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## Understanding and producing the reduced relative construction: Evidence from ratings, editing and corpora

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### Abstract

Two rating studies demonstrate that English speakers willingly produce reduced relatives with internal cause verbs (e.g., *Whisky fermented in oak barrels can have a woody taste*), and judge their acceptability based on factors known to influence ambiguity resolution, rather than on the internal/external cause distinction. Regression analyses demonstrate that frequency of passive usage predicts reduced relative frequency in corpora, but internal/external cause status does not. The authors conclude that reduced relatives with internal cause verbs are rare because few of these verbs occur in the passive. This contrasts with the claim in McKoon and Ratcliff (McKoon, G., & Ratcliff, R. (2003). Meaning through syntax: Language comprehension and the reduced relative clause construction. *Psychological Review*, 110, 490–525) that reduced relatives like *The horse raced past the barn fell* are rare and, when they occur, incomprehensible, because the meaning of the reduced relative construction prohibits the use of a verb with an internal cause event template.

### Keywords

Lexical semantics; Language comprehension; Language production; Meaning through syntax (MTS)

### Introduction

More than three decades ago, Bever (1970) used reduced relatives such as *the horse raced past the barn fell* as the centerpiece of an argument that merely adding performance considerations such as limited working memory capacity to a linguistic competence grammar would be insufficient to explain linguistic performance in sentence perception. Bever argued that the field of psycholinguistics would have to develop its own independently motivated theories of how grammatical relations are recovered during comprehension. The force of Bever's argument was that neither grammatical competence, nor memory limitations, nor any simple combination of the two, would provide a plausible account for why *the horse raced past the barn fell* is typically judged to be unacceptable. A grammatical explanation fails because propositions that can be realized in unreduced relative clauses invariably can occur in reduced relative clauses. There is no principled linguistic argument for why there should be an exception to this general characteristic of English grammar for *the horse that was raced past the barn fell*. A memory load explanation fails because other sentences that seem to make heavier demands on a limited capacity memory

are clearly acceptable, as for example, *The horse that was presented to the visiting dignitary as a gift by the Arabian Horse Foundation was a truly magnificent beast.*

Bever's alternative explanation for the difficulty of *the horse raced past the barn fell* was based on his observation that *the horse raced past the barn* is ambiguous between a reduced relative and a main clause. Bever (1970) proposed that readers and listeners are gardenpathed because they follow a general Subject-Main verb-Object processing strategy, which biases them towards the more canonical main clause and away from the less likely reduced relative. We should note that Bever's perceptual strategies approach was a precursor of recent evidence-based approaches to ambiguity resolution, all of which adopt essentially Bayesian perspectives. In the subsequent decades, especially the 1980s and 1990s, temporary ambiguity became a central empirical testing ground for evaluating models of parsing and interpretation (for reviews, see Frazier, 1987; MacDonald, Pearlmutter, & Seidenberg, 1994; Tanenhaus & Grodner, 2006; Tanenhaus & Trueswell, 1995). Reduced relatives have featured prominently in many theoretical and empirical debates, especially debates about whether certain classes of constraints, such as verb-specific information and referential context, influence initial syntactic commitments, as claimed by constraint-based models (MacDonald, 1993; McRae, Spivey-Knowlton, & Tanenhaus, 1998; Pearlmutter & MacDonald, 1995; Trueswell, 1996; Trueswell & Tanenhaus, 1991; Trueswell, Tanenhaus, & Garnsey, 1994), or the ease of garden-path recovery, as claimed by twostage models (Clifton et al., 2003; Ferreira and Clifton, 1986; Frazier, 1995; Rayner, Carlson, & Frazier, 1983; Rayner, Garrod, & Perfetti, 1992).

Stevenson and Merlo (1997) observed that many difficult reduced relatives contain unergative (manner-of motion) verbs such as *race*, whereas easier reduced relatives contain unaccusative (external cause change of state) verbs. Adopting the syntax-in-the-lexicon approach of Hale and Keyser (1993), they proposed that garden-path recovery for reduced relatives with unergative verbs exceeds the resource limitations of the competitive-attachment parser proposed by Stevenson (1994). McKoon and Ratcliff (2003, 2005) build upon Stevenson and Merlo's observations about manner of motion verbs, but present a dramatically different approach. McKoon and Ratcliff argue that there is a principled grammatical reason why *the horse raced past the barn fell* is unacceptable. They claim that verbs like *race*, which have an internal cause in their event template, are grammaticality prohibited from being used in the reduced relative construction because internal control by the entity in head position is prohibited by the construction meaning of the reduced relative. Thus, in contrast to the standard view in the field, they argue that *the horse raced past the barn fell* is unacceptable because it is not grammatically licensed. This analysis of the reduced relative construction forms the centerpiece of a new theory of sentence comprehension and production, Meaning through Syntax (MTS). The data offered in support of the MTS analysis, presented in McKoon and Ratcliff (2003, 2005), come from rating studies, reading time experiments, and most crucially, a large-scale corpus analysis, from which the authors conclude that reduced relatives occur so rarely with internal cause change of state verbs, such as *erode*, and manner of motion verbs, such as *race*, that the few occurrences can be considered errors.

McRae, Hare, and Tanenhaus (2005) critiqued the MTS approach to reduced relatives and defended ambiguity-resolution accounts, in particular constraint-based approaches, which had been criticized by McKoon and Ratcliff (2003). Here we build on our earlier work by presenting data from a rating study (which was briefly summarized in McRae et al., 2005) an editing study and a corpus analysis. The results are incompatible with the MTS approach, while supporting alternatives based upon more standard linguistic and processing assumptions, including those incorporated into most constraint-based models. Before we

turn to the experimental work, we review some of linguistic background that McKoon and Ratcliff (2003) use to motivate MTS and its approach to the reduced relative construction.

### Verb meaning and verb argument structure

It is well known that there is a systematic relationship among the type of event or activity that a verb denotes, the nature of the entities that participate in that event, and the types of syntactic complements with which that verb can occur. As one example, events described by verbs of transfer typically involve three participants: The agent of the transfer, the recipient, and the entity being transferred, which is the theme or patient. [Note that although we adopt the terminology of thematic roles to describe modes of participation, the point we are making is independent of one's theoretical stance about the usefulness of thematic roles as a linguistic or conceptual construct.] These verbs typically occur in the dative construction (i.e., Noun Phrase Verb Noun Phrase *to* Noun Phrase; *Cole sent the flyer to the man*) or the double object construction (Noun Phrase Verb Noun Phrase Noun Phrase; *Cole sent the man the flyer*), where the structural arguments in the syntax align with the semantic arguments of the verb. Similarly, certain classes of verbs denote events or activities with only one participant (*She laughed; I sneezed*) and these occur predominantly in intransitive structures. Children as well as adult comprehenders exploit these correlations between a verb's meaning and its preferred argument structure (Fisher, Gleitman, & Gleitman, 1991; Gillette, Gleitman, Gleitman, & Lederer, 1999; Hare, McRae, & Elman, 2004).

Observations like these underlie both the syntactic bootstrapping hypothesis for how young children might learn words whose meaning cannot easily be depicted (Gleitman, 1990) and the competing semantic bootstrapping hypothesis, which argues that the child relies on the cognitive distinction between things and actions to develop the syntactic categories of noun and verb (Pinker, 1989). The non-arbitrary mapping between syntactic complements and verb meaning also provides some of the motivation for the influential research program of Levin and colleagues (Levin, 1993; Levin & Rappaport Hovav, 1995), which uses shared alternations like the *to*-dative and double-object construction to construct more fine-grained verb classes. This work, along with the notion of construction meaning proposed in Goldberg (1995), provides the foundation for MTS, and so we review the most relevant findings before turning to the details of the MTS account of reduced relatives.

Levin and Rappaport Hovav (1995), among others, have noted the close fit between syntactic structure and the causal structure of the event denoted by the verb. As a general rule, the entity construed as the cause of an event or activity appears in subject position, while an entity that changes as a result of the event, or otherwise undergoes its effects, appears as direct object. This intuition is formalized as an event template that represents those aspects of a verb's meaning (including causality) that determine the syntactic structures in which the verb will occur. On Levin and Rappaport Hovav's account, there are two types of causal structure, *external* and *internal*. External cause verbs such as *break* have two arguments, the entity that becomes broken and an agent, instrument, or natural force that causes the breaking event. In contrast, internal cause verbs such as *walk* or *erode* have one argument, which is responsible for bringing about the activity or event in which it participates. Linking or movement rules relate the causal argument in both cases to syntactic subject, and (for external cause verbs) link the affected argument to direct object position. As a result, external cause verbs like *break* are predicted to occur in transitive sentences (*I broke the dish*), and internal cause verbs in intransitives (*The dog walked*). These are the dominant syntactic patterns for these verbs, but other structures are also acceptable, and therefore this account includes mechanisms to account for transitivity alternations. These allow an external cause argument not to surface with external cause verbs (*The dish broke*) or be added to the syntax with internal cause verbs (*High waves eroded the beach; I walked my dog along the embankment*).

The apparently straightforward relationship between the syntax and lexical semantics is complicated by the important observation that syntactic constructions themselves can contribute to meaning (Goldberg, 1995, 2003; Goldberg & Jackendoff, 2004; Jackendoff, 1997, 2002a, 2002b). Some of the strongest evidence comes from the observation that constructions can *coerce* interpretations that are clearly not licensed by the verb itself. For example, the caused-motion construction, exemplified by sentences such as *Ken finally hit the ball out of the infield*, expresses the meaning that the cause argument (*Ken*) causes the theme (*the ball*) to move along the path indicated by the directional phrase (*out of the infield*), and the sentence is interpreted that way even though *hit* is not a caused motion verb. More strikingly, the same interpretation is available in *Fred sneezed the tissue off the table*, or *They laughed the poor guy out of the room*, which are grammatical even though neither *sneeze* nor *laugh* licenses a direct object. The caused-motion meaning is contributed by the construction itself, and the verb is said to be coerced into that meaning by the construction.

### Meaning through syntax

With MTS, McKoon and Ratcliff (2003) adopt ideas about event templates taken from the work of Levin and colleagues, and ideas about construction meaning that are inspired by construction grammar, and combine these in a novel way to derive empirical predictions about sentence processing, in particular comprehension of the reduced relative construction. On the MTS account, the reduced relative construction expresses “participation in an event caused by some force or entity external to itself” (McKoon & Ratcliff, 2003, p. 492). Internal cause verbs cannot appear in reduced relatives in which the head is the entity engaging in the activity because this is inconsistent with the meaning of the construction. Coercion (in the standard construction grammar sense) does not play a role, and therefore reduced relatives like *The horse raced past the barn fell* simply violate this restriction and are deemed ungrammatical. In contrast, external cause change of state verbs like *break* or *fade* abide by the restriction, and are permitted in the reduced relative (McKoon & Ratcliff, 2003, p. 496). Thus MTS claims that a simple dichotomous variable, presence or absence of an external cause in a verb’s event template, coupled with the meaning of the reduced relative construction, can account for whether or not a verb is licensed to participate in a reduced relative.

This claim is strong and counter-intuitive, and thus deserves careful scrutiny. It also leads to three clear empirical predictions. First, the status of a verb as external or internal cause will determine its acceptability and likelihood of occurrence in reduced relative constructions. Reduced relatives with external cause verbs will be acceptable (McKoon & Ratcliff, 2003, p. 496), while those in which the head is an internal cause will not be (McKoon & Ratcliff, 2003, p. 502). Consequently, MTS also predicts that reduced relative comprehension will be unrelated to ambiguity, contrary to the more generally accepted prediction that pragmatic, discourse and semantic factors that are known to influence ambiguity resolution should affect the acceptability of sentences with reduced relatives. Finally, MTS states that different syntactic forms interact differently with the meaning of verbs (McKoon & Ratcliff, 2005, p. 1035), such that the ungrammaticality of a verb in the reduced relative is unrelated to its acceptability in the unreduced relative or the passive. Again, this contrasts with the standard account, assumed by linguistic analyses and ambiguity-based accounts, that the reduced relative is a type of passive construction, and the degree to which any particular verb occurs in the simple passive should predict that verb’s likelihood of occurring in other passive constructions, like the reduced relative.

We present two questionnaire studies and a corpus analysis that were designed to contrast these predictions of the MTS event template approach with those made by standard ambiguity-based accounts, including both constraint-based accounts and two-stage models (Clifton et al., 2003; Ferreira & Clifton, 1986; MacDonald et al., 1994; McRae et al., 1998;

Rayner et al., 1983; Sturt, Scheepers, & Pickering, 2002; Tanenhaus, Spivey-Knowlton, & Hanna, 2000; Tanenhaus & Trueswell, 1995). In the first questionnaire study, participants rated the comprehensibility of sentences with unreduced relative clauses, reduced relative clauses, and passives for sets of (a) external cause change of state verbs and (b) internal cause change of state and manner of motion verbs. For each set, we constructed reduced relatives that were designed to be easy or hard based on factors that are known to influence ambiguity resolution. The results demonstrate that there is no categorical distinction in the comprehensibility of reduced relatives with internal or external cause verbs, that factors underlying ambiguity resolution determine comprehensibility, and that the three passive structures are related. In the second questionnaire study, we asked participants to produce shortened versions of target sentences, the most important of which were the unreduced relatives from Study 1. Easy reduced relatives for internal cause verbs were frequently generated, and received high acceptability ratings, and there was a strong relationship between reduced and unreduced relatives. These studies led us to conduct a large-scale corpus study using the two most widely vetted parsed corpora, Brown and the Wall Street Journal, and two larger corpora, the Wall Street Journal 87 and the British National Corpus. The goal was to determine if verb template, i.e., whether or not a verb is hypothesized to have an external cause, explains the occurrence of reduced relatives, when a less construction-specific factor, frequency of passive use, is taken into account.

## Study 1

Participants were presented with a set of sentences, as described above, and were asked to rate how easy each sentence was to understand on a seven-point scale, where 1 = “makes no sense”, 4 = “moderately easy to understand”, and 7 = “extremely easy to understand”. [Participants were actually given the reverse of this scale, but we reverse it here for presentation purposes so that it matches the scale used in Study 2. This conversion of responses does not influence the inferential statistics in any way.] Study 1 has three main goals. The first is to investigate whether there is a categorical distinction between external and internal cause verbs in their potential usage in reduced relatives, contradicting the MTS position that reduced relatives with an internal cause in head position are prohibited in English. If MTS was correct, internal cause reduced relatives would not be rated as easily comprehensible. Thus our first goal is to test whether reduced relatives with internal cause verbs can be easily comprehended. The second goal is to test whether, contrary to the assertions of MTS, difficulty in comprehending reduced relatives is related to their temporary ambiguity. To investigate this, we compare ratings of unreduced (unambiguous) and reduced (ambiguous) relative clauses. We also argue that the ability of a verb to appear in the reduced or unreduced relative is dependent on its ability to appear in the passive, because all three are passive constructions. Therefore, the final goal is to test whether the acceptability of a verb in the reduced and unreduced relatives is related to acceptability of the corresponding passive, and that acceptability of the passive is a better predictor of reduced relative acceptability than is the internal/external cause distinction.

To accomplish these three goals, we chose 24 external cause and 23 internal cause verbs, and created a sentence with a reduced relative clause that was predicted to be hard to understand for 12 of the verbs of each type, and a sentence that was predicted to be easy to understand for the other 12 (with one internal cause verb used twice). Using the reduced relative as the kernel sentence, we then transformed it into a sentence with an unreduced relative clause and one with a simple passive, and asked participants to rate the comprehensibility of each sentence type. The easy/hard difference was based on the specific verb, plus factors that have been identified as modulating the difficulty of reduced relative clauses.

## Method

**Participants**—Thirty-three members of the Psychology communities at Bowling Green State University and the University of Western Ontario received course credit or were paid for their participation. There were 11 participants in list 1, 10 in list 2, and 12 in list 3.

**Materials**—We constructed sentences using 24 external cause and 23 internal cause verbs (the internal cause verb *walked* was used in both the easy and hard internal cause conditions). Causal status of the verbs was determined by McKoon and colleagues' classifications (McKoon & MacFarland, 2000, 2002; McKoon & Ratcliff, 2003). All verbs had identical past tense and past participle forms. For each verb, reduced relative, unreduced relative, and passive sentences were constructed. In addition to manipulating the verb, we created easy and hard sentences. The hard sentences were designed to be difficult to interpret as a passive construction, while the easy sentences were designed to support that interpretation. To do this, we manipulated the thematic fit of the initial noun phrase (the subject of the passive or the head of the unreduced or reduced relative), using noun phrases that were more likely to be agents in the event denoted by the verb in the hard sentences (e.g., *waiter served*), and noun phrases that were more likely to be patients in the easy ones (e.g., *applicants interviewed*). In addition, we manipulated the presence and type of post-verbal prepositional phrases to increase or decrease difficulty. The easy items with external cause verbs contained good patients in all 12 cases, postverbal agentive *by*-phrases in 7 cases, and various prepositional phrases or a postverbal verb phrase in the other 5 cases. In contrast, the hard items with external cause verbs contained good agents in all 12 cases, a good patient directly following the verb in 6 cases (no preposition), and various prepositional phrases or a postverbal verb phrase in the other 6. The easy items with internal cause verbs contained good patients in all 12 cases, postverbal agentive *by*-phrases in 8 cases, various prepositional phrases in 3 cases, and an adverb in the remaining case. The hard items with internal cause verbs contained good agents and temporal or locative prepositional phrases in all 12 cases, with no *by*-phrases. The motivation for these factors comes from empirical results reported in Clifton et al. (2003), Ferreira and Clifton (1986), MacDonald (1993), McRae et al. (1998), Rayner et al. (1983), Trueswell et al. (1994), Spivey-Knowlton, Trueswell, and Tanenhaus (1993). All items are presented with their mean ratings in Appendix A.

We constructed three lists, each containing 4 items from each of the 12 conditions that were formed by crossing verb type (external vs. internal cause), difficulty (easy vs. hard), and construction (reduced relative, unreduced relative, passive). Thus each participant rated 16 reduced relatives, 16 unreduced relatives, and 16 passives. Each list also contained 96 filler sentences of various other constructions, lengths, and levels of difficulty.

**Procedure**—Participants were instructed that 144 sentences would be presented, one at a time. They were asked to rate how easy each sentence was to understand on a 7-point scale with 1 = “makes no sense”, 4 = “moderately easy to understand”, and 7 = “extremely easy to understand”. They were asked to try to use the entire scale in their ratings. Participants also were informed that judgment time was not of interest, so they were free to work at their own pace. Sentences were presented one at a time in random order on a color monitor connected to a Macintosh computer, with stimulus presentation and data recording controlled by PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993). The response scale remained on the screen below the sentence during each trial. Participants recorded their ratings by pressing the 1 through 7 keys at the top of the keyboard.

## Results and discussion

Mean sentence comprehensibility ratings for all conditions are presented in Table 1, and the analyses of variance results are presented in Table 2.

**Reduced relative comprehensibility**—The dependent variable was reduced relative comprehensibility rating, and verb type (external cause vs. internal cause) and difficulty (easy vs. hard) were the independent variables. Both independent variables were within participants, but between items. In all relevant analyses reported in this article, list was included as a between-participants dummy variable and item rotation group as a between-items dummy variable to stabilize variance that may result from rotating participants and items over lists (Pollatsek & Well, 1995). Effects involving these dummy variables are not reported. In all studies reported here, the halfwidth of the confidence interval of the difference between means is reported in parentheses with the relevant contrasts. If the halfwidth is less than the observed difference between means, then the contrast would be significant by a conventional inferential test. Confidence intervals were computed using the methods suggested by Masson and Loftus (2003).

Factors influencing ambiguity resolution had a large effect on comprehensibility ratings: Easy reduced relatives,  $M = 5.8$ , were rated as significantly more comprehensible than hard ones,  $M = 3.1$  (0.3). Crucially, comprehensibility ratings were almost identical for external cause,  $M = 4.4$ , and internal cause verbs,  $M = 4.4$  (0.3). Thus verb type did not influence comprehensibility ratings, in contrast to the MTS claim that reduced relatives are comprehensible with external cause, but prohibited with internal cause verbs.

In addition, verb type and difficulty interacted. Easy sentences with internal cause verbs were more comprehensible than hard sentences with external cause verbs (mean difference = 2.7, halfwidth = 0.38). This result is inexplicable on the MTS account: If internal cause reduced relatives are prohibited, they should not be rated as more comprehensible than the allowable reduced relatives with external cause verbs. Furthermore, although easy reduced relatives with external cause verbs were rated as more comprehensible than easy reduced relatives with internal cause verbs (mean difference = 0.4, halfwidth = 0.38), hard reduced relatives with internal cause verbs were rated as more comprehensible than hard reduced relatives with external cause verbs (mean difference = 0.4, halfwidth = 0.38).

Two further tests were conducted to provide benchmarks for the ratings for hard and easy reduced relative clauses with internal cause verbs. In the first, we contrasted the ratings for the internal cause verbs with seven filler sentences. These fillers were all grammatically acceptable, but some were semantically anomalous, while others did have meaning but were difficult to understand (see Appendix B). These seven sentences ( $M = 2.2$ ,  $SE = 0.1$ ) were rated as significantly less comprehensible than even the hard internal cause reduced relatives ( $M = 3.3$ ,  $SE = 0.2$ ). More importantly, we also contrasted the ratings for the 12 easy internal cause sentences with those of 12 grammatical and perfectly comprehensible filler sentences (also presented in Appendix B). Both groups had a mean rating of 5.6 out of 7, with a standard error of 0.2. Together, the two benchmarks demonstrate that the high ratings for the internal cause reduced relatives were not due to a participant strategy of accepting grammatically coherent strings whether or not they were interpretable semantically. High ratings were reserved for sentences that were both grammatical and semantically coherent.

In summary, the results from the comprehension task provided no support for the hypothesis that reduced relatives with internal cause verbs are prohibited. Reduced relatives with internal cause verbs were rated as highly as those with external cause verbs, and in fact easy reduced relatives with internal cause verbs were rated as significantly more comprehensible

than the hard reduced relatives with external cause verbs, and equal to grammatical and semantically coherent sentences of other types.

Because of considerations discussed later, in Study 3, where we consider precisely which reduced relatives are most relevant to the claims of MTS, we eliminated three items with manner of motion verbs in which one might argue that the head is not the participating entity. These are *The path traveled by many settlers extended far to the west*, *The mountain climbed by the tourists sloped gently upward*, and *The city streets roamed by gangs of young men were too dangerous for tourists*. Removing these items did not affect the interpretation of any of the analyses because the mean comprehensibility rating for the easy internal cause sentences changed only minimally, from 5.6 to 5.5, and any change in the inferential statistics was minimal as well, with no changes in the pattern of effects.

**Ambiguity effects**—Our second goal was to show that much of the variability in the comprehension of reduced relatives is related to temporary ambiguity. The first piece of evidence for this was the main effect of difficulty described above. Further evidence comes from a comparison of the comprehensibility ratings for unreduced and reduced relatives. If the difficulty is indeed due to ambiguity, then the ambiguous reduced relatives should be rated as less comprehensible than the unambiguous unreduced relatives. Furthermore, ambiguity (unreduced vs. reduced relatives) should interact with difficulty (hard vs. easy), with larger ambiguity effects for hard than for easy sentences. This interaction should be found for both the external cause and internal cause verbs. Here we present analyses of variance testing these predictions.

We conducted analyses of variance in which verb type was within participants but between items, ambiguity was within participants and within items, and difficulty was within participants but between items. Overall, easy sentences ( $M = 5.9$ ) were rated as more comprehensible than hard sentences ( $M = 4.1$ ). There was a main effect of ambiguity, with unreduced sentences ( $M = 5.6$ ) receiving higher comprehensibility ratings than reduced sentences ( $M = 4.4$ ). Collapsed across verb type, ambiguity and difficulty interacted because there was a larger effect of ambiguity for hard sentences (unreduced:  $M = 5.2$ , reduced:  $M = 3.1$ ) than for easy sentences (unreduced:  $M = 6.1$ , reduced:  $M = 5.8$ ), as predicted by two-stage and constraint-based ambiguity accounts. The overall difference between internal ( $M = 4.9$ ) and external ( $M = 5.1$ ) cause verbs was significant by participants, but not by items. Collapsed across difficulty, the interaction between verb type and ambiguity was significant by participants, and marginal by items. This occurred because the difference between the internal cause unreduced ( $M = 5.5$ ) and reduced sentences ( $M = 4.4$ ) was smaller than for the external cause unreduced ( $M = 5.8$ ) and reduced sentences ( $M = 4.4$ ). Note that this difference is due solely to the unreduced sentences; comprehensibility ratings were equal for the reduced relatives. Verb type did not interact with difficulty.

Finally, there was a three-way interaction among verb type, difficulty, and ambiguity. Our main prediction for these analyses was that difficulty and ambiguity should interact for both internal and external cause verbs. And indeed, although the three-way interaction resulted from a larger interaction for external cause than for internal cause verbs, both interaction contrast effects were much larger than the relevant confidence interval. For the external cause verbs, the difficulty by ambiguity contrast effect was 2.7, with a halfwidth of 0.4. For the internal cause verbs, the contrast effect was 1.1, with the same halfwidth. Both of these two-way simple interaction effects occurred because the ambiguity effect was larger for hard than for easy sentences, as predicted. For internal cause verbs, ratings were 0.5 higher for easy unreduced than for easy reduced sentences (0.5), whereas they were 1.5 higher for the unreduced hard sentences. For the external cause verbs, ratings were only 0.1 higher for easy



unreduced than for easy reduced sentences, whereas they were 2.7 higher for the unreduced hard sentences.

In summary, ambiguity interacted with difficulty overall, and within each verb class. These interactions occurred because the ambiguity effects were substantially larger for sentences designed to be hard than for those designed to be easy.

**Relations among constructions**—On the MTS account, the meanings of the passive, unreduced relative, and reduced relative are different (cf. McKoon & Ratcliff, 2003, pp. 490, 502–503, 513). Importantly, the differences are assumed to influence verb usage in the different constructions. Or, as McKoon and Ratcliff (2005) argue, “different syntactic forms interact differently with the meanings of verbs. The interaction of *race*’s event template meaning with the simple transitive structure or the simple passive structure leads to comprehensible sentences but the interaction with the reduced relative structure does not.” (p. 1035, their italics). Note that the comment about *race* is intended to be true of all internal cause verbs.

We adopt instead the standard assumption that these three constructions are closely related in a way that argues against the claim that they interact differently with the same verbs. All are types of passive constructions, and consequently in all cases the head or subject noun phrase must be interpreted as experiencing or affected in some way by the action of the verb, rather than causing it. If this is true, then it should have consequences for the comprehensibility ratings. Our prediction was that ratings for reduced relatives, unreduced relatives, and passives should be correlated, and thus passive and unreduced relative comprehensibility ratings should predict reduced relative ratings. MTS predicts instead that comprehensibility of the reduced relative is predicted by verb type.

We used the 48 sentence triads (reduced relative, unreduced relative, and passive) created by crossing verb type and difficulty. We calculated Pearson correlations (across the 48 items) between each pair of constructions and found significant correlations ( $p < .001$  in all cases): reduced relative and passive,  $r = .53$ ; reduced and unreduced relative,  $r = .56$ ; and unreduced relative and passive,  $r = .53$ . This demonstrates that comprehenders are sensitive to the relationships among these three types of passive constructions.

As a stronger test, we conducted a stepwise regression analysis in which the dependent variable was the reduced relative comprehensibility rating, and the independent variables were the dichotomous internal/external cause distinction, the passive comprehensibility rating, and the unreduced relative comprehensibility rating. Unreduced relative rating entered first, followed by passive comprehensibility rating, predicting 39% of the variance in reduced relative comprehensibility ratings,  $F_2(1,45) = 14.30$  (for all inferential statistics reported in this paper,  $p < .05$  unless otherwise stated). Each of the two variables predicted significant unique proportions of variance (unreduced relative:  $r^2 = .15$ ,  $t_2(45) = 2.85$ ; passive:  $r^2 = .11$ ,  $t_2(45) = 2.34$ ). The internal/external cause distinction did not enter ( $p = .94$  before any variables had entered,  $p = .30$  after unreduced relative had entered,  $p = .09$  after both unreduced relative and passive had entered).

In summary, Study 1 makes three important points. First, reduced relative clauses with internal cause verbs are not always hard to understand. Second, the resolution of temporary structural ambiguity is an important factor in the comprehension of reduced relatives. Third, the passive, unreduced relative, and reduced relative constructions are related, as reflected in the related comprehensibility judgments across the three constructions, and the fact that unreduced relative and passive comprehensibility judgments predict the comprehensibility

of the reduced relative. In Study 2, we test whether a similar pattern of results is found in a production task.

## Study 2

We created all of the test sentences for Study 1. Therefore, it could be argued that whereas participants might judge some experimenter-generated reduced relatives with internal cause change of state and manner of motion verbs to be acceptable, participants would never willingly *produce* reduced relatives using these verbs. To create a situation that would facilitate, but not coerce, participants to produce sentences containing reduced relatives, we used a variation of a task taken from the Comprehensive Assessment of Spoken Language (Carrow-Woolfolk, 1999). In this task, grammatical proficiency in children is assessed by having an experimenter read aloud sentences containing nouns modified by prepositional phrases (e.g. *The dog with long hair jumped over the fence*) and asking the child to shorten these into grammatical sentences with the same meaning (e.g. *The long-haired dog jumped over the fence*). In our version of the sentence-shortening task, we presented participants with 35 filler sentences intermixed with the unreduced relative and the passive versions of the sentences used in Study 1, and asked them to generate a sentence similar in meaning to the original but at least two words shorter. This procedure was designed to evaluate the MTS hypotheses about the role of the internal/external cause distinction in the production and acceptability of the reduced relative construction, and to allow us to look more closely at the relationship between the reduced and unreduced relative.

Analogous to Study 1, Study 2 had three major goals. The first was to test whether English speakers would produce reduced relatives with internal cause verbs in an experimental setting, and, if they did, whether they would rate their own productions as acceptable. The second goal was to test whether ambiguity influences the production of reduced relatives. If it does, then we would expect participants to generate more reduced relatives from easy than from hard unreduced relatives, and to rate their own productions more acceptable for the easy than for the hard items. Finally, we again tested whether the constructions are related. This was accomplished in two ways. First, participants were asked to rate the similarity in meaning of the original unreduced relatives and their shortened productions. In addition, we asked participants to rate acceptability of the original unreduced relatives and passives. We conducted regression analyses on the proportion of reduced relatives produced for each item, with unreduced relative acceptability, passive acceptability, and internal/external cause verb status as the predictor variables.

## Method

**Participants**—Twenty undergraduates from the University of Rochester were paid for their participation.

**Materials**—The 24 unreduced relatives and 24 matched passives from Study 1 were used as test sentences. There were also 35 filler sentences. Crucially, none of the sentences in Study 2, whether test or filler item, contained a reduced relative. This was done to avoid inflating the accessibility of the reduced relative construction. Three of the filler sentences were intended to be semantically anomalous, as in *Colorless green ideas sleep furiously*, and 10 were designed to make it difficult to eliminate two words or more and still create a grammatically acceptable sentence. These fillers were included to create some variation in the acceptability of the sentences that participants would rate, and to provide some examples where it was impossible to create an acceptable sentence or a sentence with similar meaning to the target sentence.

We created two lists by assigning the unreduced relative and passive for each verb to a different list. The fillers and test sentences were then randomly intermixed, with the restriction that each half of the list contained the same number of test sentences for each of the eight conditions created by crossing verb type (internal and external cause), type of construction (passive and unreduced relative), and predicted reduced relative difficulty (easy and hard). We then created two random orders for each list, resulting in four lists. Each participant was assigned randomly to a single list.

**Procedure**—Participants were given a rating form with the instructions and the sentences, and were instructed to read each sentence and rate its acceptability as an English sentence on a scale of 1–7, where 1 was “extremely unacceptable” and 7 was “completely acceptable”. They were asked to shorten the sentence by deleting two or more words, without adding words or rearranging those already present, and to write out the new sentence. Participants were asked to try to preserve the meaning of the original sentence, but were told that this would not always be possible. They were also told that it might not always be the case that the shortened sentence would be grammatically correct. After re-writing the sentence, they were asked to rate the acceptability of the shortened version on the same 7-point scale. In addition, they were asked to rate how similar in meaning it was to the original on a 5-point scale, with 1 indicating “very different meanings” and 5 “the same meaning”. Participants were given three examples (one of which could not be shortened grammatically). The full instructions, the example sentences, and the form of the response sheet are presented in Appendix C.

Note that it was possible to shorten each target sentence in a number of ways. For example, the unreduced relative sentence *The guard who was searched inside the prison walls had cocaine hidden in his jacket* could be shortened into the reduced relative *The guard searched inside the prison walls had cocaine hidden in his jacket*, but also into other constructions like *The guard who was searched inside the prison had cocaine in his jacket*, *The guard who searched inside the prison had cocaine in his jacket*, or *The guard had cocaine in his jacket*, among other possibilities. In fact, all unreduced relatives could be shortened by deleting the entire relative clause. Thus, although participants could produce reduced relative versions of the unreduced relative sentences, they were not required to do so—other grammatical options were available.

**Design**—Ninety-three percent of the shortened versions of the unreduced relative sentences were grammatical, as judged by a research assistant and checked by the second author. Analyses of variance were conducted on these items, using participants ( $F_1$ ) and items ( $F_2$ ) as random variables. Separate analyses were conducted for each of three dependent variables: Proportion of reduced relatives produced, reduced relative acceptability ratings, and ratings of similarity between the original unreduced relative and shortened reduced relative sentences. The independent variables were verb type (internal or external cause) and difficulty (easy or hard). Both variables were within subjects and between items. The analyses of ratings of reduced relative acceptability, and ratings of similarity between the original unreduced relatives and the shortened reduced relative were conducted by items only. This was necessary because the independent variables were within participants, and so if a participant produced no reduced relatives in one or more of the four conditions, they would be excluded from the analysis. As a result, only 7 of 20 participants would have been included. In contrast, the independent variables were between items, so this aspect of the analysis was not a problem in the by-items analyses (at least one participant produced a reduced relative for every easy external and easy internal cause item, and for 8 of the hard external cause and 9 of the hard internal cause items). All confidence intervals are based on the items analyses.

Correlation and regression analyses are reported as well, with proportion of reduced relatives produced as the dependent variable, and unreduced relative acceptability, passive acceptability, and internal/external cause verb status as the predictors.

Finally, note that for all analyses in both Studies 2 and 3 in which the dependent variable was a proportion, we also conducted the analyses using arc sine transformations. Because the results were the same in every case in both studies, we report only the analyses based on untransformed proportions.

## Results and discussion

Condition means for each dependent variable are presented in Table 3, and the analyses of variance are presented in Table 4.

**Reduced relative probability and acceptability**—According to MTS, participants should avoid generating reduced relatives with internal cause verbs because they are prohibited. However, the data do not support this prediction. Instead, participants shortened the internal cause unreduced relatives into reduced relatives with a probability of .34. The probability of reduced relatives created with external cause verbs (.42) was marginally higher (halfwidth = 0.10). However, it is important to note here that MTS predicts that reduced relatives with internal cause verbs should be prohibited, not slightly disfavored. Therefore we conducted a  $z$ -test of the difference between proportions to test whether the proportion of reduced relatives produced for internal cause verbs was significantly greater than 0. Because 0 cannot be used as the baseline proportion in this test (it would result in dividing by 0), we used 0.001 as the MTS predicted proportion of reduced relatives for internal cause verbs. The proportion of reduced relatives produced was significantly greater than .001 for both the easy internal cause items, .52,  $z = 56.90$ , and the hard internal cause items, .17,  $z = 18.53$ .

The interaction between difficulty and verb type was non-significant because verb type had roughly the same influence on reduced relative production for both levels of difficulty. The proportion of produced reduced relatives did not differ for easy external versus internal cause items (mean difference = 0.12, halfwidth = 0.13), nor for the hard external versus internal cause items (mean difference = 0.02, halfwidth = 0.13).

Because the unreduced relatives were taken from Study 1, they included the three easy internal cause verb items containing path nominals. Although without these items the proportion of produced reduced relatives for the easy internal cause items drops from 0.52 to 0.45, the main conclusions drawn from these data do not change. That is, participants still produced reduced relatives for 45% of the easy internal cause items, and as was shown above, even the 17% produced reduced relatives for hard internal cause items was significantly greater than 0.001, which was used as the baseline in the  $z$ -tests.

The finding that over a third of the internal cause unreduced relatives were shortened into reduced relatives is clear evidence that reduced relative production is not governed by a binary internal/external cause distinction, at least not for the production of sentences in an experimental setting. Nonetheless, one might argue that the constraints of the task led participants to produce sentences that they considered to be ungrammatical, and that this influenced the production of reduced relatives with internal cause verbs. This is unlikely because, as noted earlier, the original unreduced relatives could be shortened in a number of grammatical and sensible ways. But if we assume for the moment that it is true, then the acceptability ratings should reflect the ungrammaticality, with internal cause reduced relatives judged less acceptable than reduced relatives with allowable external cause verbs. Again, this turns out not to be the case. Acceptability ratings for reduced relatives with

internal cause verbs were similar to those with external cause verbs (halfwidth = 0.4), and both were at the high end of the 7-point scale (internal cause:  $M = 6.4$ , range = 5.3–7.0; external cause:  $M = 6.4$ , range = 4.0–7.0). There was no interaction between difficulty and verb type because verb type had roughly the same influence on reduced relative acceptability ratings for the two levels of difficulty. Reduced relative acceptability was only 0.2 higher for the easy external than for the easy internal cause items (0.5), and only 0.4 higher for the hard internal than for the hard external cause items (0.5). [When the three path nominal items were dropped, mean acceptability ratings for easy internal cause reduced relatives changed only from 6.5 to 6.4.] Note also that these ratings were equivalent to those for other constructions produced by shortening the original unreduced relatives, indicating that the participants did not rate the internal cause reduced relatives as less acceptable than other types of sentences (see Table 3, “Other Acceptability”).

Finally, the ratings for both the external cause and the internal cause reduced relatives were similar to those given to non-controversially grammatical sentences like the original unreduced relatives (Table 3). In contrast, truly ungrammatical sentences were much less frequent, and were rated as less acceptable than the internal cause reduced relatives. The percentage of shortened unreduced relatives that were ungrammatical was 7%, and the mean acceptability rating of these sentences was 4.2. In addition, the internal cause reduced relatives were also rated as more acceptable than grammatical but semantically anomalous sentences like *Colorless green ideas sleep furiously*, three of which were included in the shortening study ( $M = 3.5$ ) to address concerns raised by McKoon and Ratcliff (2005). Thus it also cannot be argued that participants rated meaningless internal cause reduced relatives highly simply because they were grammatically coherent.

Reduced relative acceptability ratings, especially those for the hard sentences, were higher in Study 2 than they were in Study 1. This is due to the fact that in Study 1 participants provided acceptability ratings for all reduced relatives, including those intentionally designed to be difficult to comprehend. In Study 2, on the other hand, participants had the option of creating other constructions, and so generally only produced reduced relatives if they considered them to be acceptable. Because participants rated only their own productions in Study 2, they tended to give them high acceptability ratings.

In summary, these data clearly show that the production of reduced relatives for internal cause verbs is not prohibited—on the contrary, participants frequently produced internal cause reduced relatives, and judged them to be as acceptable as other grammatical sentences.

**Ambiguity effects**—The previous section shows that a binary internal/external cause distinction fails to make the correct predictions for the shortening data. Alternatively, the difficulty in reduced relative comprehension may be due to temporary ambiguity. If this is correct, then fewer reduced relatives should be produced for the hard sentences, which were intentionally designed to be difficult to interpret as a type of passive construction. This prediction was borne out. Reduced relative probability was over three times greater for easy ( $M = 0.58$ ) than for hard ( $M = 0.18$ ) sentences (0.09). In addition, the difference held for both the external cause (mean difference = 0.45, halfwidth = 0.13) and the internal cause verbs (mean difference = 0.35, halfwidth = 0.13).

In addition to being more frequent, easy reduced relatives ( $M = 6.6$ ) were also judged to be more acceptable than hard reduced relatives ( $M = 6.1$ ), showing that the factors that increase ambiguity made the hard reduced relatives more difficult to understand (0.4). Difficulty and verb type did not interact. Reduced relative acceptability was 0.8 higher for external cause easy versus hard items (0.5), but there was only a 0.2 difference for the internal cause easy versus hard items (0.5). The effects of difficulty on the reduced relative acceptability ratings

in Study 2 are not as pronounced as in Study 1 (nor are they as pronounced as in the proportion of produced reduced relatives) because in Study 2, participants rated the acceptability of only their own productions, which by and large they considered to be highly acceptable.

**Relations among constructions**—A further difference between MTS and an ambiguity resolution account involves the relationship between unreduced and reduced relative clauses. On the MTS account, the two have different meanings, and as a result internal cause verbs are blocked from the reduced relative even though they are acceptable in other passive constructions. On the approach taken here, reduced and unreduced relatives are highly related in meaning, but one is temporarily ambiguous whereas the other is not. Consequently, participants should rate the two as very similar in meaning.

The similarity ratings support the latter approach. Overall, the reduced relatives were rated as highly similar in meaning to the original unreduced relatives ( $M = 4.7$  on a scale in which  $5 = \textit{the sentences have the same meaning}$ ). In contrast, when constructions other than the reduced relative were generated, they were rated as less similar to the original sentence than were the reduced relatives (overall  $M = 4.0$ ; see Table 3 for means by condition). The analysis of variance showed a significant effect of verb type, with internal cause reduced relatives,  $M = 4.9$ , judged to be closer in meaning to the original unreduced relatives than were the external cause reduced relatives,  $M = 4.4$  (0.4). Reduced relatives were rated as marginally more similar to the original unreduced relatives for the easy,  $M = 4.8$ , than for the hard sentences,  $M = 4.4$  (0.4). Furthermore, difficulty interacted with verb type. Similarity ratings differed by 0.9 for external cause easy versus hard items (0.6), but were identical for the internal cause easy and hard items. Making the comparisons in the other direction, for the easy items, there was only a 0.1 difference between internal and external cause verbs, whereas for hard items, the similarity ratings were 1.0 higher for internal than for external cause verbs.

Although the similarity ratings are consistent with an ambiguity account, we believe that they should be interpreted with caution. The means are consistently high, indicating that participants in almost all cases took the reduced relatives they created to have very much the same meaning as the original unreduced relatives. The primary difference in the ratings was due to the lower mean rating for hard external cause items, and this in turn was driven by the response of a single participant, who produced *The waiter served the steak enjoyed it immensely* and rated it at 1 on the 1–5 scale in similarity to the unreduced relative. This rating was then the mean for that item. Overall, participants rated the great majority of the reduced relatives that they produced as highly similar in meaning to the original unreduced relatives.

A better method for testing relatedness across constructions is to use the acceptability ratings for the original unreduced relatives and passives, plus the internal/external cause distinction, to predict the proportion of reduced relatives created. In bivariate correlations, the proportion of reduced relatives correlated significantly with unreduced relative acceptability,  $r = .58$ , and passive acceptability,  $r = .57$ . However, it did not correlate with the internal/external cause distinction,  $r = -.15$ ,  $p > .3$ .

These variables were entered into a stepwise regression with the probability of a reduced relative for a given sentence as the dependent variable, and acceptability of the unreduced relative, acceptability of the passive, and internal/external cause status as the predictors. Unreduced relative acceptability entered on the first step, followed by passive acceptability. Combined, these two factors accounted for 42% of the variance in the probability of producing a reduced relative,  $F_2(2,45) = 16.02$ . Both variables predicted significant unique

proportions of variance: unreduced relative acceptability,  $r^2 = .14$ ,  $t_2(45) = 2.64$ ; passive acceptability,  $r^2 = .12$ ,  $t_2(45) = 2.53$ . At no time was the internal/external cause distinction a significant predictor:  $p > .8$  following step one and  $p > .3$  following step two. The correlation and regression analyses together provide further evidence that a verb's behavior is related among passive constructions, while providing no evidence for the importance of a categorical distinction between external and internal cause verbs. Finally, note that the results were virtually identical when the three path nominals with easy internal cause verbs were excluded. Together, unreduced relative and passive acceptability accounted for 43% of the variance in the probability of producing a reduced relative,  $F_2(2,42) = 15.88$ . Again, both variables predicted significant unique proportions of variance: unreduced relative acceptability,  $r^2 = .14$ ,  $t_2(42) = 2.65$ ; passive acceptability,  $r^2 = .11$ ,  $t_2(42) = 2.28$ .

### Study 3

McKoon and Ratcliff (2003) argue that English speakers will not produce reduced relatives with internal cause verbs because the meaning of the reduced relative construction combines with the internal cause verb template to block production (p. 506). In Study 2, by contrast, native speakers willingly produced such reduced relatives, and judged their own productions to be highly acceptable. One caveat, however, is that these reduced relatives were produced under somewhat artificial experimental conditions, and this may have led participants to create sentences that they might have otherwise avoided.

Thus it is also important to show that internal cause reduced relatives are found in more naturally occurring text, in order to provide converging evidence for the claims made in Study 2. McKoon and Ratcliff (2003, Corpus Studies 4 and 5) searched corpora for instances of internal cause change of state and manner of motion reduced relatives, and discovered that these do in fact occur. However, in their Corpus Study 7, they found that external cause reduced relatives were 100 times more frequent: The probability of a reduced relative was .06 for external cause verbs, but only .0006 for internal cause verbs when the two internal cause verb classes were combined. This difference in occurrence rate was taken as evidence for a categorical distinction between the two verb classes with respect to reduced relative grammaticality.

Interestingly, however, when the results of McKoon and Ratcliff's (2003) Corpus Studies 4 and 5 are considered individually, it becomes clear that the difference in reduced relative probability was actually larger between the two classes of internal cause verbs than between the external cause and internal cause change of state verbs, a comparison that crosses the internal/external cause category boundary. External cause verbs were 15 times more likely to occur in reduced relatives than were internal cause change of state verbs (probabilities of .06 and .004, respectively). This is a notable difference, but reduced relatives with internal cause change of state verbs were in turn 27 times more frequent than with internal cause manner of motion verbs (probability of .00015).

Although MTS offers an account of the clear distinction between the external cause and internal cause change of state verbs, it fails to explain the more striking difference between the internal cause manner of motion verbs, on the one hand, and the internal cause change of state verbs on the other. It is possible that a single factor underlies both differences, and one likely candidate is the availability of related constructions like the passive. The three verb classes do differ in this respect: All external cause verbs may appear in the transitive (Levin, 1993) and so can occur freely in the passive. The basic sense of the internal cause change of state verbs is intransitive, but many of these also occur in the causative, and so may occur in the passive as well (McKoon & MacFarland, 2000). In contrast, although manner of motion verbs can occur in the causative, they rarely do so, and McKoon and Ratcliff (2003, p. 498)

argue from the “rarity of external cause sentences for the class of manner of motion verbs” that speakers and writers follow the constraints imposed by internal control. Although we offer a different account of these data in the General Discussion, we do agree that causatives occur infrequently with manner of motion verbs, which are therefore also infrequent in the passive. Thus a standard account would predict that manner of motion verbs would rarely be found in the reduced relative, which is also a passive construction. In the General Discussion, we describe the factors that underlie use in the intransitive, transitive, and passive in terms of real events in the world that verbs (and the sentences containing them) are used to describe.

Study 3 had two main goals. First, we replicated McKoon and Ratcliff’s (2003) Corpus Studies 4 and 5 to verify their finding that reduced relatives are relatively frequent in change of state verbs, compared to verbs describing manner of motion. Second, we tested whether the probability that a verb will occur in a simple passive is related to its use in a reduced relative. We conducted several regression analyses to test whether a verb’s tendency to occur in the reduced relative is better predicted by its probability of occurring in the transitive and the passive, or by its status as an external or internal cause verb.

## Method

Fifty-four verbs were used. These were all of the verbs used in McKoon and Ratcliff (2003, Experiment 1), and McKoon and MacFarland (2002) Experiments 1–3. There were 24 external cause change of state verbs, 14 internal cause change of state verbs, and 16 internal cause manner of motion verbs.

Four parsed corpora were used: The Wall Street Journal corpus and Brown Corpus (each one million words); Wall Street Journal 1987 (25 million words) and the British National Corpus (100 million words). The corpora differ in genre as well as size. Wall Street Journal and Wall Street Journal 1987 are derived exclusively from Dow Jones newswire stories, while the Brown Corpus and the British National Corpus are balanced corpora that include literature and news articles. In addition, approximately 10% of the British National Corpus consists of transcribed spoken material. The Wall Street Journal corpus and Brown Corpus were parsed as part of the Penn Treebank Project (Marcus, Santorini, & Marcinkiewicz, 1993). The Wall Street Journal 1987 consists of the three year Wall Street Journal collection from the Association for Computational Linguistics Data Collection Initiative corpus, and was parsed using methods developed by Eugene Charniak and associates from Brown Laboratory for Linguistic Information Processing (Charniak, 1997). All three parsed corpora are available from the Linguistic Data Consortium at the University of Pennsylvania. The British National Corpus is available unparsed from Oxford University, and was parsed by Jeff Elman using the Charniak parser (Roland, Elman, & Ferreira, 2006.)

All sentences containing the 54 internal/external cause verbs were extracted automatically from the four corpora using scripts modified from earlier studies (Hare et al., 2004; Roland, Dick, & Elman, 2006). These scripts classified the verbs into a set of subcategorization frames, which were then collapsed into the more general classifications *transitive*, *passive*, *reduced relative*, and *other*. Sentences with an immediately post-verbal noun phrase were classified as transitive. Because some verbs with passive morphology could also be interpreted as adjectival, we followed McKoon and Ratcliff (2003, p. 507) and categorized as passive all uses of the verb that could be interpreted that way, both for simple passives and passive reduced relatives.

The Brown and Wall Street Journal corpora have been extensively hand-corrected, so their error rate is quite low. In the Wall Street Journal 1987 and British National Corpus, however, the tallies of infrequent constructions tended to be inflated relative to the other two



corpora. Therefore two raters (the first author and a research assistant who was unaware of the hypotheses) hand-checked all passives and reduced relatives in those two corpora, and any examples that both raters considered misclassified were eliminated. Any disagreements were resolved through discussion between the two raters.

### Basic search results

To compare our results with those of McKoon and Ratcliff (2003, *Corpus Studies* 4, 5, and 7) we begin with descriptive statistics before proceeding to analyses of variance and regression analyses that focus on the proportion of sentences that use a verb in particular structures. We included only reduced relatives in which the head is the entity participating in the activity denoted by the verb. We also eliminated all non-restrictive reduced relatives that were marked as such by punctuation (either commas or hyphens), as well as any that could solely be interpreted as an adjectival phrase according to MTS criteria. (We are grateful to Gail McKoon for clarifying precisely which of our reduced relatives adhered strictly to MTS criteria.)

McKoon and Ratcliff (2003, *Corpus Study* 4) searched for 69 internal cause manner of motion verbs, and found 6 reduced relatives out of a total of 39,159 sentences. Thus they computed the probability of a reduced relative sentence with a manner of motion verb as .0002 for their corpus. We searched for 16 manner of motion verbs, with similar results: 4 reduced relatives out of 39,000 total sentences (.0001). This occurred despite the fact that our verb set did not include *parade* or *hurry*, the two manner of motion verbs with 4 of the 6 reduced relatives found in the earlier study. Our results with internal cause change of state verbs were also comparable to those of McKoon and Ratcliff's *Corpus Study* 5. Those authors searched for 17 such verbs, and report finding 21 reduced relatives in 4775 sentences (.004). For our largely overlapping set of 14 verbs there were 26 reduced relatives in 4429 sentences (.006).

Interestingly, although our results with internal cause verbs are similar to those reported by McKoon and Ratcliff, the proportion of reduced relatives in our external cause verbs is much lower: The proportion (reduced relatives divided by sentences) is reported as 0.06 in McKoon and Ratcliff (2003, *Corpus Study* 7), but the comparable figure is 0.002 (87 reduced relatives in a total of 35,000 sentences) in our study. This is most likely due to the specific verbs used. Our search involved the change of state verbs used in earlier online internal/external cause studies by McKoon and colleagues, which tended to be matched for overall frequency, whereas 73 of the 85 external cause verbs used by McKoon and Ratcliff (2003, *Corpus Study* 7) were from previous structural ambiguity experiments that focused on the reduced relative. As a result, these verbs were highly transitive, with correspondingly high occurrence in the passive. Both sets of verbs were external cause, however, and so MTS would predict that the reduced relative construction should be equally possible in both cases.

We suggest that the difference in reduced relative frequency may be related to these differences in passivizability. Our external cause verbs differ from those in McKoon and Ratcliff (2003) in their passive probabilities: The probability of passive occurrence for the external cause verbs in McKoon and Ratcliff (2003, p. 513) was .55, while it was .09 in the present study. If reduced relative occurrence is related to the ability to passivize, there should be fewer reduced relatives in the present set of verbs, and that is what was found. Further note that the passive probabilities are similar in the two studies for the internal cause change of state verbs—as would be expected because they are largely the same verbs—and the reduced relative probabilities are similar as well.

MTS addresses a narrowly defined set of reduced relative clauses, but in general, theories of reduced relative processing attempt to account for a wider range of data. For this reason, our search also included sentences in which, by the criteria of MTS, the head is not a participant in the activity denoted by the verb, such as in, *it...supersedes a pitch climbed by Grant Farquhar a few weeks previously*, perhaps because the verb was used in a non-canonical sense, as in *this could be done through shares floated on the stock market*. It also included sentences in which the reduced relative is non-restrictive, since non-restrictives may or may not be marked by punctuation, and therefore might be difficult or not depending on factors related to ambiguity resolution. For completeness, we note that in this set, we find a much larger number of reduced relatives for all classes of verbs: 159 in the 35,000 external change of state sentences; 61 in the 4429 internal cause change of state sentences, and 19 in the 39,000 internal cause manner of motion sentences.

To this point, we have focused on comparisons of our results with those of McKoon and Ratcliff's (2003) corpus studies. In the next section, we report inferential tests on the probability of reduced relatives, passives, and transitives in each verb class.

## Results and discussion

This section begins with analyses of variance on the probability of passive occurrence,  $P(\text{passive})$  and probability of transitive occurrence,  $P(\text{transitive})$ . These analyses show that both variables differ across external cause change of state, internal cause change of state, and manner of motion verbs. We then present three analyses including only the reduced relatives that adhere strictly to the criteria of MTS (McKoon & Ratcliff, 2003, 2005). The analysis of variance on  $P(\text{reduced relative})$  shows that internal cause change of state reduced relatives have a higher probability of occurrence than either external cause change of state or manner of motion reduced relatives. We then predict  $P(\text{reduced relative})$  using three predictors, the internal/external cause distinction,  $P(\text{passive})$ , and  $P(\text{transitive})$ .  $P(\text{passive})$  is the sole significant predictor. Next, we use a binary logistic regression analysis to predict the existence or non-existence of reduced relatives for each verb.  $P(\text{passive})$  and  $P(\text{transitive})$  are significant predictors, whereas the internal/external cause distinction again is not.

As noted above, MTS addresses a narrowly defined set of reduced relative clauses, but other theories of reduced relative comprehension do not. Therefore it is important to investigate whether the same results are obtained when more general inclusion criteria are applied—criteria that do not depend on the fine-grained distinctions that are central to the MTS account. For this reason, we report the same analyses using expanded criteria for inclusion of reduced relatives. These analyses also include sentences in which the head is not a prototypical participant in the activity denoted by the verb (such as path nominals with manner of motion verbs), and those in which the reduced relative is potentially non-restrictive. We did, however, continue to eliminate cases that could solely be interpreted as an adjectival phrase according to MTS criteria. The analyses of variance show a significant main effect of verb class, with internal cause change of state verbs again having the highest  $P(\text{reduced relative})$ . When predicting  $P(\text{reduced relative})$ ,  $P(\text{passive})$  and the internal/external cause distinction are significant predictors, although internal cause reduced relatives are predicted to have a higher probability of occurrence, contrary to MTS. The binary logistic regression again shows that  $P(\text{passive})$  and  $P(\text{transitive})$ , but not the internal/external cause distinction, predict the existence of reduced relative clauses.

## Probability of passives and transitives

The proportion of each type of construction was calculated as the number of times each verb appeared in a specific structure divided by the number of times that any morphological form of the verb appeared in the corpus. Thus, for the first two analyses of variance, the

dependent variables were the proportion of passives and proportion of transitives. The independent variable was verb subtype, which had three levels: external cause change of state, internal cause change of state, and internal cause manner of motion. Verb subtype was between items ( $F_2$ ). Mean passive, transitive, and reduced relative probabilities for each verb subtype are presented in Table 5, and the analyses of variance statistics are presented in Table 6.

For P(passive), there was a main effect of subtype. Passive probability was .0747 higher for internal cause change of state than for manner of motion verbs (.0559). It was .0839 higher for external cause change of state than for manner of motion verbs (.0493). The 0.0092 difference was not reliable for internal cause versus external cause change of state verbs (0.0538).

For P(transitive), there was also a main effect of subtype. Transitive probability was .0898 higher for external cause change of state verbs than for the manner of motion verbs (.0662). Internal cause change of state verbs had a marginally higher P(transitive) than manner of motion verbs, with a difference of 0.0724 (0.0751). The 0.0174 difference was not reliable for internal cause versus external cause change of state verbs (0.0690).

We note that Merlo and Stevenson (1998), who conducted a similar analysis, found similar results. In particular, in their data, the probability of an intransitive use was significantly higher for manner of motion verbs (their unergatives) than for external cause change of state (their unaccusatives).

### Analyses using MTS criteria

The following set of analyses includes only reduced relatives that meet MTS inclusion criteria (McKoon & Ratcliff, 2003, 2005).

### Probability of reduced relatives

There was a main effect of subtype. Reduced relative probability was .0143 higher for internal cause change of state than for manner of motion verbs (.0114). The probability of a reduced relative was marginally higher, with a difference of .0093, for internal cause change of state than for external cause change of state verbs (.0105). The .0050 advantage for external cause change of state over manner of motion verbs was not reliable (.0101). Therefore, using MTS criteria for inclusion of reduced relatives, the corpus data show that reduced relatives with internal cause verbs are clearly not prohibited. This result is consistent with the production data in Study 2.

In summary, no categorical difference was found in reduced relative occurrence rate between internal and external cause change of state verbs, contrary both to the predictions of MTS and to the corpus studies presented in McKoon and Ratcliff (2003). The current results also show that the change of state verbs in our corpus search are evenly matched on their tendency to occur in the passive. This was not the case for the change of state verbs in the McKoon and Ratcliff (2003) corpus analyses, and might explain why the reduced relative—another passive construction—occurred more frequently with external cause than with internal cause verbs in that study. This is also consistent with our finding that manner of motion verbs, which have a lower probability of a passive than the change of state verbs, differ from those verbs in their reduced relative probability as well.

Our analyses of the verbs from McKoon and colleagues' on-line studies suggests that reduced relatives are not prohibited with internal cause verbs. It also suggests that the relevant distinction among these three verb types is change of state versus manner of motion, because of the differential availability of the passive in the three verb types. In the

next set of analyses, we test more directly whether the probability of the passive predicts a verb's tendency to occur in the reduced relative construction.

**Factors predicting reduced relative probability**—We first tested whether the probability of a reduced relative for each verb,  $P(\text{reduced relative})$ , correlates with the probability of a passive  $P(\text{passive})$ , probability of a transitive  $P(\text{transitive})$ , and the categorical variable internal/external cause class (coded as external cause = 0, internal cause = 1). When each variable was regressed separately against  $P(\text{reduced relative})$ ,  $P(\text{passive})$  predicted 21% of the variance,  $F(1,52) = 13.64$ , and  $P(\text{transitive})$  predicted 13% of the variance,  $F(1,52) = 7.67$ . In contrast, internal/external cause verb class predicted less than 1%,  $F < 1$ .

We then entered these variables into a stepwise regression with  $P(\text{reduced relative})$  as the dependent variable, and  $P(\text{passive})$ ,  $P(\text{transitive})$ , and internal/external cause as the predictors.  $P(\text{passive})$  was the sole significant predictor, and thus the percent variance accounted for and its significance are the same as in the zero-order analyses reported in the previous paragraph. After  $P(\text{passive})$  entered the equation,  $P(\text{transitive})$  was nonsignificant,  $p > .2$ . The internal/external distinction was a marginal predictor, with a partial correlation of .26,  $t(52) = 1.92$ ,  $p = .061$ . However, contrary to the predictions of MTS, this correlation is positive, indicating that there is a higher probability of reduced relatives in the internal cause than in the external cause verbs when  $P(\text{passive})$  is already in the equation. In addition, as shown above, the internal/external cause distinction does not correlate with  $P(\text{reduced relative})$  on its own.

**Factors predicting the existence of reduced relatives**—In the previous section, the dependent variable was the probability of a reduced relative. MTS, however, makes categorical predictions regarding the existence or non-existence of reduced relatives for certain classes of verbs. Therefore, it could be argued that a more appropriate test of the MTS account is a logistic regression in which the dependent variable represents whether or not reduced relatives were found for each verb (i.e., reduced relatives do not exist = 0, reduced relatives exist = 1). Overall, there was at least 1 reduced relative that fit the MTS criteria for 21 of the 54 verbs. Twelve of the 24 external cause change of state verbs, and 9 of the 30 internal cause verbs, including 7 of the 14 internal cause change state verbs, and 2 of the 16 manner of motion verbs, occurred in the reduced relative.

We conducted a binary logistic regression using  $P(\text{passive})$ ,  $P(\text{transitive})$  and verb type (internal/external cause) as predictors. The forward conditional method was used in SPSS for conducting stepwise logistic regressions. The model began with a baseline prediction rate of 61%. Because 33 of the 54 verbs did not occur in reduced relatives, the baseline prediction was that no verbs occur in reduced relatives (thus  $33/54 \times 100 = 61\%$  correct predictions).

$P(\text{transitive})$  and  $P(\text{passive})$  were the only significant predictors of the existence of reduced relatives.  $P(\text{transitive})$  entered first, Nagelkerke  $R^2 = .30$ ,  $\chi^2(1) = 13.53$ , and correctly assigned 42 of the 54 verbs (78%).  $P(\text{passive})$  entered next, increasing the prediction rate to 43 of the 54 verbs (80%), with Nagelkerke  $R^2 = .39$ ,  $\chi^2(1) = 4.92$ . The  $LR$  statistic, which indicates how the model's predictions would change if a specific variable was removed, showed that, at this point,  $P(\text{transitive})$  was a significant predictor,  $LR(1) = 5.01$ , as was  $P(\text{passive})$ ,  $LR(1) = 4.44$ . At no step was internal/external cause a significant predictor of the existence/non-existence of reduced relatives, all  $p$ 's  $> .7$ .

In summary, this pair of regression analyses show that a verb's probability of appearing in the passive is the dominant predictor of its probability of appearing in a reduced relative

when MTS criteria for the inclusion of reduced relatives is used. Furthermore, the verb's probability of appearing in the transitive also was a significant predictor of the existence of reduced relatives. In no analysis did the internal/external cause distinction account for the reduced relative production in corpora.

### Analyses using expanded criteria

The following analyses use somewhat expanded criteria for including reduced relatives, ones that do not follow all of the MTS criteria, as outlined above.

**Probability of reduced relatives**—There was a main effect of subtype. Reduced relative probability was .0238 higher for internal cause change of state than for manner of motion verbs (.0154). The probability of a reduced relative was .0166 higher for internal cause change of state than for external cause change of state verbs (.0142). The .0072 advantage for external cause change of state over manner of motion verbs was not reliable (.0136). Therefore, using the expanded criteria for inclusion of reduced relatives, the corpus data again show that reduced relatives with internal cause verbs are clearly not prohibited. This result is consistent with the production data in Study 2, as well as the analysis of variance using the MTS criteria.

**Factors predicting reduced relative probability**—We again tested whether P(reduced relative) correlates with P(passive), P(transitive), and the categorical variable internal/external cause class. We first used each variable on their own. P(passive) predicted 26% of the variance in P(reduced relative),  $F(1,52) = 18.62$ . P(transitive) predicted 12% of the variance in P(reduced relative),  $F(1,52) = 6.80$ . Internal/external cause verb class predicted a non-significant 1% of the variance,  $F < 1$ .

We then entered these variables into a stepwise regression with P(reduced relative) as the dependent variable, and P(passive), P(transitive), and internal/external cause as the predictors. P(passive) entered first, as the results in the previous paragraph indicate. Internal/external cause entered on the second step. Its partial correlation was  $r = .34$ ,  $t(51) = 2.58$ , with P(passive) having a partial correlation of  $r = .59$ ,  $t(51) = 5.15$ . Thus, internal/external cause is a significant predictor when the variance due to P(passive) is removed. Contrary to the predictions of MTS, however, this correlation is positive, indicating that there is a higher probability of reduced relatives in the internal cause than in the external cause verbs when P(passive) is already in the equation. In addition, as shown above, the internal/external cause distinction does not correlate with P(reduced relative) on its own. P(transitive) was not significant at any step.

**Factors predicting the existence of reduced relatives**—Overall, there was at least 1 reduced relative for 33 of the 54 verbs. Eighteen of the 24 external cause verbs and 15 of the 30 internal cause verbs, including 11 of the 14 internal cause change state verbs, and 4 of the 16 manner of motion verbs, occurred in the reduced relative.

We again conducted a logistic regression using P(passive), P(transitive) and verb type (internal/external cause) as predictors. The model began with a baseline prediction rate of 61%. Because 33 of the 54 verbs appeared in reduced relatives, the baseline prediction was that all verbs occur in reduced relatives (thus  $33/54 \times 100 = 61\%$  correct predictions).

P(transitive) and P(passive) were the only significant predictors of the existence of reduced relatives. P(transitive) entered first, Nagelkerke  $R^2 = .41$ ,  $\chi^2(1) = 19.41$ , and correctly assigned 39 of the 54 verbs (72%). P(passive) entered next, increasing the prediction rate to 43 of the 54 verbs (80%), with Nagelkerke  $R^2 = .52$ ,  $\chi^2(1) = 6.81$ . The LR statistic showed that, at this point, P(transitive) was a significant predictor,  $LR(1) = 7.37$ , as was P(passive),

$LR(1) = 7.51$ . At no step was internal/external cause a significant predictor of the existence/non-existence of reduced relatives, all  $p$ 's  $> .4$ .

The regression analyses show that a verb's probability of occurrence in the passive is the most consistent predictor of whether it will occur in the reduced relative construction. This is expected on any account in which the reduced relative is a type of passive construction, and difficulty with the reduced relative arises when factors conspire to make the head noun difficult to interpret as the patient of the passive verb. On such accounts, reduced relatives should be more common for verbs with a higher passive probability, and the results of the regression models bear this out. In addition,  $P(\text{transitive})$  was a significant predictor of the existence of reduced relatives both when the MTS and the expanded inclusion criteria were used. Transitive usage is one determinant of whether a passive construction can be formed, and thus whether a reduced relative might be used. Finally, the internal/external cause distinction failed to be a significant predictor of the existence or non-existence of reduced relatives. When the probability (rather than the existence) of reduced relatives was the dependent variable in the expanded criteria analyses, the internal/external cause distinction was a significant predictor, but in the direction opposite to the predictions of MTS.

Study 3 found that reduced relatives are more common for change of state than for manner of motion verbs, and that the probability that a change of state verb occurs in a reduced relative is similar for both internal and external cause verbs. This contradicts the claims of MTS, but is consistent with the results of previous corpus studies. As mentioned earlier, McKoon and Ratcliff (2003) found a similar difference between internal cause change of state and manner of motion verbs in their own corpus. Merlo and Stevenson (1998) found the same pattern when they contrasted three sets of verbs: Unergatives (internal cause manner of motion), unaccusatives (external cause change of state) and "object-drop" verbs. As in our corpus, the unaccusative (change of state) verbs were much more frequent in the passive and transitive than were the unergative (manner of motion) verbs, and showed a correspondingly higher probability of occurrence in the reduced relative. The authors noted that significant differences on these and related dimensions paralleled speakers' intuitive judgments of comprehension difficulty.

The third set, so-called "object-drop" verbs, were external cause verbs from a variety of semantic sub-classes, as were those in McKoon and Ratcliff's (2003) Study 7. These (like McKoon & Ratcliff's external cause verbs) had a much higher proportion of transitive and passive uses than did their external cause change of state verbs, and a higher probability of reduced relatives as well. This is consistent with our results, and, in addition, supports the argument that McKoon and Ratcliff found more external cause reduced relatives than we did because the verbs they searched for had a higher probability of passive occurrence.

## General discussion

The results of the current studies fail to support any of the empirical claims made by the Meaning through Syntax theory of the reduced relative construction, as articulated in McKoon and Ratcliff (2003, 2005). English speakers readily produce reduced relatives with internal cause verbs, and their ease of comprehension is based on factors that facilitate ambiguity resolution, such as the goodness of the head as patient of the verb and the presence of a postverbal prepositional phrase. This is true whether or not the head noun phrase is a prototypical participant in the activity. Furthermore, the best predictor of whether or not a verb will occur in a reduced relative is its probability of occurring in the transitive and in the passive more generally. These findings are inconsistent with the MTS claim that the difficulty in comprehending sentences such as *The horse raced past the barn fell* results from the ungrammaticality of internal cause verbs in the reduced relative construction. On

the contrary, our results show that many reduced relatives with internal cause verbs are acceptable and easy to comprehend, whereas many with external cause verbs are difficult to comprehend, and rated as less acceptable. One might argue that nothing in MTS excludes difficulty with external cause reduced relatives: These are predicted to be grammatical, but a variety of factors contributing to holistic meaning may then influence how easy they are to comprehend (McKoon & Ratcliff, 2005). However, appealing to holistic meaning, which was defined in only very general terms by McKoon and Ratcliff (2005), does not explain why reduced relatives with internal cause verbs were rated to be as comprehensible as those with external cause verbs (Study 1). Perhaps more importantly, it does not account for the fact that English speakers produced numerous reduced relatives with internal cause verbs (Study 2). Even if the graded acceptability of reduced relatives with external cause verbs could be explained by a notion of holistic meaning, it is unclear what additional contribution is offered by MTS itself, and how holistic meaning might offer a more satisfactory account than existing, more clearly articulated constraint-based models (MacDonald et al., 1994; McRae et al., 1998; Tanenhaus & Trueswell, 1995).

Stated differently, there are two fundamental weaknesses with the MTS account of the production and comprehension of the reduced relative construction. First, the variables that best explain the data are not incorporated into the MTS account, whereas they are central to other current views of the language processing system, whether two-stage or constraint-based. Moreover, incorporating those variables would seem to be inconsistent with the basic tenets of the MTS program (McKoon & Ratcliff, 2003). Second, the factor that is central to MTS, the dichotomous classification of verbs into those that do or do not have an external cause in their event template, does not account for a significant portion of the variance.

Could the MTS account of reduced relatives be revised to accommodate the current results? McKoon and Ratcliff (2003, p. 498) do note that internal causality can be overridden. MTS could incorporate this into the theory by positing that internal cause verbs also have an external cause template, which would be the basis for causative uses such as *the boy walked his dog* or *winter storms eroded the beach*. The advantage of this approach is that it would allow these verbs to avoid the prohibition on internal causality, and also capture the fact that internal cause reduced relatives are possible in precisely those cases where the causative is also allowed.

McKoon and Ratcliff (2003) consider and reject this possibility both for change of state (p. 502) and manner of motion verbs (p. 498). And indeed, it would seriously undermine the empirical support for MTS, in particular the interpretation of the reading time and lexical decision results in McKoon and Ratcliff (2003, 2005) and McKoon and MacFarland (2000, 2002). In these studies, differences in reaction times to internal and external cause verbs have been taken to indicate differences in processing time due to the greater complexity of the external cause template. This interpretation would not be possible if an external cause template were available to the internal cause verbs as well, because that would eliminate the difference in template complexity. Hence it does not appear that MTS could permit any straightforward modification of the single-template assumption, even if it would allow MTS to accurately account for the ease or difficulty of reduced relatives.

Alternatively, the MTS program could abandon the effort to explain the difficulty of some reduced relatives. This could be done as part of a more general decision to restrict the MTS program to explaining verb-based complexity differences in the comprehension of unambiguous sentences, and the production patterns associated with different classes of verbs in different syntactic constructions. Given the well-documented systematic relationship among the type of event or activity that a verb denotes, the nature of the entities that participate in that event, and the types of syntactic complements with which that verb

can occur, exploring the interaction of verb-type and construction is likely to lead to important insights. However, as we discuss below, we anticipate that the assumptions that compromise the MTS account of the reduced relative construction, in particular the assumption that each verb has only one event template, are likely to prove problematic for MTS accounts of the comprehension and production of other verb types in other constructions.

In the remainder of the article, we focus on the broader implications of our results. We begin by considering the dangers of drawing certain types of inferences about acceptability from frequency of occurrence in corpora. We then focus on the relationships among the type of event or activity that a verb denotes, the nature of the entities that participate in that event, and the types of syntactic complements with which that verb can occur.

### Estimating occurrence from corpora

McKoon and Ratcliff (2003) point out advantages of combining experimental studies with corpus analyses, and we concur. Although both methods are useful, each has its strengths and weaknesses. In experimental studies, the experimenter can carefully construct materials to test specific hypotheses. However, these materials are unlikely to be representative of typical language and the use of somewhat artificial stimuli and tasks may bias the results. Corpus analyses, on the other hand, involve more natural and realistic language use and can provide valuable insights about frequency of occurrence, as well as patterns of co-occurrence. However, the relevant data may be sparse, with results that are likely to vary depending on the corpus.

It is important to keep in mind that even the largest corpus represents a relatively small sample of the recorded exemplars of the sentences and utterances of a language. Any corpus or composite of corpora is limited, and may not contain data that exists elsewhere. Thus one must keep in mind the probabilistic nature of locating rare constructions like the reduced relative, given infrequent verbs and a restricted language sample (cf. Tomasello & Stahl, 2004).

The sparseness problem becomes particularly acute when drawing conclusions from the absence of particular classes of exemplars. McKoon and Ratcliff's (2003, 2005) crucial evidence for a prohibition on reduced relatives for verbs of internal causality was that such reduced relatives were rare in their corpora. However, there are at least two reasons to be wary of drawing such conclusions from negative corpus results (in essence, a null effect). First, the frequency of a construction in a corpus needs to be evaluated relative to its expected occurrence. McKoon and Ratcliff (2003, Studies 4 and 5) do find reduced relatives with internal cause verbs, but dismiss them as errors because they are so rare. However, when one considers how infrequently these verbs occur in passive constructions in which (according to MTS) they are *not* prohibited, then the observed probability of their occurring in a reduced relative is, in fact, consistent with the expected probability.

Second, although both our corpus and that of McKoon and Ratcliff (2003) are quite large, they still represent only a limited sample of the language. Hence the fact that a particular low-frequency verb is not found in a reduced relative in one corpus or the other is, at best, extremely weak evidence that such reduced relatives do not exist. Drawing this conclusion is akin to accepting the null hypothesis, based on negative results with a small sample and no power estimate. And indeed, McKoon and Ratcliff's corpus contained reduced relatives with the internal cause verb *deteriorate*, although ours did not; conversely, our corpus, but not theirs, contained internal cause reduced relatives with *blister* and *wither*. Thus the lack of evidence for internal cause reduced relatives, in a particular corpus, cannot be taken as evidence that they are either prohibited or unacceptable. Corpus data can serve as a source



of hypotheses, but these hypotheses need to be evaluated by behavioral data, including judgments. Our general point here, of course, simply echoes Chomsky's classic arguments about the limitations of building a linguistic theory whose goal is to account for observations from corpora (Chomsky, 1957, 1965).

### Events, verb semantics, and structure

**Sense and structure**—An appealing aspect of the Meaning Through Syntax approach is that it incorporates formal apparatus from lexical semantics as a way of implementing the insight that a verb's semantic representation is reflected in, and at least partially determines, the syntactic frames in which the verb appears. MTS predicts that the relationship is straightforward, such that “the syntactic positions in a sentence are defined, at least in major part, in terms of the semantic event templates” (p. 495). Thus, for example, in the sentence *John broke the window*, “*John* being the subject of the sentence conveys that something John did is the immediate cause of the breaking event and *the window* being the direct object conveys that the window changes state as a result of the event” (McKoon & Ratcliff, 2003, p. 495). Furthermore, MTS takes the novel step of combining verb-based event-templates with Construction Grammar, which argues that grammatical constructions like the passive or the transitive make an independent contribution to meaning.

We want to emphasize that the problems with the MTS model of the reduced relative are not due to any problems with the ideas from construction grammar and lexical verb semantics that MTS draws upon. Rather they come from claims that are specific to MTS. The most problematic assumption—one that is crucial to the MTS account of reduced relatives—is that with the exception of truly ambiguous verbs, each verb has only a single event template, which remains invariant across different senses and syntactic frames. This assumption contributes to MTS's inability to account for reduced relative use, and the problems become even more evident when MTS is faced with a broader range of data than the reduced relative construction. Most verbs have different senses, and these tend to occur in different structural frames, and theories of lexical semantics take it as a major goal to account for such alternations (cf. Pustejovsky, 1995). Consider the verb *race*. Its internal cause template correctly predicts that *race* will occur in intransitive sentences like *the horse raced*. It also correctly predicts that *the horse* will occur in subject position, because that is the grammatical role filled by the internal cause of the event. However, this template does not predict that the verb will occur in transitive sentences like *John raced the horse*. Nor can it account for the fact *John* surfaces as subject. Instead, this entity is said to come from other parts of the verb's meaning (McKoon & Ratcliff, 2003, p. 496), not from the syntactically relevant event template (p. 494). Thus the one-template stipulation not only leads to the wrong structural predictions, but it also undermines the essential notion of MTS, that “the event template meaning of the verb is expressed through the syntax of the sentence” (p. 495).

Clearly, if all things were equal, it would be desirable for all instances of a verb to have a single event representation. However, theories of lexical semantics must balance the desire to unite multiple verb senses with the need to account for structural alternations. The requirement to handle a broader range of data leads theories of lexical semantics to take a more nuanced approach than the one verb, one event template approach adopted by MTS. As one example, Levin and Rappaport Hovav (1995) propose lexical rules that alter the causal status of the intransitive subject in specific contexts. More compellingly, Pustejovsky (1995) argues that the verb's representation itself does not change, but the senses it will express (and the structures it will occur in) derive from a generative process combining the verb's lexical representation with those of specific arguments with which it co-occurs in each sense. Although this approach has not yet been fully tested, it indicates the richness of

the representational system required to capture the complex relationship between structure and meaning.

**Event templates and event representations**—The MTS account assumes that use of a verb in a given construction is determined by its event template. On an ambiguity account, the interpretability of a reduced relative is related to the ease with which the initial noun phrase can be construed as the patient of the passive—or more generally, as affected by the event. For a wide variety of cases, this is equivalent to saying that the event must be interpretable as externally caused. However, the interpretation is influenced by factors that do not always align with verb class. In what follows, we summarize these factors and their relationship to the internal/external cause distinction.

First, a verb is likely to occur in the passive only if it is acceptable in the transitive. As a result, different verb classes will vary in their passivizability. As noted earlier, external cause verbs are transitive in their basic sense, and so will passivize freely. Internal cause verbs, if they are used in a causative sense, will occur in the transitive as well. Pinker (1989) investigates the conditions on causativization, and finds that individual verbs differ in their degree of inherent internal cause, even though they may belong to the same semantic class. As a result, the likelihood that a given type of event will be construed as externally caused falls on a continuum, and as a general rule, the internal and external cause verbs will be found at its extremes. However, this is a probabilistic distinction, not a categorical one. Thus although manner of motion verbs like *totter* or *scurry* are rare in the causative, they will be used that way if the movement is construed as externally induced, as McKoon and Ratcliff (2003) find in their corpora with examples like *she tottered him home after one of his binges* or *...she had some rather unusual things to say about CNN, and we ...very quickly scurried her off*.

Second, the causative requires an agent that is capable of inducing the action. McKoon and Ratcliff (2005) find that in the majority of cases, the grammatical subjects of manner of motion verbs are humans, actions by humans, or natural forces (p. 1034), but the options are much wider when the verb is an external cause change of state. This is offered as evidence for a categorical distinction between internal and external cause verbs, but in fact it follows from more general aspects of thematic fit, and as such it again reflects probabilities rather than a rigid distinction. Human agents (or their actions) are more likely than artifacts or abstract entities to cause an animate entity to move, as manner of motion verbs generally require. But manner of motion verbs are also used in non-literal senses that do not require physical force, and thematic fit extends to cases of this sort, which McKoon and Ratcliff acknowledge as problematic for MTS: “For example, in *An epilogue jumps us from April to August*, with the manner-of-motion verb *jump* (from McKoon & Ratcliff’s, 2003, corpus), the restrictions listed in Table 1 are violated because an epilogue is not a person, an act by a person, or a natural force.” (2005, p. 1035).

Third, seminal work by Lakoff (1977) and Hopper and Thompson (1980) argues that transitivity is based not simply on the verb, but on characteristics of the clause as a whole, such as the number of participants, the volitionality of the agent, and the degree to which the patient is construed as affected. Passivizability is directly related to these factors (Rice, 1987), particularly to the interpretation of the patient’s role. Crucially, this account acknowledges that locations or paths are generally not treated as direct objects, yet if they are construed as affected by an event—if the event is habitual in that location, or otherwise characterizes it as special—they are interpreted as participants in the event and one finds acceptable passives, as in *That peak was first climbed by Hillary in 1952* (Bolinger, 1975, 1977; Rice, 1987).

These constraints translate directly to the findings on reduced relative probability. Highly transitive verbs, particularly those with human agents, are more likely to occur in the passive, and therefore in the reduced relative (McKoon & Ratcliff, 2003; Merlo & Stevenson, 1998). Change of state verbs, whether external cause like *break* or internal cause like *erode*, will occur in the reduced relative if the change is viewed as caused or induced by some other entity. Manner of motion verbs, which are the least likely to be construed as induced, are not surprisingly the least likely to be found in the reduced relative: The majority of manner of motion verbs encode highly specific movements that are difficult to construe as caused by some entity other than the mover. Those that do occur in the causative, however, tend to have animate, volitional agents (McKoon & Ratcliff, 2005) or highly affected patients, two factors that the work cited above has shown to facilitate occurrence in passive constructions like the reduced relative. Finally, even non-prototypical patients like locations will appear as subject of the passive if they are construed as participants in the event. These can then appear as the head of a corresponding reduced relative, as in our example *the storm...hurled rocks and boulders onto the path walked by tourists*, where the habitual use of that path by tourists marks it as distinct.

Thus, whereas semantic factors largely determine whether or not a verb may occur in the reduced relative, these factors go beyond the information that could be encoded in the event template of individual verbs. It is possible that these factors could be captured in a more richly articulated and dynamic model of lexical representation, perhaps along the lines sketched by Pustejovsky (1995) and Jackendoff, among others. However, we would argue that a complete account of reduced relative comprehension and use will include considerations that extend beyond the lexical semantics of specific verbs, to the multitude of factors that influence how the language user construes the event being described. On this view, the relevant generalizations are not strictly about lexical knowledge, but rather the speakers' interpretation of generalized events in the world.

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## Appendix A

Study 1 and 2 Sentences: Reduced relatives, unreduced relatives, and full passives, along with their mean acceptability rating

### Easy sentences with external cause verbs

Most of the applicants interviewed by the catering company were offered jobs. 6.82

Most of the applicants that were interviewed by the catering company were offered jobs. 6.10

Most of the applicants were interviewed by the catering company. 6.42

The evidence reviewed by the judge turned out to be unreliable. 6.36

The evidence that was reviewed by the judge turned out to be unreliable. 5.90

The evidence was reviewed by the judge. 7.00

The suspect detained for questioning was later released. 6.64

The suspect who was detained for questioning was later released. 6.40

The suspect was detained for questioning. 7.00

Most of the intelligence evaluated by the subcommittee was badly flawed. 4.83

Most of the intelligence that was evaluated by the subcommittee was badly flawed. 5.45

Most of the intelligence was evaluated by the subcommittee. 4.70

Whiskey aged for less than a decade often has a harsh taste. 6.58

Whiskey that has been aged for less than a decade often has a harsh taste. 6.27

The whiskey was aged for less than a decade. 6.00

The raccoons examined by the vet were confused but not rabid. 5.36

The raccoons that were examined by the vet were confused but not rabid. 4.90

The raccoons were examined by the vet. 6.75 430

The students caught cheating on exams were suspended for at least a semester. 6.25

The students who were caught cheating on exams were suspended for at least a semester. 6.18

The students were caught cheating on exams. 7.00

The POW tortured by his captors eventually escaped. 5.50

The POW who was tortured by his captors eventually escaped. 6.45

The POW was tortured by his captors. 6.70

The movie directed by Robert Redford won three Academy awards. 6.50

The movie that was directed by Robert Redford won three Academy awards. 6.75

The movie was directed by Robert Redford. 7.00

The customer served by the efficient and good-natured waiter left him a big tip. 5.30

The customer who was served by the efficient and good-natured waiter left him a big tip. 5.42

The customer was served by the efficient and good-natured waiter. 6.18

The tasks assigned to the secretary kept her busy all day. 6.50

The tasks that were assigned to the secretary kept her busy all day. 6.83

The tasks were assigned to the secretary. 6.91

The murderer sentenced to life in prison was never given parole. 5.80

The murderer who was sentenced to life in prison was never given parole. 6.42

The murderer was sentenced to life in prison. 6.55

### **Hard sentences with external cause verbs**

The bicycle smashed into the wall had been stolen. 3.36

The bicycle that had been smashed into the wall had been stolen. 5.10

The bicycle was smashed into the wall. 6.25

The tree snapped in half during the storm took down a power line. 3.09

The tree that had been snapped in half during the storm took down a power line. 6.10

The tree was snapped in half during the storm. 7.00

The lioness hunted throughout the night was pregnant with cubs. 3.55

The lioness that was hunted throughout the night was pregnant with cubs. 5.40

The lioness was hunted throughout the night. 6.17

The mailman handed a letter put it in his bag. 2.55

The mailman who was handed a letter put it in his bag. 5.80

The mailman was handed a letter. 6.92

The general expected to win the battle was soundly defeated. 3.75

The general who was expected to win the battle was soundly defeated. 5.73

The general was expected to win the battle. 6.70

The motorcycle crashed into a fire hydrant will be expensive to repair. 3.42

The motorcycle that had been crashed into a fire hydrant will be expensive to repair. 5.18

The motorcycle was crashed into a fire hydrant. 6.30

The patient refused treatment for cancer sued for damages. 3.50

The patient who had been refused treatment for cancer sued for damages. 6.82

The patient was refused treatment for cancer. 5.80

The judge denied parole served time. 3.42

The judge who was denied parole served time. 4.64

The judge was denied parole. 5.30

The waiter served a steak enjoyed it immensely. 1.70

The waiter who was served a steak enjoyed it immensely. 5.92

The waiter was served a steak. 4.18

The employer sent flowers as a gesture of thanks just loved them. 1.80

The employer who was sent flowers as a gesture of thanks just loved them. 5.08

The employer was sent flowers as a gesture of thanks. 6.82

The guard searched inside the prison walls had cocaine hidden in his jacket. 2.20

The guard who was searched inside the prison walls had cocaine hidden in his jacket. 5.25

The guard was searched inside the prison walls. 5.18

The general presented an ultimatum surrendered. 1.90

The general who was presented an ultimatum surrendered. 5.75

The general was presented an ultimatum. 6.55

### **Easy sentences with internal cause verbs**

The gunshot victims rushed to the hospital were placed on life support. 5.27

The gunshot victims who were rushed to the hospital were placed on life support. 6.20

The gunshot victims were rushed to the hospital. 7.00

The beaches eroded by the storm were closed to the public. 6.18

The beaches that had been eroded by the storm were closed to the public. 6.30

The beaches were eroded by the storm. 7.00

Whiskey fermented in oak barrels can have a woody taste. 5.73



Whiskey that has been fermented in oak barrels can have a woody taste. 5.70

Whiskey is fermented in oak barrels. 7.00

Dogs walked frequently are usually well behaved. 5.64

Dogs that are walked frequently are usually well behaved. 6.50

Dogs are walked frequently. 6.75

The flowers wilted by the midday sun recovered in the cool of the night. 5.33

The flowers that had been wilted by the midday sun recovered in the cool of the night. 5.91

The flowers were wilted by the midday sun. 6.70

The path traveled by many settlers extended far to the west. 6.00

The path that was traveled by many settlers extended far to the west. 6.09

The path was traveled by many settlers. 6.80

The seeds germinated on the windowsill were killed by an early frost. 4.83

The seeds that had been germinated on the windowsill were killed by an early frost. 5.45

The seeds were germinated on the windowsill. 5.60

The silver tray tarnished by damp air was restored by the antique dealer. 5.58

The silver tray that had been tarnished by damp air was restored by the antique dealer. 6.64

The silver tray was tarnished by damp air. 5.60

The sinks corroded by the dripping water were eventually replaced. 6.00

The sinks that had been corroded by the dripping water were eventually replaced. 6.33

The sinks were corroded by the dripping water. 6.64

The mountain climbed by the tourists sloped gently upward. 5.40

The mountain that was climbed by the tourists sloped gently upward. 5.83

The mountain was climbed by the tourists. 6.18

The city streets roamed by gangs of young men were too dangerous for tourists. 5.60

The city streets that were roamed by gangs of young men were too dangerous for tourists.  
5.42

The city streets were roamed by gangs of young men. 6.27

Canadian cars rusted by road salt don't last as long as they should. 5.10

Canadian cars that have been rusted by road salt don't last as long as they should. 6.50

Canadian cars are rusted by road salt. 5.82

### Hard sentences with internal cause verbs

The worm wiggled in front of the fish was irresistible bait. 3.82

The worm that was wiggled in front of the fish was irresistible bait. 5.30

The worm was wiggled in front of the fish. 5.42

The horse raced past the barn fell. 2.64

The horse that was raced past the barn fell. 2.80

The horse was raced past the barn. 5.33

The raft floated down the river sank. 3.27

The raft that was floated down the river sank. 4.60

The raft was floated down the river. 5.67

The princess waltzed across the dance floor waved at the band. 3.18

The princess who was waltzed across the dance floor waved at the band. 5.10

The princess was waltzed across the dance floor. 6.08

The woman walked through the park every day was suffering from Alzheimer's disease.  
3.83

The woman who was walked through the park every day was suffering from Alzheimer's  
disease. 4.55

The woman was walked through the park every day. 4.20

The pony galloped past the crowd held its head high. 3.92

The pony that was galloped past the crowd held its head high. 4.82

The pony was galloped past the crowd. 4.50

The virus mutated in the dish was extremely virulent. 4.33

The virus that was mutated in the dish was extremely virulent. 5.09

The virus was mutated in the dish. 5.80

The plane coasted to a safe landing had a damaged engine. 3.33

The plane that was coasted to a safe landing had a damaged engine. 5.18

The plane was coasted to a safe landing. 5.20

The teens trekked through Europe were unhappy. 3.10

The teens that were trekked through Europe were unhappy. 4.58

The teens were trekked through Europe. 3.91

The soldiers marched for five hours straight were exhausted. 2.70

The soldiers that were marched for five hours straight were exhausted. 5.67

The soldiers were marched for five hours straight. 5.09

The prisoner snuck out of the jail at night was taken to a nearby warehouse. 2.50

The prisoner who was snuck out of the jail at night was taken to a nearby warehouse. 5.75

The prisoner was snuck out of the jail at night. 5.18

The car slid across the icy road was actually part of a stunt for a movie. 2.60

The car that was slid across the icy road was actually part of a stunt for a movie. 4.67

The car was slid across the icy road. 4.27

## Appendix B

Baseline comparison sentences for hard and easy internal cause reduced relatives

### **Anomalous sentences (found to be less acceptable than hard internal cause reduced relatives)**

The purple cow designed bushes math.

Put the plate on the napkin on the bench yesterday.

When the light turned green, everyone put and brought.

The doctor said and stated for hours.

The bartender grasped the mug of beer had been given to the wrong customer.

That there exist politicians who like to talk and never seem to pay attention to anyone else even though it is their job to is well known.

Getting a job isn't the easiest thing for a person to refrain from doing these days.

### **Comprehensible sentences (equal to easy internal cause reduced relatives in acceptability)**

That smoking is bad for you is a well known fact.

The biotech industry banks on the Medicare law for help on drug bills.

A little before they thought that it would, spring arrived.

The committee's annoyance at the mayor's insistence on being heard at every meeting was getting obvious.

John and Susan were having an affair after hours in the lab last year.

A sports announcer and her husband went to dinner at her mother's house.

Because my watch constantly loses time, I'm always late.

The leaves were turning colors, and her thoughts turned toward winter.

In the hallway there ticked a grandfather clock.

A convenience store was robbed by two teenagers but they got away with only \$200.

Only six of the smallest doughnuts were left.

The bananas were way too ripe to eat.

## Appendix C. Instructions for Study 2

After reading the first sentence below, please rate how acceptable it is as an English sentence, using a scale of 1–7. A rating of 1 indicates that the sentence is extremely unacceptable, while a rating of 7 would indicate the sentence is completely acceptable. After you are done rating the sentence, shorten the sentence's length by deleting two or more words. You cannot add any new words or rearrange the words. Try not to change the meaning of the sentence. Write out the shortened sentence in the space provided, then rate how acceptable you feel the shortened sentence is, also using a scale from 1 to 7. While we want you to try to produce good sentences with as similar a meaning as you can, not all sentences can be shortened in a grammatically correct fashion and you may sometimes have trouble preserving the meaning of the first sentence. Your last task for this sentence is to decide how similar the meaning of the shortened sentence is to that of the original sentence, using a scale from 1 to 5. A rating of 1 would mean the sentences have very different meanings, while a rating of 5 would mean the sentences have the same meaning. After you are done with the first sentence, go on to the rest in sequential order. If you have any questions regarding the tasks, please let the experimenter know now.

## EXAMPLES

1. The teenager was taping some music for his friend when his stereo stopped working.  
Acceptability rating:    1    2    3    4    5    6    7
- 1a. The teenager was taping music for his friend when his stereo stopped.  
Acceptability rating:    1    2    3    4    5    6    7  
Similarity rating:        1    2    3    4    5
2. John was planning not to go on to the store.  
Acceptability rating:    1    2    3    4    5    6    7
- 2a. John was planning to go to the store.  
Acceptability Rating:    1    2    3    4    5    6    7  
Similarity rating:        1    2    3    4    5
3. Tarzan knifed the large leopard.  
Acceptability rating:    1    2    3    4    5    6    7
- 3a. Tarzan knifed leopard.  
Acceptability rating:    1    2    3    4    5    6    7  
Similarity rating:        1    2    3    4    5

Table 1

Sentence comprehensibility ratings by condition for Study 1

Construction	External cause				Internal cause			
	Easy		Hard		Easy		Hard	
	M	SE	M	SE	M	SE	M	SE
Reduced relative	6.0	0.1	2.9	0.2	5.6	0.2	3.3	0.2
Unreduced relative	6.1	0.2	5.6	0.2	6.1	0.1	4.8	0.2
Passive	6.5	0.1	6.1	0.1	6.4	0.1	5.1	0.2

**Table 2**

## Analyses of variance for Study 1

Effect	Participants	Items	minF'
<i>Reduced relative clauses only</i>			
Difficulty	$F(1,30) = 321.78$	$F(1,36) = 409.80$	$F(1,63) = 180.25$
Verb type	$F < 1$	$F < 1$	$F < 1$
Interaction	$F(1,30) = 11.14$	$F(1,36) = 11.04$	$F(1,66) = 5.54$
Anomalous Fillers vs. Hard Internal	$F(1,32) = 38.69$	$F(1,17) = 9.24$	$F(1,25) = 7.46$
Easy Fillers vs. Easy Internal	$F < 1$	$F < 1$	$F < 1$
<i>Ambiguity, difficulty, and verb type</i>			
Difficulty	$F(1,30) = 338.68$	$F(1,36) = 187.13$	$F(1,64) = 120.53$
Ambiguity	$F(1,30) = 224.85$	$F(1,36) = 190.18$	$F(1,66) = 103.03$
Ambiguity $\times$ Difficulty	$F(1,30) = 83.44$	$F(1,36) = 111.36$	$F(1,63) = 47.70$
Verb type	$F(1,30) = 6.76$	$F(1,36) = 2.32^{ns}$	$F(1,57) = 1.73^{ns}$
Verb type $\times$ Ambiguity	$F(1,30) = 6.88$	$F(1,36) = 3.66^{ns}$	$F(1,63) = 2.39^{ns}$
Verb type $\times$ Difficulty	$F < 1$	$F < 1$	$F < 1$
Three-way interaction	$F(1,30) = 28.06$	$F(1,36) = 20.73$	$F(1,66) = 11.92$

Note. all  $F$ 's significant unless otherwise noted. ns = non-significant.

**Table 3**

A number of measures by condition for Study 2

Dependent variable	External cause			Internal cause				
	Easy		Hard	Easy		Hard		
	M	SE	M SE	M	SE	M SE		
Proportion reduced relative	0.64	0.04	0.19	0.06	0.52	0.05	0.17	0.04
Reduced relative acceptability	6.7	0.1	5.9	0.3	6.5	0.1	6.3	0.2
Other acceptability	6.5	0.2	6.3	0.1	6.5	0.1	6.1	0.1
Unreduced/reduced similarity	4.8	0.1	3.9	0.5	4.9	0.1	4.9	0.1
Other similarity	4.1	0.1	3.6	0.2	4.3	0.1	3.9	0.1
Unreduced relative acceptability	6.5	0.1	6.2	0.1	6.4	0.1	5.6	0.2
Passive acceptability	6.8	0.1	6.5	0.1	6.6	0.1	5.8	0.2

*Note.* Acceptability was rated on a seven-point scale, whereas similarity was rated on a five-point scale. We used different scales for acceptability and similarity to reduce confusion for participants.

**Table 4**

## Analyses of variance for Study 2

Analysis	Effect	Participants	Items	min <i>F'</i>
Production	Verb type	$F(1,18) = 6.94$	$F(1,40) = 2.83^{ns}$	$F(1,58) = 2.01^{ns}$
Production	Difficulty	$F(1,18) = 64.14$	$F(1,40) = 78.13$	$F(1,46) = 35.22$
Production	Interaction	$F(1,18) = 2.59^{ns}$	$F(1,40) = 1.28^{ns}$	$F < 1$
Acceptability	Verb type		$F < 1$	
Acceptability	Difficulty		$F(1,33) = 8.40$	
Acceptability	Interaction		$F(1,33) = 2.76^{ns}$	
Similarity	Verb type		$F(1,33) = 7.17$	
Similarity	Difficulty		$F(1,33) = 3.62^{ns}$	
Similarity	Interaction		$F(1,33) = 4.22$	

Note. all  $F$ 's significant unless otherwise noted; ns = non-significant.



**Table 5**

Proportions of each type of construction for Study 3 corpora analyses

Construction	External cause change of state		Internal cause change of state		Internal cause manner of motion	
	M	SE	M	SE	M	SE
Passive	0.090	0.014	0.081	0.023	0.006	0.003
Transitive	0.205	0.018	0.188	0.024	0.115	0.019
<i>MTS Criteria</i>						
Reduced relative	0.0051	0.0020	0.0144	0.0059	0.0001	0.0001
<i>Expanded Criteria</i>						
Reduced relative	0.0075	0.0024	0.0241	0.0083	0.0003	0.0001

**Table 6**

Analyses of variance for Study 3 corpora analyses

<b>Dependent variable</b>	<b>Effect</b>	<b>Items</b>
Probability passive	Verb type	$F(2,51) = 9.22$
Probability transitive	Verb type	$F(2,51) = 5.61$
<i>MTS Criteria</i>		
Probability reduced relative	Verb type	$F(2,51) = 4.68$
<i>Expanded Criteria</i>		
Probability reduced relative	Verb type	$F(2,51) = 7.26$

*Note.* Verb type = external cause change of state vs. internal cause change of state vs. internal cause manner of motion; all  $F$ 's are significant.