

CHAPTER 6. EFFECTS OF TELICITY AND TRANSITIVITY IN THE WORD MAZE EXPERIMENT

6.1 Introduction

This chapter reports the results of an experiment that tests the Event Structure Processing (ESP) hypothesis in a paradigm that provides a measurement of comprehension difficulty throughout the sentence. The ESP hypothesis, as introduced in Chapter 1, is that event structure information, such as inherent verb telicity, affects on-line sentence comprehension. The ESP hypothesis predicts that inherent verb telicity information should affect the comprehension of reduced relative clause sentences. As discussed in the previous chapters, reduced relative clause sentences like the one in (115)a can easily be interpreted as a simple main clause sentence like the one in (115)c until the disambiguating word *were* is encountered.

(115)

- a. *The agents watched at the entrance were dangerous.*
- b. *The agents who were watched at the entrance were dangerous.*
- c. *The agents watched at the entrance for the rebels.*

This temporary ambiguity is the reason that reduced relative clause sentences have been studied extensively in the past thirty years, beginning with Bever 1970. The difference in processing difficulty between the reduced relative in (115)a and the unambiguous unreduced relative clause sentence in (115)b is known as the Reduced Relative Effect (RRE). Studies of the RRE can provide evidence on which factors affect the comprehension system's degree of commitment to the simple main clause interpretation of the sentence.

In the experiment in this chapter and in chapters 4 and 5, the question is whether the factors of telicity and transitivity affect the RRE independently of each other. The ESP hypothesis predicts that RREs will be smaller in sentences with embedded telic verbs compared to those with embedded atelic verbs. This prediction was borne out in the early disambiguation (verb plus *by*) region in the analyses of prior self-paced reading experiments (Clarke, Townsend, & Bever, 2000; McRae, Spivey-Knowlton, & Tanenhaus, 1998; Tabossi, Spivey-Knowlton, McRae, & Tanenhaus, 1994) presented in chapter 4. Since those studies were not designed to test the hypothesis, they included an unequal number of items in each of the four verb types. This imbalance made it difficult to determine whether verb telicity and verb transitivity had a statistically significant effect on reading times. The ESP hypothesis was further tested in the speaker change monitoring experiment presented in chapter 5. This experiment did include an equal number of items in each of the four verb types, and it did reveal a statistically significant effect of telicity on speaker change detection errors. However, the speaker change experiment had the limitation that the earliest possible probe point within the

disambiguating region was the noun in the *by*-phrase. This position showed the smallest effects of telicity and transitivity on the reduced relative effect (RRE) in the self-paced reading analyses in chapter 4. In those analyses, the telicity and transitivity effects were much larger on the embedded verb and the preposition *by* and also on the main verb. The word maze paradigm (Freedman & Forster, 1985) provides a measure of processing difficulty not only on these two critical regions, but also on each of the other words in the sentence. It is for this reason that the word maze paradigm was chosen to further test the ESP hypothesis.

6.2 Methods

6.2.1 Participants

The participants were 56 monolingual speakers of English. All of the participants were students in introductory psychology courses at the University of Arizona. For their participation, they received credit in their course. Fifty-four of the participants were right-handed, and two of the participants were left-handed.

6.2.2 Materials

The experimental materials were 24 sets of 8 sentences such as those in (111).

(116)

- a. *Reduced, Obligatorily Transitive, Atelic: The actress described by the writer left in a hurry.*
- b. *Unreduced, Obligatorily Transitive, Atelic: The actress that was described by the writer left in a hurry.*
- c. *Reduced, Obligatorily Transitive, Telic: The actress spotted by the writer left in a hurry.*
- d. *Unreduced, Obligatorily Transitive, Telic: The actress that was spotted by the writer left in a hurry.*
- e. *Reduced, Optionally Transitive, Atelic: The actress sketched by the writer left in a hurry.*
- f. *Unreduced, Optionally Transitive, Atelic: The actress that was sketched by the writer left in a hurry.*
- g. *Reduced, Optionally Transitive, Telic: The actress awakened by the writer left in a hurry.*

- h. *Unreduced, Optionally Transitive, Telic: The actress that was awakened by the writer left in a hurry.*

The experimental material sentences are almost identical to the materials used in speaker change monitoring experiment in chapter 5. However, a few of the verbs were changed, in order to make the exact event structures of the verbs in each of the four verb types more uniform. In this experiment, all of the potentially intransitive telic verbs are unaccusative, and all of the potentially intransitive atelic verbs are object drop verbs. The complete set of material sentences for the word maze experiment is given in Appendix 7.

The verbs were controlled for lexical frequency using the Kucera Francis database. An ANOVA on verb frequency counts showed no significant difference in the lexical frequencies between the verbs in the four different verb type categories.

6.2.3 Procedure

In the word maze paradigm (Freedman & Forster, 1985), participants navigate through a series of word pairs, choosing the word that can be a grammatical continuation at each step. Successful completion of a trial requires the participant to process the sentence incrementally, parsing all of the previously presented words in order to make each choice. The experimenter read the instructions in (117) to each participant as they looked at the example in Figure 16.

- (117) *Instructions: The Word Maze Game. In this experiment, you must follow a sentence through a “maze”. The sentences will be presented on a computer. You will see two words at a time, and one of the words will be the correct word that*

continues the sentence. You can only reach the end of the sentence by selecting the correct word at each step. For example, you will see something like this (sic., Figure 16). The correct selections would be “The rain fell silently.” At each step make your selection by pressing one of two buttons. Press the button on the left to select the word on the left. Press the button on the right if you want to select the word on the right. You will begin each new sentence by pressing the red button. Try not to make mistakes, but also try to respond as quickly as possible. If you do make an error, the computer will say so, and will stop the sentence at that point. You will be asked to go on to the next sentence. Press the red button to continue. If you make it to the end of the sentence, the computer will tell you that you were correct. Press the red button to begin the next sentence. You will be given ten practice sentences so that you can get used to the procedure. A message will let you know when the real experiment begins.

Figure 16. Example screens and responses from the word maze

The Word Maze Paradigm		
<u>Computer Screen</u>		<u>Correct Response</u>
The ...		LEFT
rain were		LEFT
them fell		RIGHT
clock silently		RIGHT

Participants sit in front of a computer screen and use a game pad to hit the left (left word choice), right (right word choice), and red (start next trial) buttons. The left button is most

easily pressed using the index finger on the left hand, and the right button is most easily pressed using the index finger on the right hand. The red button is most easily pressing using the right-hand thumb. Participants were instructed to use these fingers on the game pad.

The experimental software, DMDX, collects reaction times and errors for each choice in the sentence. As mentioned above, the dependent variable of interest is the reduced relative effect (RRE), measured as the reaction time difference between the reduced and unreduced conditions at each position in the sentence.

In each run of the experiment, the participant was presented with 24 experimental sentences. Each participant was presented with three sentences in each of the eight experimental conditions. The eight experimental conditions result from fully crossing three bi-level factors: reduction (reduced relative versus unreduced relative), telicity (telic versus atelic), and transitivity (obligatorily transitive versus optionally transitive). The experimental sentences were interspersed between 48 distracter items, which were sentences of varying lengths and structures. The participants were not asked to answer comprehension questions or paraphrase the sentences. Such checks for comprehension were considered unnecessary, because successfully navigating through the word maze requires the participant to comprehend the sentence.

Construction of the maze task stimuli required the use of non-continuation words, which served as the incorrect choices at each point in the sentences. For example, *were*, *them*, and *clock* are the non-continuation words in Figure 16. The non-continuation words

were incorrect choices because they resulted in an ungrammatical sentence fragment, not just an implausible sentence fragment.

6.2.4 Predictions

The prediction is that RREs will be smaller in sentences with embedded telic verbs than in those with embedded atelic verbs. In keeping with MacDonald's (1994) results, the transitivity prediction is that sentences with obligatorily transitive verbs will have smaller RREs than those with optionally transitive verbs, at least on the main verb region of the sentence.

6.3 Results

Table 13 shows the mean reaction times for each verb type in each sentence region for the reduced and unreduced conditions as well as the RRE. The table shows that on the *by* and *the* regions, the RREs in the atelic conditions are larger than those in the telic conditions. The table also shows that on the *the*, *noun*, *main verb*, and *next word* regions, RREs in the optionally transitive conditions are larger than those in the obligatorily transitive conditions. Another striking result is that RREs are much larger on the word *by* than on any other region, except for in the optionally transitive telic condition.

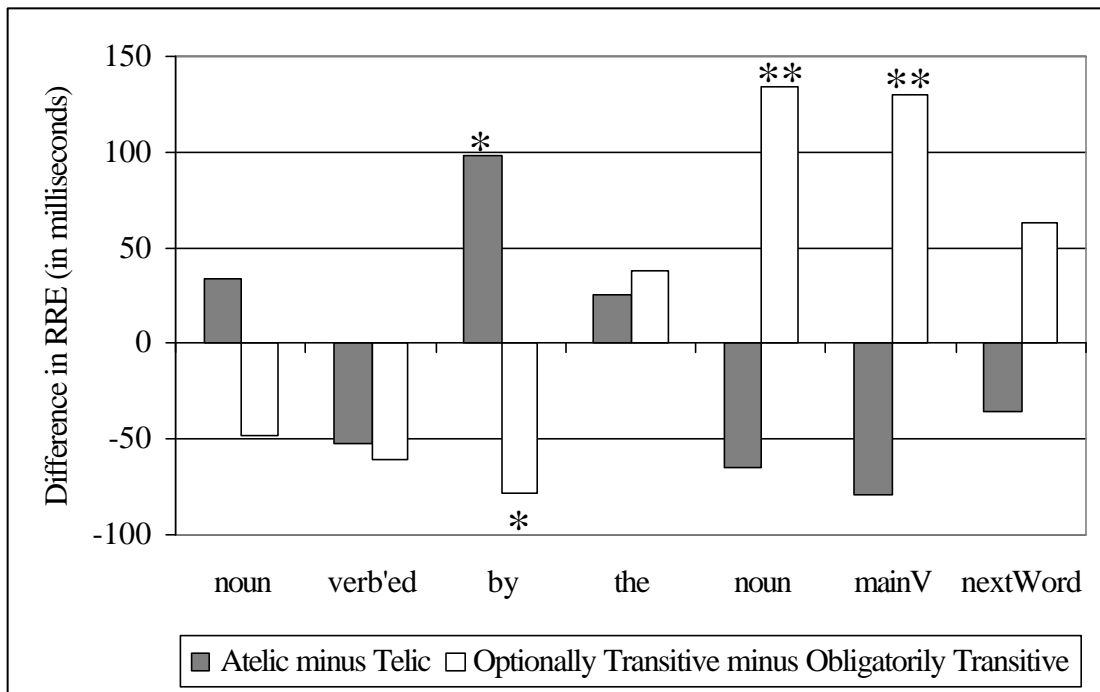
Table 13. Mean reaction times for each verb type in each sentence region in the word maze task

Transitivity	Telicity	Example	Reduction	Sentence Region					
				embedded verb	by	the	noun	main verb	next word
<u>Obligatorily Transitive</u>	<u>Atelic</u>	The N carried by the N mainV...	<i>Red.</i>	1275	1197	796	978	1188	959
			<i>Unred.</i>	1358	855	743	1005	1164	964
			<i>RRE</i>	-83	342	53	-27	24	-5
<u>Obligatorily Transitive</u>	<u>Telic</u>	The N accused by the N mainV...	<i>Red.</i>	1215	1161	748	1061	1126	902
			<i>Unred.</i>	1160	834	729	1043	1132	888
			<i>RRE</i>	56	327	19	18	-6	14
<u>Optionally Transitive</u>	<u>Atelic</u>	The N lectured by the N mainV...	<i>Red.</i>	1225	1138	803	1047	1235	967
			<i>Unred.</i>	1281	791	720	959	1191	925
			<i>RRE</i>	-56	347	83	88	44	41
<u>Optionally Transitive</u>	<u>Telic</u>	The N tripped by the N mainV...	<i>Red.</i>	1254	1027	814	1223	1395	1061
			<i>Unred.</i>	1345	862	748	1051	1161	968
			<i>RRE</i>	-91	165	66	172	233	93

Figure 17 shows the mean RREs for the two atelic conditions minus the RREs for the two telic conditions and the RREs for the two obligatorily transitive conditions minus the two optionally transitive conditions. Thus, positive bars indicate that the telicity or transitivity effect was in the predicted direction; negative bars indicate that the effect was opposite of the predicted direction. The y axis represents the sentence regions; each region is

composed of one and only one word. The stars indicate on which regions the telicity effect or the transitivity effect is statistically significant.²⁶

Figure 17. Telicity and transitivity effects on the RRE in the word maze task



The analysis of variance results are presented in Table 14. Telicity has a significant effect on the RRE in the predicted direction at the early disambiguation point, on the word *by*.

²⁶ One star indicates that the effect is significant; in other words, the *p* value is greater than .01 but less than .05. Two stars indicates that the effect is highly significant, meaning that the *p* value is less than .01.

Table 14. ANOVA results on RREs in word maze with 56 subjects and 24 items

Factor(s)	Sentence Region											
	embedded verb		by		the		noun		main verb		next word	
	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>
Telicity	1.9	n.s.	4.9	< .05	< 1	n.s.	3.3	0.08	2.9	0.1	< 1	n.s.
Transitivity	3.5	0.07	4.4	< .05	2.4	n.s.	19.5	< .01	9.2	< .01	4	0.05
Telicity X Transitivity	4.1	< .05	4.6	< .05	< 1	n.s.	< 1	n.s.	5.8	< .05	< 1	n.s.

Transitivity also has a significant effect on the RRE in this region, but it is the opposite direction of the prediction. Transitivity has a highly significant effect on the RRE in the predicted direction on the noun in the *by*-phrase and on the main verb. The interaction between telicity and transitivity has significant effect on the RRE on the *by* region and on the main verb. There is very high negative correlation of $-.98$ between the effects of telicity and transitivity throughout the critical regions (*by* through the “next word” region, which is one word following the main verb).

6.4 Discussion

The results show a significant main effect of telicity on the RRE in the predicted direction on the early disambiguation region (the word *by*). This finding clearly supports the Event Structure Processing hypothesis. As the hypothesis predicts, RREs are significantly smaller when the embedded verb is telic compared to when it is atelic.

The results also show a significant main effect of transitivity on the RRE. On the noun in the *by*-phrase and on main verb, the transitivity effect is significant in the predicted direction. That is, RREs are significantly smaller when the embedded verb is

obligatorily transitive compared to when it is optionally transitive. Pritchett (1992) predicted this result, and MacDonald's (1994) experiment 1A found essentially the same result in a self-paced reading moving window experiment. One difference between MacDonald's study and the current study is that her reduced relative clause sentences did not include *by*-phrases. Rather they included adverbial phrases, such as *just after dawn*.

On the early disambiguation (*by*) region, the transitivity effect was significant in the opposite of the predicted direction. MacDonald's Experiment 1A found that the same pattern of results was significant in the early region, which in her experiment included more words: e.g., "verbed *just after dawn*". This result seems intuitive: the obligatorily transitive reduced relative condition causes much processing difficulty, because the presence of the *by*-phrase (or the adverbial *just after dawn* in MacDonald's experiment) signals the processor that the required direct object is absent from the surface direct object position. In contrast, in the optionally transitive condition, there is no symptom of anything unusual until the main verb: consider the optionally transitive condition sentences in (118)a, (118)b, and (118)c up until the main verb disambiguation point (indicated by the pipe '|').

(118)

- a. *The ruthless dictator fought just after dawn | was hated throughout the country.*

- b. *The actress sketched by the writer | left in a hurry.*

- c. *The actress awakened by the writer / left in a hurry.*

There are a number of reasons to believe that the processing of reduced relative clause sentences is influenced by the presence and type of material in between the embedded verb and the main verb. Processing differences between MacDonald's (118)a and my (118)b and (118)c are a perfect example: MacDonald found that sentences like (118)a had negative RREs in the ambiguous "*fought just after dawn*" region, meaning that the unambiguous unreduced relative clause sentence was more difficult than the reduced relative clause condition. As shown in Table 13, the optionally transitive conditions in the word maze, exemplified by (118)b and (118)c did have smaller RREs on average than the obligatorily transitive conditions, but the RREs were all over 150 milliseconds. This difference between MacDonald's results and the results reported here is probably due to whether or not the prepositional phrase was a *by*-phrase; (118)a seems much more natural as a simple declarative sentence up to the disambiguating main verb than either (118)b or (118)c. Two other self-paced reading experiments provide more solid evidence that the type of prepositional phrase affects the processing of reduced relatives. Clarke, Townsend, and Bever 2000 found a significant RRE in sentences with a non-*by* prepositional phrase (like *in the park*) but not in sentences with *by*-phrases²⁷. Seegmiller, Ingrassia, and Townsend 2003 reported results showing no significant effect of inherent verb telicity on the RRE in the early ambiguous region. This telicity effect was found in the same region in the self-paced reading experiments reported in chapter 4

of this dissertation²⁸. The main difference between Seegmiller et al.'s self-paced reading study and the experiments analyzed in chapter 4 is that Seegmiller et al. used non-*by* prepositional phrases.

Table 13 and Table 14 reveal an interesting unpredicted result on the *by* region: there is a significant interaction between telicity and transitivity. The RRE is significantly smaller in the optionally transitive telic condition than in the other three verb types, $p < .05$. This result is interesting because the embedded verbs in the optionally transitive telic condition are unaccusative verbs. The result raises the question of whether unaccusativity or telicity is the relevant factor in reducing the RRE. In chapter 2, I presented linguistic evidence showing that all telic intransitive verbs are unaccusative and concluded that unaccusativity is inextricably connected to event structure (Arad, 1998). Thus, even if unaccusativity were the relevant factor in reducing the RRE, the result would still be consistent with the Event Structure Processing hypothesis, since unaccusatives have different event structures than unergatives. However, the specific prediction that is the focus of this dissertation is whether telicity affects comprehension. There are at least two pieces of evidence in this dissertation that suggest that telicity rather than unaccusativity is the relevant factor. The first piece of evidence is that in addition to the significant interaction, the main effect of telicity is also statistically significant in the *by* region in the word maze. The second piece of evidence is that the speaker change monitoring results presented in chapter 5 show that reduced relatives with obligatorily transitive telic verbs

²⁷ In Clarke et al.'s (2000) experiment, the effect of *by* versus non-*by* interacted with the semantic plausibility of the initial noun phrase as a good agent or good patient of the embedded verb.

have significantly smaller RREs (measured as the percentage of speaker change detection errors) than those with obligatorily transitive atelic verbs on the noun in the *by*-phrase. In that experiment, RREs in the optionally transitive telic condition were numerically smaller than those in the optionally transitive atelic condition, but the difference was not statistically significant.

In the word maze experiment reported here, the significant interaction between telicity and transitivity in the main verb condition is most likely a consequence of the interaction on the earlier *by* region: if the disambiguation occurs on the early region, then there will be less processing difficulty on the main verb region; if no disambiguation occurs on the early region, then the disambiguation occurs on the main verb and thus there is a lot of processing difficulty on that region.

The negative correlation between the telicity and transitivity effects throughout the word maze sentence regions depends on the subtraction of the telicity and transitivity conditions. In other words, in order for there to be a negative correlation, the telicity effect must be computed as the atelic condition minus the telic condition, and the transitivity effect must be computed as the optionally transitive condition minus the obligatorily transitive condition. The subtractions are done in this way, because of a similarity between the telic verb condition and the obligatorily transitive verb condition: both require an object. The difference between them is that telicity involves requiring an underlying direct object (internal argument), while obligatory transitivity involves

²⁸ The analyses of self-paced reading experiments reported in chapter 4 are also reported in O'Bryan, Folli, Harley, Clarke, McRae, Townsend, and Bever (2003).

requiring a surface direct object. Thus, the negative correlation in the early disambiguation region can be understood as follows: in the reduced relative clause sentence, integration of the preposition *by* is facilitated by the verb's requiring an underlying direct object, and it is inhibited by the verb's requiring a surface direct object. The negative correlation in the later sentence regions may be a result of whether or not disambiguation has occurred: if disambiguation occurs early, then processing will be easy later in the sentence.

The negative correlation between the telicity and transitivity effects is an important piece of evidence bearing on the question of whether event structure information is derived from argument structure information, or the reverse. If these two kinds of information were derived from each other, it would be based on information about whether or not an internal argument or direct object is required. Telicity, then, should have effects that are very similar to the effects of obligatory transitivity. The telic condition would look like the obligatory transitive condition in each sentence region, and the atelic condition would look like the optionally transitive condition. The negative correlation shows that the effect of telicity in each sentence region is very different and essentially opposite of the effect of obligatory transitivity. Thus, the negative correlation strongly suggests that event structure information is not derived from argument structure information, and that the reverse is not true either.

In summary, the results of the word maze experiment support the Event Structure Processing hypothesis, since telicity has statistically significant effects on comprehension that are independent of the transitivity effects. The results further show that transitivity

has significant effects that are independent of telicity. These results, in combination with the negative correlation between the effects in each sentence region, support the conclusion that inherent verb telicity and verb transitivity are both used during comprehension independently of each other.