89	4.89	0.48	0.4906	

Source	DF	SS	MS	F	Pr > F	
DISCO*CLAUSE	2	39.23	19.62	1.96	0.1454	
REP*DISCO*CLAUSE	2	5.80	2.90	0.29	0.7491	

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE	1	67.10	67.10	6.86	0.0110	*
REP*ICON*CLAUSE	1	1.38	1.38	0.14	0.7081	

Source	DF	SS	MS	F	Pr > F

DIS*CLAUSE	1	20.34	20.34	2.49	0.1198	
REP*DIS*CLAUSE	1	19.22	19.22	2.35	0.1303	

Source	DF	SS	MS	F	Pr > F	
DISCO*SEMREL	2	17.58	8.79	1.33	0.2672	
REP*DISCO*SEMREL	2	23.84	11.92	1.81	0.1682	

Source	DF	SS	MS	F	Pr > F	
ICON*SEMREL	1	0.90	0.90	0.12	0.7276	
REP*ICON*SEMREL	1	4.32	4.32	0.59	0.4449	

Source	DF	SS	MS	F	Pr > F	
DIS*SEMREL	1	51.26	51.26	7.41	0.0084	**
REP*DIS*SEMREL	1	3.30	3.30	0.48	0.4923	

Source	DF	SS	MS	F	Pr > F	
CLAUSE*SEMREL	1	0.39	0.39	0.05	0.8170	
REP*CLAUSE*SEMREL	1	4.17	4.17	0.58	0.4502	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON*DIS	2	48.24	24.12	2.65	0.0750	
REP*DISCO*ICON*DIS	2	3.73	1.87	0.20	0.8152	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON*CLAUSE	2	34.98	17.49	2.45	0.0904	
REP*DISC*ICON*CLAUS	2	10.24	5.12	0.72	0.4900	

Source	DF	SS	MS	F	Pr > F	
DISCO*DIS*CLAUSE	2	31.00	15.50	1.88	0.1571	
REP*DISCO*DIS*CLAUSE	2	6.78	3.39	0.41	0.6638	

Source	DF	SS	MS	F	Pr > F	
ICON*DIS*CLAUSE	1	7.39	7.39	0.71	0.4019	
REP*ICON*DIS*CLAUSE	1	13.75	13.75	1.32	0.2541	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON*SEMREL	2	124.00	62.00	10.52	<.0001	**
REP*DISC*ICON*SEMRE	2	1.74	0.87	0.15	0.8627	

Source	DF	SS	MS	F	Pr > F	
DISCO*DIS*SEMREL	2	2.96	1.48	0.20	0.8199	
REP*DISCO*DIS*SEMREL	2	5.42	2.71	0.36	0.6952	

Source	DF	SS	MS	F	Pr > F	
ICON*DIS*SEMREL	1	9.61	9.61	1.46	0.2326	
REP*ICON*DIS*SEMREL	1	7.62	7.62	1.15	0.2873	

Source	DF	SS	MS	F	Pr > F	
DISCO*CLAUSE*SEMREL	2	3.81	1.91	0.23	0.7923	
REP*DISC*CLAUS*SEMRE	2	3.36	1.68	0.21	0.8146	

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE*SEMREL	1	0.01	0.01	0.00	0.9763	
REP*ICON*CLAUS*SEMRE	1	19.25	19.25	1.79	0.1865	

Source	DF	SS	MS	F	Pr > F	
DIS*CLAUSE*SEMREL	1	8.13	8.13	0.67	0.4168	
REP*DIS*CLAUS*SEMREL	1	11.22	11.22	0.92	0.3406	

Source	DF	SS	MS	F	Pr > F	
DISC*ICON*DIS*CLAUS	2	7.34	3.67	0.40	0.6724	
REP*DIS*ICO*DIS*CLAU	2	31.78	15.89	1.73	0.1861	!

Source	DF	SS	MS	F	Pr > F	
DISC*ICON*DIS*SEMRE	2	65.14	32.57	3.64	0.0347	*
REP*DIS*ICO*DIS*SEMR	2	117.00	58.50	6.55	0.0034	** !

Source	DF	SS	MS	F	Pr > F	
DISC*ICON*CLAU*SEMRE	2	24.64	12.32	0.86	0.4317	
REP*DIS*ICO*CLA*SEMR	2	9.58	4.79	0.33	0.7178	

Source	DF	SS	MS	F	Pr > F	
DISC*DIS*CLAUS*SEMRE	2	2.58	1.29	0.15	0.8646	
REP*DIS*DIS*CLA*SEMR	2	2.24	1.12	0.13	0.8811	

Source	DF	SS	MS	F	Pr > F
DIS*ICO*DIS*CLA*SEMR	2	49.47	24.73	1.25	0.3077

APPENDIX R

Omnibus ANOVA Raw Scores (Five-ways subtracted. ! Denotes the four-way interactions that were not subtracted due to significance or borderline significance. Missing scores not replaced).

Source	DF	SS	MS	F	Pr > F	
REP	1	59.08	59.08	0.94	0.3356	

Source	DF	SS	MS	F	Pr > F	
DISCO	2	77.56	38.78	3.44	0.0351	*
REP*DISCO	2	0.84	0.42	0.04	0.9635	

Source	DF	SS	MS	F	Pr > F	
ICON	1	10.62	10.62	1.27	0.2632	
REP*ICON	1	21.70	21.70	2.61	0.1116	

Source	DF	SS	MS	F	Pr > F	
DIS	1	12.56	12.56	1.24	0.2700	
REP*DIS	1	6.63	6.63	0.65	0.4218	

Source	DF	SS	MS	F	Pr > F	
CLAUSE	1	6.84	6.84	0.84	0.3622	
REP*CLAUSE	1	22.03	22.03	2.71	0.1046	

Source	DF	SS	MS	F	Pr > F	
SEMREL	1	155.13	155.13	15.28	0.0002	**
REP*SEMREL	1	0.00	0.00	0.00	0.9937	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON	2	0.51	0.25	0.02	0.9772	
REP*DISCO*ICON	2	9.68	4.84	0.44	0.6445	

Source	DF	SS	MS	F	Pr > F	
DISCO*DIS	2	26.01	13.01	1.27	0.2836	
REP*DISCO*DIS	2	22.44	11.22	1.10	0.3367	

Source	DF	SS	MS	F	Pr > F	
ICON*DIS	1	6.40	6.40	0.60	0.4402	
REP*ICON*DIS	1	1.08	1.08	0.10	0.7507	

Source	DF	SS	MS	F	Pr > F	
DISCO*CLAUSE	2	26.84	13.42	1.33	0.2677	
REP*DISCO*CLAUSE	2	2.67	1.33	0.13	0.8761	

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE	1	57.41	57.41	6.76	0.0117	*
REP*ICON*CLAUSE	1	0.15	0.15	0.02	0.8959	

Source	DF	SS	MS	F	Pr > F

DIS*CLAUSE	1	22.92	22.92	2.68	0.1068	
REP*DIS*CLAUSE	1	20.65	20.65	2.41	0.1253	

Source	DF	SS	MS	F	Pr > F	
DISCO*SEMREL	2	12.14	6.07	0.95	0.3907	
REP*DISCO*SEMREL	2	23.22	11.61	1.81	0.1678	

Source	DF	SS	MS	F	Pr > F	
ICON*SEMREL	1	0.00	0.00	0.00	0.9967	
REP*ICON*SEMREL	1	4.31	4.31	0.54	0.4670	

Source	DF	SS	MS	F	Pr > F	
DIS*SEMREL	1	29.48	29.48	4.16	0.0455	*
REP*DIS*SEMREL	1	2.32	2.32	0.33	0.5690	

Source	DF	SS	MS	F	Pr > F	
CLAUSE*SEMREL	1	0.06	0.06	0.01	0.9319	
REP*CLAUSE*SEMREL	1	4.21	4.21	0.56	0.4575	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON*DIS	2	56.70	28.35	3.45	0.0350	*
REP*DISCO*ICON*DIS	2	4.80	2.40	0.29	0.7473	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON*CLAUSE	2	35.56	17.78	2.52	0.0842	
REP*DISC*ICON*CLAUS	2	1.31	0.65	0.09	0.9113	

Source	DF	SS	MS	F	Pr > F	
DISCO*DIS*CLAUSE	2	28.87	14.44	1.94	0.1485	
REP*DISCO*DIS*CLAUSE	2	11.24	5.62	0.75	0.4725	

Source	DF	SS	MS	F	Pr > F	
ICON*DIS*CLAUSE	1	0.53	0.53	0.05	0.8267	
REP*ICON*DIS*CLAUSE	1	7.45	7.45	0.68	0.4129	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON*SEMREL	2	123.77	61.89	10.08	<.0001	**
REP*DISC*ICON*SEMRE	2	1.77	0.89	0.14	0.8657	

Source	DF	SS	MS	F	Pr > F	
DISCO*DIS*SEMREL	2	0.87	0.44	0.06	0.9412	
REP*DISCO*DIS*SEMREL	2	6.44	3.22	0.45	0.6400	

Source	DF	SS	MS	F	Pr > F	
ICON*DIS*SEMREL	1	20.78	20.78	3.38	0.0715	
REP*ICON*DIS*SEMREL	1	7.58	7.58	1.23	0.2720	

Source	DF	SS	MS	F	Pr > F	
DISCO*CLAUSE*SEMREL	2	12.61	6.31	0.76	0.4718	
REP*DISC*CLAUS*SEMRE	2	3.31	1.66	0.20	0.8203	

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE*SEMREL	1	0.21	0.21	0.02	0.8870	
REP*ICON*CLAUS*SEMRE	1	20.68	20.68	2.00	0.1635	!

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE*SEMREL	1	8.81	8.81	0.74	0.3934
REP*DIS*CLAUS*SEMREL	1	7.99	7.99	0.67	0.4162

Source	DF	SS	MS	F	Pr > F
DISC*ICON*DIS*CLAUS	2	25.14	12.57	1.29	0.2835
REP*DIS*ICO*DIS*CLAU	2	34.37	17.19	1.76	0.1808

Source	DF	SS	MS	F	Pr > F	
DISC*ICON*DIS*SEMRE	2	76.62	38.31	3.92	0.0273	* !
REP*DIS*ICO*DIS*SEMR	2	77.23	38.61	3.95	0.0266	*

Source	DF	SS	MS	F	Pr > F
DISC*ICON*CLAU*SEMRE	2	34.60	17.30	1.30	0.2847

Source	DF	SS	MS	F	Pr > F
DISC*DIS*CLAUS*SEMRE	2	0.67	0.34	0.04	0.9591

APPENDIX S

Omnibus ANOVA Raw Scores (Four-Ways Subtracted. Missing Scores not Replaced).

Source	DF	SS	MS	F	Pr > F
REP	1	55.62	55.62	1.01	0.3184

Source	DF	Type	III	SS	Mean
DISCO	2	35.23	17.62	1.66	0.1945
REP*DISCO	2	9.31	4.66	0.44	0.6460

Source	DF	Type	III	SS	Mean
ICON	1	10.27	10.27	1.16	0.2856
REP*ICON	1	12.48	12.48	1.41	0.2395

Source	DF	Type	III	SS	Mean
DIS	1	2.05	2.05	0.27	0.6021
REP*DIS	1	0.04	0.04	0.01	0.9402

Source	DF	Type	III	SS	Mean
CLAUSE	1	16.84	16.84	1.99	0.1637
REP*CLAUSE	1	9.76	9.76	1.15	0.2874

Source	DF	Type	III	SS	Mean	
SEMREL	1	83.82	83.82	9.73	0.0027	**
REP*SEMREL	1	0.72	0.72	0.08	0.7740	

Source	DF	Type	III	SS	Mean
DISCO*ICON	2	2.40	1.20	0.17	0.8476
REP*DISCO*ICON	2	20.67	10.34	1.43	0.2439

Source	DF	Type	III	SS	Mean
DISCO*DIS	2	24.34	12.17	1.21	0.3021
REP*DISCO*DIS	2	12.97	6.48	0.64	0.5270

Source	DF	Type	III	SS	Mean
ICON*DIS	1	6.88	6.88	0.68	0.4129
REP*ICON*DIS	1	0.79	0.79	0.08	0.7804

Source	DF	Type	III	SS	Mean
DISCO*CLAUSE	2	37.19	18.59	2.23	0.1121
REP*DISCO*CLAUSE	2	2.61	1.30	0.16	0.8556

Source	DF	Type	III	SS	Mean	
ICON*CLAUSE	1	62.24	62.24	6.32	0.0145	*
REP*ICON*CLAUSE	1	5.00	5.00	0.51	0.4786	

Source	DF	Type	III	SS	Mean
DIS*CLAUSE	1	12.84	12.84	1.49	0.2272
REP*DIS*CLAUSE	1	4.05	4.05	0.47	0.4960

Source	DF	Type	III	SS	Mean	
DISCO*SEMREL	2	22.00	11.00	1.55	0.2154	
REP*DISCO*SEMREL	2	32.42	16.21	2.29	0.1054	

Source	DF	Type	III	SS	Mean	
ICON*SEMREL	1	12.65	12.65	1.58	0.2132	
REP*ICON*SEMREL	1	0.21	0.21	0.03	0.8714	

Source	DF	Type	III	SS	Mean	
DIS*SEMREL	1	40.60	40.60	5.78	0.0192	*
REP*DIS*SEMREL	1	1.39	1.39	0.20	0.6583	

Source	DF	Type	III	SS	Mean	
CLAUSE*SEMREL	1	3.42	3.42	0.42	0.5213	
REP*CLAUSE*SEMREL	1	1.57	1.57	0.19	0.6633	

Source	DF	Type	III	SS	Mean	
DISCO*ICON*DIS	2	25.12	12.56	1.29	0.2802	

Source	DF	Type	III	SS	Mean	
DISCO*ICON*CLAUSE	2	33.67	16.83	2.26	0.1088	

Source	DF	Type	III	SS	Mean	
DISCO*DIS*CLAUSE	2	6.21	3.10	0.32	0.7290	

Source	DF	Type	III	SS	Mean	
ICON*DIS*CLAUSE	1	1.81	1.81	0.21	0.6485	

Source	DF	Type	III	SS	Mean	
DISCO*ICON*SEMREL	2	132.57	66.29	9.74	0.0001	**

Source	DF	Type	III	SS	Mean	
DISCO*DIS*SEMREL	2	12.66	6.33	0.85	0.4301	

Source	DF	Type	III	SS	Mean	
ICON*DIS*SEMREL	1	3.29	3.29	0.73	0.3953	

Source	DF	Type	III	SS	Mean	
DISCO*CLAUSE*SEMREL	2	9.34	4.67	0.60	0.5505	

Source	DF	Type	III	SS	Mean	
ICON*CLAUSE*SEMREL	1	1.60	1.60	0.22	0.6432	
REP*ICON*CLAUS*SEMRE	1	17.95	17.95	2.43	0.1250	

Source	DF	Type	III	SS	Mean	
DIS*CLAUSE*SEMREL	1	2.79	2.79	0.34	0.5641	

Source	DF	Type	III	SS	Mean

REP*DIS*ICO*DIS*CLAU	4	18.97	4.74	0.44	0.7766

Source	DF	Type	III	SS	Mean
DISC*ICON*DIS*SEMRE	2	61.70	30.85	2.92	0.0589
REP*DIS*ICO*DIS*SEMR	2	14.66	7.33	0.69	0.5021

APPENDIX T

Omnibus ANOVA Raw Scores. (Missing Scores not Replaced).

Source	DF	SS	MS	F	Pr > F	
REP	1	71.67	71.67	0.94	0.3366	
SUBJ(REP)	62	4737.27	76.41	.	.	

Source	DF	SS	MS	F	Pr > F	
DISCO	2	104.56	52.28	4.91	0.0089	**
REP*DISCO	2	0.18	0.09	0.01	0.9918	
SUBJ*DISCO(REP)	124	1320.45	10.65	.	.	

Source	DF	SS	MS	F	Pr > F	
ICON	1	23.79	23.79	3.38	0.0707	
REP*ICON	1	14.00	14.00	1.99	0.1633	
SUBJ*ICON(REP)	62	436.13	7.03	.	.	

Source	DF	SS	MS	F	Pr > F	
DIS	1	7.02	7.02	0.72	0.3998	
REP*DIS	1	5.31	5.31	0.54	0.4636	
SUBJ*DIS(REP)	62	605.80	9.77	.	.	

Source	DF	SS	MS	F	Pr > F	
CLAUSE	1	7.12	7.12	0.95	0.3345	
REP*CLAUSE	1	25.64	25.64	3.41	0.0696	
SUBJ*CLAUSE(REP)	62	466.36	7.52	.	.	

Source	DF	SS	MS	F	Pr > F	
SEMREL	1	170.72	170.72	17.44	<.0001	**
REP*SEMREL	1	0.15	0.15	0.02	0.9004	
SUBJ*SEMREL(REP)	62	606.82	9.79	.	.	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON	2	0.16	0.08	0.01	0.9929	
REP*DISCO*ICON	2	8.46	4.23	0.38	0.6859	
SUBJ*DISCO*ICON(REP)	124	1386.53	11.18	.	.	

Source	DF	SS	MS	F	Pr > F	
DISCO*DIS	2	33.32	16.66	1.60	0.2056	
REP*DISCO*DIS	2	19.30	9.65	0.93	0.3980	
SUBJ*DISCO*DIS(REP)	124	1289.40	10.40	.	.	

Source	DF	SS	MS	F	Pr > F	
ICON*DIS	1	4.89	4.89	0.48	0.4906	
REP*ICON*DIS	1	5.22	5.22	0.51	0.4764	
SUBJ*ICON*DIS(REP)	62	630.87	10.18	.	.	

Source	DF	SS	MS	F	Pr > F
DISCO*CLAUSE	2	39.28	19.64	1.95	0.1460

REP*DISCO*CLAUSE	2	10.43	5.22	0.52	0.5963	
SUBJ*DISCO*CLAUSE(REP)	124	1246.12	10.05	.	.	

Source	DF	SS	MS	F	Pr > F	
ICON*CLAUSE	1	69.84	69.84	7.30	0.0089	**[1]
REP*ICON*CLAUSE	1	2.78	2.78	0.29	0.5915	
SUBJ*ICON*CLAUSE(REP)	62	593.01	9.56	.	.	

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE	1	21.49	21.49	2.61	0.1112
REP*DIS*CLAUSE	1	17.67	17.67	2.15	0.1478
SUBJ*DIS*CLAUSE(REP)	62	510.12	8.23	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*SEMREL	2	17.76	8.88	1.35	0.2618
REP*DISCO*SEMREL	2	22.19	11.09	1.69	0.1882
SUBJ*DISCO*SEMREL(REP)	124	812.74	6.55	.	.

Source	DF	SS	MS	F	Pr > F
ICON*SEMREL	1	1.37	1.37	0.19	0.6626
REP*ICON*SEMREL	1	3.67	3.67	0.52	0.4755
SUBJ*ICON*SEMREL(REP)	62	441.15	7.12	.	.

Source	DF	SS	MS	F	Pr > F	
DIS*SEMREL	1	52.55	52.55	7.56	0.0078	**[2]
REP*DIS*SEMREL	1	4.25	4.25	0.61	0.4376	
SUBJ*DIS*SEMREL(REP)	62	431.23	6.96	.	.	

Source	DF	SS	MS	F	Pr > F
CLAUSE*SEMREL	1	0.39	0.39	0.05	0.8211
REP*CLAUSE*SEMREL	1	3.14	3.14	0.42	0.5190
SUBJ*CLAUSE*SEMREL(REP)	62	463.31	7.47	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*ICON*DIS	2	53.43	26.72	2.98	0.0546
REP*DISCO*ICON*DIS	2	3.94	1.97	0.22	0.8032
SUBJ*DISCO*ICON*DIS(REP)	122	1094.68	8.97	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*ICON*CLAUSE	2	28.94	14.47	2.07	0.1307
REP*DISC*ICON*CLAUS	2	21.86	10.93	1.56	0.2138
SUBJ*DISCO*ICON*CLAUSE(REP)	124	867.41	7.00	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*DIS*CLAUSE	2	30.11	15.06	1.84	0.1633
REP*DISCO*DIS*CLAUSE	2	7.02	3.51	0.43	0.6523
SUBJ*DISCO*DIS*CLAUSE(REP)	122	998.62	8.19	.	.

Source	DF	SS	MS	F	Pr > F
ICON*DIS*CLAUSE	1	7.18	7.18	0.66	0.4182

REP*ICON*DIS*CLAUSE	1	6.69	6.69	0.62	0.4345	
SUBJ*ICON*DIS*CLAUSE(REP)	62	670.67	10.82	.	.	

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON*SEMREL	2	123.38	61.69	10.71	<.0001	**[3]
REP*DISC*ICON*SEMRE	2	4.42	2.21	0.38	0.6826	
SUBJ*DISCO*ICON*SEMREL(REP)	106	610.75	5.76	.	.	

Source	DF	SS	MS	F	Pr > F
DISCO*DIS*SEMREL	2	2.39	1.20	0.16	0.8530
REP*DISCO*DIS*SEMREL	2	2.32	1.16	0.15	0.8570
SUBJ*DISCO*DIS*SEMREL(REP)	120	900.95	7.51	.	.

Source	DF	SS	MS	F	Pr > F
ICON*DIS*SEMREL	1	10.99	10.99	1.62	0.2092
REP*ICON*DIS*SEMREL	1	9.58	9.58	1.41	0.2407
SUBJ*ICON*DIS*SEMREL(REP)	54	367.44	6.80	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*CLAUSE*SEMREL	2	4.10	2.05	0.25	0.7801
REP*DISCO*CLAUSE*SEMREL	2	3.20	1.60	0.19	0.8234
SUBJ*DISCO*CLAUSE*SEMREL(REP)	115	946.47	8.23	.	.

Source	DF	SS	MS	F	Pr > F
ICON*CLAUSE*SEMREL	1	0.01	0.01	0.00	0.9719
REP*ICON*CLAUSE*SEMREL	1	23.85	23.85	2.20	0.1440
SUBJ*ICON*CLAUSE*SEMREL(REP)	50	541.24	10.82	.	.

Source	DF	SS	MS	F	Pr > F
DIS*CLAUSE*SEMREL	1	8.83	8.83	0.70	0.4082
REP*DIS*CLAUSE*SEMREL	1	11.81	11.81	0.93	0.3395
SUBJ*DIS*CLAUSE*SEMREL(REP)	52	660.68	12.71	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*ICON*DIS*CLAUSE	2	8.08	4.04	0.43	0.6553
REP*DISCO*ICON*DIS*CLAUSE	2	60.06	30.03	3.16	0.0496
SUBJ*DISCO*ICON*DIS*CLAUSE(REP)	58	550.40	9.49	.	.

Source	DF	SS	MS	F	Pr > F	
DISCO*ICON*DIS*SEMREL	2	72.60	36.30	3.76	0.0316	
REP*DISCO*ICON*DIS*SEMREL	2	114.90	57.45	5.96	0.0054	**
SUBJ*DISCO*ICON*DIS*SEMREL(REP)	41	395.39	9.64	.	.	

Source	DF	SS	MS	F	Pr > F
DISCO*ICON*CLAUSE*SEMREL	2	26.30	13.15	0.90	0.4154
REP*DISCO*ICON*CLAUSE*SEMREL	2	11.81	5.90	0.41	0.6700
SUBJ*DISCO*ICON*CLAUSE*SEMREL(REP)	32	466.00	14.56	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*DIS*CLAUSE*SEMREL	2	1.21	0.60	0.07	0.9331

REP*DISCO*DIS*CLAUSE*SEMREL	2	2.46	1.23	0.14	0.8685
SUBJ*DISCO*DIS*CLAUSE*SEMREL(REP)	41	357.06	8.71	.	.

Source	DF	SS	MS	F	Pr > F
DISCO*ICON*DIS*CLAUSE*SEMREL	2	46.38	23.19	1.15	0.3395
REP*DISCO*ICON*DIS*CLAUSE*SEMREL	2	31.72	15.86	0.78	0.4712
SUBJ*DISCO*ICON*DIS*CLAUSE*SEMREL(REP)	18	363.70	20.21	.	.

[1] Fmax=4, ~1339=1.02, P>.05,
[2] Fmax=4, ~1337=1.26, P>.05
[3] Fmax=12, ~454=1.05, P>.05

APPENDIX U

Least Squared Means.

Discourse Order by Iconicity by Semantic Relationship

	Physical Chrono	Social Chrono	Physical Nchrono	Social Nchrono
GivenGiven	5.128	6.073	5.225	5.740
GivenNew	6.345	5.964	5.598	6.529
NewGiven	5.613	6.595	5.608	6.091

Iconicity by Clause

	Main Clause First	Main Clause Last
Chronological	5.657	6.249
Non-Chronological	5.945	5.652

Semantic Relationship by Psychological Distance

	Physical	Social
Near	5.545	6.357
Far	5.627	5.974

Discourse Order

GG	5.542
GN	6.109
NG	5.977

APPENDIX V

Paired Comparisons.

DISCOURSE ORDER BY ICONICITY BY SEMANTIC RELATIONSHIP

ICON at GivenGiven, Physical

Source	DF	SS	MS	F Value	Pr > F
ICON	1	0.25	0.25	0.05	0.8158
SUBJ*ICON(REP)	60	269.10	4.48	.	.

ICON at GivenGiven, Social

Source	DF	SS	MS	F Value	Pr > F
ICON	1	26.20	26.20	2.48	0.1205
SUBJ*ICON(REP)	63	666.18	10.57	.	.

ICON at GivenNew, Physical

Source	DF	SS	MS	F Value	Pr > F	TK F Value*	Pr > F
ICON	1	25.38	25.38	4.11	0.0469	4.28	>.05
SUBJ*ICON(REP)	62	382.91	6.18	.	.		

ICON at GivenNew, Social

Source	DF	SS	MS	F Value	Pr > F	TK F Value	Pr > F
ICON	1	28.03	28.03	5.53	0.0218	3.91	>.05
SUBJ*ICON(REP)	63	319.28	5.07	.	.		

ICON at NewGiven, Physical

Source	DF	SS	MS	F Value	Pr > F
ICON	1	6.13	6.13	0.96	0.3312
SUBJ*ICON(REP)	63	402.65	6.39	.	.

ICON at NewGiven, Social

Source	DF	SS	MS	F Value	Pr > F	TK F Value	Pr > F
ICON	1	45.68	45.68	5.20	0.0259	2.74	>.05
SUBJ*ICON(REP)	63	553.02	8.78	.	.		

* Tukey-Kramer F-value

SEMREL at GivenGiven, Chrono

Source	DF	SS	MS	F Value	Pr > F	TK F Value	Pr > F
SEMREL	1	57.16	57.16	8.58	0.0048	5.4	<.05
SUBJ*SEMREL(REP)	62	413.08	6.66	.	.		

SEMREL at GivenGiven, Nchrono

Source	DF	SS	MS	F Value	Pr > F
SEMREL	1	35.06	35.06	3.63	0.0612
SUBJ*SEMREL(REP)	63	607.84	9.65	.	.

SEMREL at GivenNew, Chrono

Source	DF	SS	MS	F Value	Pr > F
SEMREL	1	13.12	13.12	2.83	0.0976
SUBJ*SEMREL(REP)	63	292.36	4.64	.	.

SEMREL at GivenNew, Nchrono

Source	DF	SS	MS	F Value	Pr > F	TK F Value	Pr > F
SEMREL	1	103.34	103.34	14.32	0.0003	2.83	>.05
SUBJ*SEMREL(REP)	63	454.68	7.22	.	.		

SEMREL at NewGiven, Chrono

Source	DF	SS	MS	F Value	Pr > F	TK F Value	Pr > F
SEMREL	1	147.77	147.77	19.90	<.0001	5.42	<.05
SUBJ*SEMREL(REP)	63	467.83	7.43	.	.		

SEMREL at NewGiven, Nchrono

Source	DF	SS	MS	F Value	Pr > F
SEMREL	1	12.06	12.06	1.50	0.2254
SUBJ*SEMREL(REP)	63	507.05	8.05	.	.

ICONICITY BY CLAUSE

CLAUSE at Chrono

Source	DF	SS	MS	F Value	Pr > F	TK F Value	Pr > F
CLAUSE	1	99.12	99.12	9.96	0.0025	6.38	<.05
SUBJ*CLAUSE(REP)	63	627.09	9.95	.	.		

CLAUSE at Nchrono

Source	DF	SS	MS	F Value	Pr > F
CLAUSE	1	26.27	26.27	3.49	0.0662
SUBJ*CLAUSE(REP)	63	473.65	7.52	.	.

ICON at Mcfirst

Source	DF	SS	MS	F Value	Pr > F
ICON	1	12.51	12.51	2.16	0.1466
SUBJ*ICON(REP)	63	370.81	5.89	.	.

ICON at Mclast

Source	DF	SS	MS	F Value	Pr > F	TK F Value	Pr > F
ICON	1	134.51	134.51	12.61	0.0007	6.44	<.05
SUBJ*ICON(REP)	63	671.89	10.66	.	.		

PSYCHOLOGICAL DISTANCE BY SEMANTIC RELATIONSHIP

DIS at Physical

Source	DF	SS	MS	F Value	Pr > F
DIS	1	0.40	0.40	0.05	0.8160
SUBJ*DIS(REP)	63	460.20	7.30	.	.

DIS at Social

Source	DF	SS	MS	F Value	Pr > F
DIS	1	37.23	37.23	3.42	0.0690
SUBJ*DIS(REP)	63	685.59	10.88	.	.

SEMREL at Near

Source	DF	SS	MS	F Value	Pr > F	TK F Value	Pr > F
SEMREL	1	226.05	226.05	32.46	<.0001	7.99	>.05
SUBJ*SEMREL(REP)	63	438.80	6.97	.	.		

SEMREL at Far

Source	DF	SS	MS	F Value	Pr > F
SEMREL	1	19.25	19.25	2.39	0.1269
SUBJ*SEMREL(REP)	63	506.73	8.04	.	.