# Processing Direct Object and Oblique Relative Clauses

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This study investigates whether native English speakers experience any processing difficulty in direct object and oblique relative clauses. Both of these relative clause types typically take inanimate heads and have a non-canonical word order in English, allowing this study to avoid animacy and word-order canonicity effects. The study compared both comprehension accuracy and total reading times for direct object relative clauses and oblique relative clauses. The fifty-two participants (1) comprehended direct object relative clauses more accurately than oblique relative clauses and (2) spent much more time reading oblique relative clauses than direct object relative clauses. The results indicate that direct object relatives are less complex than oblique relatives in English. Sentences with oblique relatives were more demanding to process than direct object relatives, and their difficulty increased at the region of the relative clause and the following regions. The findings support the effect of the length of the filler-gap dependency because dependencies between the filler and the gap are longer in oblique relatives than in direct object relatives.

**Keywords:** sentence processing, relative clause, filler-gap dependency, animacy, canonical word order

## 1. Introduction

The structure of relative clauses (RC) has received much attention in the psycholinguistics literature. The processing of RCs is a focus of interest because of their long-distance dependencies between the head and the gap. Previous studies on RC processing have usually compared two types

of RCs, subject and direct object RCs, as in (1):

(1) Subject RC:
The reporter [that _ attacked the senator] disliked the editor.

(2) Direct object RCs:
The reporter [that the senator attacked _] disliked the editor.

Such comparisons have been frequently employed in first/second language acquisition and psycholinguistics research, which has confirmed that subject RCs have processing advantages over direct object RCs (Warren & Maratsos, 1978; Flynn & Lust, 1980; Fodor, 1989; Frazier & d'Arcais, 1989; King & Just, 1991; Carpenter et al., 1994; Gibson, 1998; Caplan & Gloria, 2001; Gennari & MacDonald, 2008). Although the two types of RC structures involve identical lexical items, direct object RCs are much more complex to process than subject RCs. Hence, the complexity of direct object RCs has been explained by the properties of their syntax.

According to Kidd et al. (2007), direct object RCs in actual speech usually have inanimate head nouns, as in (3).

(3) Direct object RC with an inanimate head noun:
The report [that the senator submitted_] surprised the governor.

It is very rare to find direct object RCs like (2) with an animate head in either child speech or child-directed speech; most direct object RCs have an inanimate noun as a head, as in (3). If this is indeed the case, the difficulty of the direct object RC may not come only from its syntactic properties. However, the test items used in previous studies did not separate animacy of the head noun from filler-gap dependency, which raises the question of how to test the processing difficulty of certain types of RCs.

The present study investigates RC processing in English and examines how the factor of filler-gap dependency affects the comprehension of RC construction in English. Section II discusses previous studies on relative

clause processing in English. In addition, factors that have been shown to influence the computation of various types of relative clause will be discussed, with a focus on the effects of filler-gap dependency on sentence processing. This section also explains the rationale for the present study, which attempts to resolve several problems in previous research. Section III provides a detailed description of the study's design and procedure. An analysis of the data and discussion of the results follows in Section IV. In Section V, the implications of the results and suggestions for possible follow-up studies are discussed.

## 2. Processing of Rrlative Clauses

### 2.1. Length of the filler-gap dependency

As pointed out, previous research on the processing of English relative clauses has mainly focused on the comparison of subject and direct object relative clauses. The advantage of subject RCs over direct object RCs has been reported in child language acquisition studies (Friedmann, Belletti, & Rizzi, 2009; Kim, 2013; Kim & O'Grady, 2015), as well as in psycholinguistic studies (Warren & Maratsos, 1978; King & Just, 1991; Gibson, 1998; Gennari & MacDonald, 2008). Processing difficulty in RCs states that longer or shorter distance between the filler and the gap leads to more difficult or easier processing. In particular, O'Grady (2011) predicts that English direct object RCs, as in (4b), are processed with more difficulty than subject RCs, as in (4a). Gibson (1998) proposes that the amount of lexical material between the head and the gap, such as NPs and verbs, influences the difficulty of processing. This happens because the distance between the head noun and the gap in the unfolding relative clause is smaller in (4a) than in (4b).

(4a) Subject RC
the reporter [that _ attacked the senator]
└──1──┘

(4b) Direct object RC
the reporter [that the senator attacked _]
└──────────────0──────2──┘

In particular, Gibson's (1998) Dependency Locality Theory (DLT) explains that dependencies between the head and the gap are constrained by both processing storage and integration resources. No materials intervene between the filler and the gap in (4a), allowing the parser to resolve the filler-gap dependency with minimal effort (Gibson, 2000; Hawins, 2004; Grodner & Gibon 2005; Hawkins, 1999).

In contrast, new discourse materials (*the senator* and *attacked*) intervene between the filler and the gap in (4b); therefore, resolving this filler-gap dependency creates a burden on working memory. Thus, direct object RCs require more integration resources because they have two intervening lexical items, thus requiring a longer time to connect the filler with the empty gap.

## 2.2. Animacy

Some researchers have proposed that the difficulty of direct object RCs reported in the previous literature arises from the fact that the studies have employed animate head nouns as in (5) while the vast majority of direct object RCs in actual speech have inanimate head nouns as in (6) (Mak et al., 2002; Reali & Christiansen, 2007).

(5) Direct object RC with animate head:
<u>the reporter</u>[that the senator attacked_]

(6) Direct object RC with inanimate head:
<u>the report</u>[that the senator submitted_]

In addition, the processing difficulty of the filler-gap dependency in direct object RCs may be lessened when the head noun is inanimate (Traxler et al., 2005; Mak et al., 2002; Reali & Christiansen, 2007). Furthermore,

according to Aissen (2003), subject RCs generally take animate NPs, unlike direct object RCs. All in all, the issue of animacy has been an obstacle in previous studies of sentence processing that compared subject RCs with direct object RCs.

For this reason, some recent studies have instead investigated filler-gap dependencies in subject RCs and indirect object RCs (Kim, 2013, 2015a, 2015b; Kim & O'Grady, 2015), controlling the animacy of the head nouns as exemplified in (7a) and (7b).

(7a) Subject RC: the musician [that _ sent the book to the director]
(7b) Indirect object RC: the musician [that the director sent the book to _]

With RCs such as those in (7a-b), the subject and indirect object relatives with an animate head require the same level of syntactic processing because the animate nouns (e.g., *the musician*) are good candidates for both agent and experiencer, and the phrases are semantically reversible (e.g., both *the musician sent the book to the director* and *the director sent the book to the musician* are possible). Therefore, these studies have been able to test the distance effect controlling the animacy effect in order to explore whether either or both factors may have an effect on the processing of RCs.

In Kim's (2015a) work, forty-two native speakers of English showed no difference in comprehension scores for the two types of RCs; however, their total reading times for indirect object RCs were longer than those for subject RCs. In sum, the study's results support the suggestion that the length of the filler-gap dependency is strongly relevant to sentence processing difficulty, because they prove that the dependencies in the indirect object RCs were more difficult for the readers to process.

### 2.3. Word-order canonicity

As discussed, because the traditional comparison of RCs in processing research is problematic, some recent studies have tried to tease apart the animacy and distance effects (Kim, 2013, 2015a, 2015b; Kim & O'Grady, 2015) by using subject and indirect object relatives. Although the results clearly showed that subject RCs were easier to produce and comprehend

than indirect object RCs, which appears to support a distance effect, an issue arises with respect to word order. Kim and O'Grady (2015) pointed out that the comparison (subject vs. indirect object RCs) is still troublesome because subject relatives follow the canonical word order, but indirect object relatives do not, as (8) shows.

(8a) Subject RCs:
the musician [that _ sent the book to the director]
S V DO IO

(8b) Indirect object RCs:
the musician [that the director sent the book to _]
IO S V DO

The subject RC follows a canonical SVX-like word order whereas the indirect object RC displays a non-canonical pattern. This suggests a possible alternative explanation for the difficulty of indirect object RCs (Hsiao & Gibson, 2003; Traxler et al., 2005). Both English-speaking kids and second language learners of English sometime make errors as shown in (9), because they are lack in taking the filler out of the unfolding RCs properly and trying to follow an English canonical word order.

(9) Direct object with resumptive NP
the boy [that the woman are seeing *<u>the boy</u>]
S V O

To tease apart word order canonicity from the distance factor, the current study compares the difficulty of direct object RCs and oblique RCs, as in (10).

(10a) Direct object RC:
the book [that the boy put _ on the carton]
DO S V OBL

(10b) Oblique RC:
the carton [that the boy put the book on _]
OB S V DO

There are two advantages to this comparison. First, oblique relatives, like direct object relatives, usually have inanimate heads—effectively controlling the animacy factor. Relative clauses with two inanimate arguments cannot be comprehended based on real-world relations alone: actual syntactic processing is required to interpret *the book* in (10b) as the theme (or patient)/direct object and *the carton* as the locative/oblique. Second, because both patterns have a non-canonical word order, the comparison allows a more direct test of the effect of length on filler-gap dependency processing. If in fact a longer dependency increases processing cost, oblique relatives should prove to be more difficult than their direct object counterparts.

### 2.4. Research question

The research question motivating the present study is as follows:

Do native English speakers process direct object relatives more easily than oblique relatives when both the animacy of the head nouns and word order canonicity are controlled? Does the factor of sentence complexity affect readers' sentence processing?

The prediction of the study is that, with animacy and canonicity controlled, the greater length of the filler-gap dependency in the oblique relative clauses should make them harder to process than the direct object RCs.

## 3. Method

In this experiment, participants read sentences containing relative clauses. Half of the sentences contained a direct object relative clause and half contained an oblique relative clause. In both types of sentences, the sentential subjects were animate and human (e.g. 'I'), the noun phrases in the relative clauses were reversible (i.e., both were inanimate and

non-human), and both were good themes (or patients) for the action denoted by the verb in the relative clause.

### 3.1. Participants

Fifty-two native speakers of English participated in the experiment. Thirty-two undergraduate and twenty graduate students participated. They were paid $5 for their participation in the experiment, which lasted less than 15 minutes. All of the participants were native speakers of American English.

### 3.2. Materials and design

A self-paced moving-window reading task was used to explore whether direct object RCs were read faster than oblique RCs when the head noun phrase was an inanimate noun and both types of RCs had a non-canonical word order. There were sixteen sets of experimental sentences and 32 fillers of various types. Sample sentences of each condition are shown in Table 1. All the sentences were automatically randomized. After the last word of each sentence, participants used the keyboard to reply to yes-no or wh-comprehension questions.

**Table 1.** Sample test items

| | (11a) Direct object RC | (11b) Oblique RC |
|---|---|---|
| R1 | the | the |
| R2 | book | carton |
| R3 | that | that |
| R4 | I | I |
| R5 | put | put |
| R6 | on | the |
| R7 | the | book |
| R8 | carton | on |
| R9 | was | was |
| R10 | very | very |
| R11 | small | small |

Only the order of the words in the relative clauses is changed for the direct object relative as in (11a) or the oblique relative as in (11b). The two types of sentences had the same length in terms of number of words across conditions, and each word was considered a region (R). The items were randomized and assigned to one of two lists following a Latin-square design, so that no reader was shown more than one version of each sentence.

### 3.3. Procedure

The task adopted in the study used non-cumulative, self-paced, word-by-word reading with a moving window display (Just, Carpenter, & Woolley, 1982). The E-Prime experimental software package on a PC was used to test participants. Participants sat in front of a computer screen in a booth and they saw one word at a time, beginning with the first word. They pressed a button to call up the next word. Every time they pressed the button, a new word appeared and the preceding word disappeared. After each sentence, participants responded to a yes-no question or a wh-question about its content (e.g., "What did I put on the carton?"). Their reading times at all regions in the sentences and their answers to the comprehension questions were recorded for analysis. Before the experiment began, participants were given practice items until they understood how the task worked.

## 4. Results

### 4.1. Comprehension accuracy

The mean scores on the comprehension questions are shown in Figure 1. The overall mean proportion of correct responses to all comprehension questions was 70%. Comprehension accuracy in the direct object RC and oblique RC conditions was 83% and 56%, respectively, and differed significantly across conditions ($t1(1,51) = -7.603$; $p = .000$; $t2(1,15) = -5.067$; $p = .000$). Overall, these results indicate that the participants comprehended direct object RCs better.

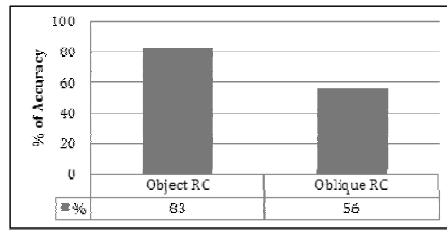


**Figure 1.** Mean scores by condition.

4.2. Total reading times (RTs)

Only the reading time data from items with correct answers to the comprehension questions were analyzed. For the total reading times, RTs higher than 2.5 *SD* (standard deviation) of the mean per word position were replaced by a cutoff value within this range. Three different analyses on total RTs were conducted for three sets of regions: (1) R1-R8, (2) R1-R9, and (3) R1-R11. Analyzing total reading times was adopted in the study since the words each region were different.

The first analysis looked at the RTs for R1-R8; (12a) and (12b) are examples showing the words included in this region set. This region has both the head noun and a RC region. The results are shown in Figure 2.

(12a) Direct object RC: the book [that I put _ on the carton]
(12b) Oblique RC: the carton [that I put the book on _]

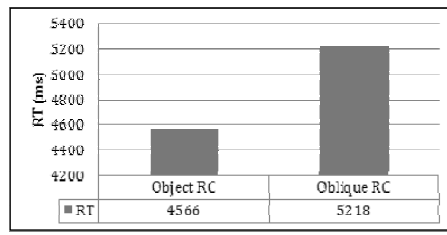


**Figure 2.** Total RTs in ms from R1-R8.

The grammatical function of the gap (direct object vs. oblique) was used as an independent variable, and total RTs as the dependent variable. Data were submitted to paired *t*-tests to compare differences in total RTs for

each condition. The total RT for the direct object RC condition was shorter than the total RT for the oblique RC condition (4566 ms vs. 5218 ms). ($t1(1,51) = -4.76$; $p = .000$, $t2(1, 15) = -2.24$; $p < .05$).

The second analysis looked at total RTs in R1-R9; region 9 was the main verb region, as shown in (13a) and (13b).

(13a) Direct object RC: the book [that I put _ on the carton] was
(13b) Oblique RC: the carton [that I put the book on _] was

The total RT results in these regions are shown in Figure 3. The analysis at the main verb region showed a gap position effect; there was a main effect of grammatical function of the gap.

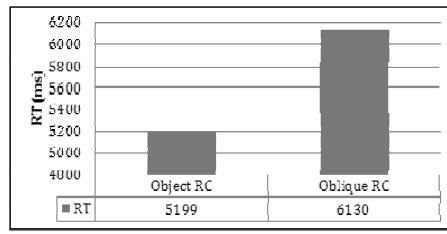


**Figure 3.** Total RTs in ms from R1-R9.

The total RT for the direct object RC condition was significantly shorter than that for the oblique RC condition (5199 ms vs. 6130 ms; $t1(1,51) = -5.438$; $p = .000$; $t2(1,15) = -2.201$; $p < .05$). The total RT in the main verb region for the direct object RCs was shorter than that for the oblique RCs (633 ms vs. 912 ms).

In the last analysis, from R1 to R11, as shown in (14a) and (14b), there was a significant effect for gap type ($t1(1,51) = -4.734$; $p = .000$; $t2(1,15) = -2.739$; $p < .05$).

(14a) Direct object RC: the book [that I put _ on the carton] was very small.
(14b) Oblique RC: the carton [that I put the book on _] was very small.

As shown in Figure 4, the total reading time for the direct object RC condition was shorter than that for the oblique RC condition (6605 ms vs. 7727 ms).

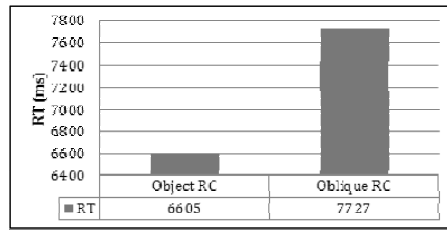


**Figure 4.** Total RTs in ms from R1-R11.

These total RT data analyses demonstrate that the participants actually read the oblique relatives much more slowly than they read the direct object relatives. In sum, based on reading time measurements, the oblique relatives were more difficult than the direct relatives.

## 5. Discussion

Both comprehension scores and total RTs show a difference across relative clause types. The findings reported here will be discussed in accordance with the research question. The question asked whether the type of relative clause (i.e., the gap position) has an effect on sentence processing. As reported above, the results of the comprehension scores indicated that English direct object RCs are significantly easier for English-speaking adults to comprehend and judge than oblique RCs (56% vs. 83%).

The analyses of the total reading times (RTs) also supported that participants had more difficulty processing oblique RCs than direct object RCs, showing a significant difference in the RTs between the direct object and oblique relatives. This difference was caused by elevated RTs in all three region sets tested: (1) relative clause with a head noun; (2) relative clause with a head noun and main verb; (3) whole sentence. The slowdown that appeared in each analysis for the oblique relative condition suggests that it is the length of the filler-gap that affects syntactic processing.

The first region set consisted of eight words (*the book that I put _ on the carton* in the direct object condition vs. *the carton that I put the book on _* in the oblique condition), which was critical to the experimental

research question. A gap type effect was detected in this set, which included only the relative clause with the head noun, with participants in the study spending much more time on the oblique than the direct object condition.

The second region set additionally included the main verb (R9). At R9, the matrix verb was read much faster in the direct object RC condition (633 ms vs. 912 ms), and the differences between the two RC conditions were larger for this region set. Again, the difference in RTs leads to the conclusion that the readers had greater difficulty in the oblique RC condition than in the direct object RC condition. As already pointed out, it is the distance of the filler-gap dependency that causes more difficulty in the processing of the former condition.

The last region set was the whole sentence, which still showed a main effect of relative clause type at all regions, confirming that the readers in general had greater difficulty in the oblique relative condition than in the direct object relative condition. The results of these three different analyses of the total RT data thus all indicate that oblique relatives are more difficult to comprehend than direct object relatives.

These results lead to the question of what strategies parsers have recourse to when they are processing relative clauses. The basic source of the difficulty of the relative clauses has to do with the filler-gap dependency. The active-filler strategy hypothesis suggests that parsers first consider the head as the subject of the relative clause, for example, *the book* in (15), and they seek to use it to fill the subject gap position. However, as previous works pointed out, there is a possibility that the readers consider an inanimate noun as the head of the direct object RCs (Mak et al., 2002; Reali & Christiansen, 2007). For this reason, it is unclear for the readers to find the subject of the following RC until they have the pronoun '*I*'.

For both types of RCs in (15), the parsers then encounter the pronoun *I*. As they comprehend that the head nouns *the book* in the object condition and *the carton* in the oblique condition are the subjects of the relatives, they realize that their initial analysis for each condition is flawed and that reanalysis cannot be avoided. In particular, the parsers begin to experience more difficulty in the oblique relative when they must keep three lexical items (e.g., *I, put, the book*) in memory, whereas in the direct object

relative they encounter only two intervening lexical items (e.g., *I, put*) between the filler and the gap.

(15a) Direct object RC:
The book [that I put _ on the carton]
1 2

(15b) Oblique RC:
The carton [that I put the book on _]
1 2 3

This study provides evidence that working memory loads increase in the gap position; thus, the addition of one more item (*the book*) in the oblique RC certainly creates more of a burden when readers must process it. In the direct object condition, the readers notice that the head noun is not the subject of the relative clause they are reading, and they also surely realize the same thing happening in the oblique relative condition. In direct object relatives, however, the relation between the filler and the gap can be resolved by region 6 (e.g., *on*), which is not the case in oblique relatives, where region 6 (e.g., *the*) instead leads to one more syntactic reanalysis. In other words, in direct object relatives, readers' initial analysis fails once and recovers after region 5, at the gap position, whereas their analysis will fail twice in oblique relatives: when the parser puts the head noun in the subject position, and when the parser puts the head noun in the direct object position. Thus, the processing difficulty of oblique relatives remains high at region 8, as readers work to resolve the unintegrated lexical item (*the carton*). By region 8, the working memory load is becoming substantial in this condition, because the distance between the filler and the gap demands more reactivation than is needed in direct object relatives.

The distance between the filler and the embedded verb causes more retrieval activity, which is shown at the main verb region, R9. As both conditions have the same word here (e.g., *was*), the cause of the reading time difference (633 ms vs. 912 ms) at this region is because this is the place where additional retrieval is occurring to connect the filler to the

gap position in the oblique relative condition. In fact, it is possible that after R9, retrieval continuously occurs in oblique relatives.

Overall, this study shows that both comprehension accuracy and total RTs manifest a robust gap effect on sentence processing, establishing that the readers had greater difficulty in the oblique relative than the direct object relative condition. Three analyses of total RTs for different region sets confirmed this difficulty, providing detailed information that demonstrates that the difficulty takes place in the relative clause region, the main verb region, and the whole sentence.

## 6. Conclusion

This study investigated how the effects of gap position in RCs arise while parsers read direct object and oblique RCs. The advantage of this comparison is that both RCs follow non-canonical patterns in word order. In addition, both direct object and oblique NPs are typically inanimate, allowing this comparison to avoid issues related to animacy.

The results from this experiment confirm that the distance factor between the filler and the gap can predict processing difficulty. O'Grady (2011) and Hawkins (2004) affirmed that the memory difficulties of distance increase when there is more intervening material. Oblique relatives have more lexical items - e.g., in the examples used in the paper, the NP *I*, the verb *put*, and the NP *the book* - and thus when the head noun is integrated at the gap position, parsers have extra processing difficulty in oblique relatives. The comprehension score and total RT data analyses showed that participants comprehended direct object RCs better and quicker than oblique RCs, with a significant difference between the two types. Reading time slowdown in the oblique condition fully supports this idea. Therefore, the effect of the factor of distance in processing difficulty is supported by the present study. The fact that identical words were used in the two conditions, but comprehension accuracy and total reading times nonetheless differed significantly, indicates that differing levels of filler-gap dependency give rise to asymmetrical patterns; in addition, different syntactic patterns are associated with greater or lesser working memory loads

in relative clause processing.

The results of this study show similar patterns to those found by Kim (2013) and Kim and O'Grady (2015), who observed that direct object RCs were easier to produce than oblique RCs. Their works focused on how English-speaking kids and adults responded to the situation where the two conditions (direct object and oblique RCs) were supposed to produce. They used an elicited production task with a picture description helping kids make a target structure (see Kim & O'Grady, 2015). The current findings suggest that the native speakers of English in this study tended to differentiate between the two types of RCs, while the findings of previous works on L1 acquisition have revealed that English- and Korean-speaking children are better at producing direct object relatives than oblique relatives. These findings of more processing difficulty in oblique relatives by both young children and adults are compatible with the order predicted by Keenan and Comrie's (1978) Noun Phrase Accessibility Hierarchy (NPAH) hypothesis.

This study used a new comparison (direct object vs. oblique relatives) and controlled the factors of animacy and word order canonicity to investigate the effect of the length of the filler-gap dependencies. However, there is still a possibility that direct object relatives are easier to process than oblique relatives because of frequency: direct object relatives are more common than oblique relatives. For this reason, Kim (2015b) conducted an experiment in order to compare two different types of English oblique RCs having different length between the filler and the gap and proved that oblique RCs with (relatively) shorter filler-gap dependency are much easier to comprehend than oblique RCs with (relatively) longer filler-gap dependency (see Kim, 2015b).

However, further studies of the distance effect are needed. Given the possibility that second language learners of English are also influenced by the same pressures, the future research needs to be conducted to see how L2 learner process parallel contrasts (e.g., direct object RC easier than oblique RC).

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## APPENDIX. Test Items

1. The book that I lifted onto the box was too heavy.
   The box that I lifted the book onto was too heavy.
2. The soda that I mixed the beer into was quite delicious.
   The beer that I mixed into the soda was quite delicious.
3. The scarf that I twisted around the rope was so cheap.
   The rope that I twisted the scarf around was so cheap.
4. The table that I moved toward the couch was really messy.
   The couch that I moved the table toward was really messy.
5. The letter that I hid under the photo was very surprising.
   The photo that I hid the letter under was very surprising.
6. The paper that I placed on the binder was too large.
   The binder that I placed the paper on was too large.
7. The paper that I positioned over the handkerchief was so colorful.
   The handkerchief that I positioned the paper over was so colorful.
8. The saucer that I set on the dish was really dirty.
   The dish that I set the saucer on was really dirty.
9. The purse that I laid on the blanket was very antique.
   The blanket that I laid the purse on was very antique.
10. The towel that I left on the laptop was quite pretty.
    The laptop that I left the towel was quite pretty.
11. The bag that I threw onto the cushion was too big.
    The cushion that I threw the bag onto was too big.
12. The hat that I tossed onto the pillow was so light.
    The pillow that I tossed the hat onto was so light.
13. The purse that I stashed in the bag was very expensive.
    The bag that I stashed the purse in was very expensive.
14. The water that I poured into the wine was really cold.
    The wine that I poured the water into was really cold.
15. The book that I put on the carton was very small.
    The carton that I put the book on was very small.
16. The ball that I dropped on the container was quite old.
    The container that I dropped the ball on was quite old.