Event Structure and Discourse Coherence Biases in Pronoun Interpretation

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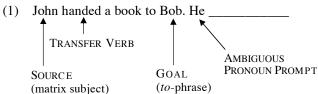9500 Gilman Drive, La Jolla, CA 92093-0515, USA

Abstract

In a story completion study involving transfer-of-possession passages (*John handed a book to Bob. He _____*), Stevenson et al. (1994) identified a pronoun interpretation preference that is compatible with two possible explanations: a superficial thematic role bias for Goals over Sources, and a deeper event structure bias toward focusing on the end state of such events. To distinguish these hypotheses, we conducted an experiment manipulating the salience of the end state by comparing the perfective (*handed*) and imperfective (*was handing*) forms of the transfer verb. We found that sentences in the imperfective yielded significantly more Source resolutions than those in the perfective, supporting the event-structure hypothesis. Furthermore, we found that a significant proportion of Goal interpretations arise from continuations which use Occasion (i.e. narration-based) coherence relations. As such, the interpretation preferences are better explained at the level of event structure and discourse coherence, rather than by appeal to superficial heuristics.

Keywords: discourse processing, pronoun interpretation

Interpreting Ambiguous Pronouns

The question of whether pronouns are interpreted based primarily on surface-level linguistic cues (subjecthood, first mention, recency, parallelism) or as a byproduct of deeper discourse-level processes and representations (inference, event structure) remains unresolved in the literature. These two views come together in a story-completion study by Stevenson, Crawley, and Kleinman (1994; see also Arnold 2001) where they test the influence of thematic roles on pronoun interpretation. One of their most striking results comes from an experiment with story completions like (1) with a transfer-of-possession context sentence followed by an ambiguous pronoun.

(1) John handed a book to Bob. He _____

TRANSFER VERB

SOURCE
(matrix subject)

GOAL
(*to*-phrase)

AMBIGUOUS
PRONOUN PROMPT

The context sentence in these passages contains two possible referents for the pronoun, one that appears in subject position and fills the Source thematic role, and one that appears as the object of a sentence-final prepositional phrase and fills the Goal thematic role. They found that Goal continuations (continuations which correspond to a Goal interpretation for the pronoun) rivaled Source continuations in frequency. This result is unexpected in light of a variety of existing models of pronoun interpretation. The subject preference (Crawley, Stevenson, & Kleinman 1990) predicts that an ambiguous pronoun ought to be coreferential with the subject of the previous sentence, in this case the Source. The first-mention privilege (Gernsbacher & Hargreaves 1988) also points to the salience of the Source subject. The grammatical parallelism preference (Smyth 1994; Chambers & Smyth 1998) predicts that an ambiguous subject pronoun resolves preferentially to a subject antecedent, again the Source for examples like (1).

Stevenson et al.'s results are compatible with two explanations for the promotion of the non-subject Goal. The first is a thematic-role-level preference which amounts to a heuristic ranking Goals above Sources. The second explanation is an event-level bias for focusing on the end state of the previously described event. Stevenson et al. consider the Goal to be more salient than the Source with respect to the end state in transfer-of-possession events.

In this paper, we seek to separate out the thematic-role preference from the event structure bias in Stevenson et al.'s results. We further investigate whether the Goal preference can receive deeper motivation from mechanisms that are used in establishing coherence in discourse.

Thematic-Role Preference or Event-Level Bias

We designed an experiment to distinguish Stevenson et al.'s two hypotheses. Taking passages like (1), repeated here as (2), we formed minimal pairs with the imperfective (3).

(2) COMPLETED EVENT (PERFECTIVE)

John$_{SOURCE}$ handed a book to Bob$_{GOAL}$. He _____

(3) INCOMPLETE EVENT (IMPERFECTIVE)

John$_{SOURCE}$ was handing a book to Bob$_{GOAL}$. He _____

The thematic roles remain the same in examples (2) and (3), but the perfective verb in (2) describes a completed event which is compatible with end-state focus, whereas the imperfective verb in (3) describes an event that is an ongoing process, making it incompatible with end-state focus (Moens & Steedman 1988). Thus the thematic role preference predicts a Goal bias for both (2) and (3), while

the event structure hypothesis predicts fewer Goal interpretations for (3) since the imperfective verb is inconsistent with a salient end state. The differences in verbal aspect therefore allow us to distinguish between the two explanations of Stevenson et al.'s data by separating out the intrinsic thematic role assignments of the verb from the end-state focus at the event level.

Experiment and Methodology

Following Stevenson et al., we used a story completion task to elicit continuations which were then evaluated to determine the participants' intended pronoun interpretations.

Participants   Forty-eight monolingual English-speaking undergraduates at UC San Diego participated in the study for extra credit in Linguistics courses.

Stimuli   The twenty-one experimental stimuli consisted of a transfer-of-possession context sentence followed by an ambiguous pronoun prompt, as in (2) and (3). To manipulate event structure, we varied the aspect of the verb. Participants saw either the perfective or imperfective form of each verb, but not both. The Source referent always appeared in subject position, and the Goal was the object of a *to*-phrase. All verbs described physical transfer events (ex. *hand, throw*). We excluded verbs that described abstract or conceptual transfer (ex. *show, teach*), though prior work on transfer of possession has included them (e.g. Arnold 2001).

The twenty-one verbs in the stimuli were classified along two dimensions: co-location of event participants and guarantee of successful transfer. We were interested in how these properties might affect the salience of the available referents. Verbs in Class 1 describe events in which the Source and Goal are co-located and the default assumption is successful transfer. Verbs in Class 2 lack this sense of guaranteed transfer but have co-located participants. Verbs in Class 3 lack a co-located Source and Goal and have a diminished sense of guaranteed transfer.

Table 1: Transfer-of-possession verb classes

Class 1:	*hand, give, bring, pass, deliver, carry, serve*	co-located guaranteed transfer
Class 2:	*throw, kick, toss, roll, fling, chuck, lob*	co-located no guaranteed transfer
Class 3:	*send, mail, ship, fax, forward, transmit, wire*	not co-located no guaranteed transfer

Fillers   We also included twenty-nine sentences with non-transfer verbs in the context sentence. These fillers consisted of transitive and intransitive verbs in the perfective or imperfective.   The transitive verbs (Agent-Patient and Experiencer-Stimulus) varied in active and passive voice. Adverbs, proper names, or gender-unambiguous pronouns served as prompts.

Task   Participants were asked to write continuations for the fifty passages. They were instructed to imagine a natural continuation to the story, writing the first continuation that came to mind and avoiding humor. In this task, participants create a mental model of the event in the context sentence and then write a continuation that reflects their expectations about where the story is going. As such, the task involves both interpretation and production. The pronoun prompt constrains the surface realization of their continuation, but their continuation depends on their expectations about how the discourse will proceed and which individual in the event will be mentioned again.

Evaluation and Analysis   Two trained judges assessed the participants' intended pronoun interpretations. Judges were instructed to be cautious, erring on the side of categorizing a pronoun as ambiguous if the pronoun could be interpreted plausibly as coreferential with either referent.[1] As such, not all responses could be disambiguated; our treatment of the ambiguous cases will be discussed in the next section. Analyses of variance were conducted on the assessed pronoun interpretations. We tested for main effects of verbal aspect and verb type on pronoun interpretation, as well as an interaction between the two factors.

Results and Interpretation

The results show a main effect of verbal aspect (F(1,48)=50.622, p<0.0001), as summarized in Figure 1.
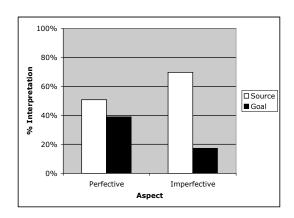

Figure 1: Effects of verbal aspect on pronoun interpretation (conservative assessment of ambiguity)

Our results indicate that pronoun interpretation strategies are sensitive to verbal aspect: The proportion of Source and Goal interpretations are roughly equal in the perfective condition, whereas the imperfective condition shows an increase in the proportion of Source interpretations (from 51% to 70%). Since imperfective aspect is used to describe an event as ongoing and incomplete, it is incompatible with

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[1] Our use of judges follows Arnold (2001). Stevenson et al. (1994) had participants circle their intended referents after completing the passages. However, they too ultimately relied on judges to remedy contradictions in the participants' circling.

a focus on the end state where the Goal is most salient. Because Figure 1 excludes cases that were judged to be ambiguous, the Source and Goal bars do not sum to 100%.

Treatment of Ambiguity

In evaluating each continuation, the judges either assigned a Source or Goal interpretation for the pronoun, or marked the continuation as ambiguous. Across 1008 continuations, there were no conflicts in which one judge assigned a Source interpretation while the other assigned a Goal interpretation. There was variation, however, in the determination of ambiguity. To be cautious, we set aside all responses in which at least one judge assessed the pronoun as potentially ambiguous; Figure 1 represents this conservative evaluation. If, on the other hand, we include all cases in which at least one judge assigned an interpretation, the effect of verbal aspect becomes stronger: Imperfectives yield even more Source resolutions (75%) than perfectives (53%; $F(1,48)=51.679$, $p<0.0001$).

To illustrate, the pronoun in the underlined continuation in (4) may be biased toward a Goal interpretation, but either interpretation is possible. As such, both judges agreed that the participant's continuation in (4) was ambiguous.

(4) Angela forwarded a gossipy email to Kelly. She deleted it.

In contrast to (4), the continuations in (5) and (6) force clear Source and Goal readings respectively, given the subsequent full-name mention of the other referent in (5) and the implausibility of a Source reference in (6).

(5) Matt passed a sandwich to David. He felt sympathy for David, since he forgot his lunch at home.

(6) Matt passed a sandwich to David. He said thanks, and took a bite.

Overall, the cases for which both judges agreed on a pronoun's ambiguity represent 13% of the total responses, but a worst-case analysis shows that either interpretation for these cases still results in a significant effect supporting the event structure hypothesis ($F(1,48)=9.501$, $p<0.003$).

Summary

Because imperfective aspect resulted in an increased percentage of Source interpretations, we conclude that participants' interpretations of ambiguous pronouns appear to reflect deeper event-level biases rather than surface-level thematic role preferences.

Additional Results: Verb Classes

We found a main effect of verb class ($F(2,98)=15.840$, $p<0.0001$): All three classes showed a bias towards the Source in the imperfective cases, but interpretation differed in the perfective. Figure 2 shows the Class 3 verbs, in which the Goal is not presumed to be co-located with the

Source; for these, we found a Source preference across the board (perf: $\chi^2=25.8$, $p<0.0001$, imp: $\chi^2=69.78$, $p<0.0001$).
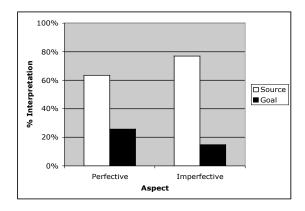

Figure 2: Source preference in Class 3

On the other hand, the Source preference for Classes 1 and 2 was limited to the imperfective cases: Neither the slight Source preference for Class 1 perfectives (Figure 3) nor the slight Goal preference for Class 2 perfectives (Figure 4) was significant (Class 1: $\chi^2=1.68$, $p<0.195$; Class 2: $\chi^2=2.40$, $p<0.121$). The co-location of the Source and Goal appears to increase the accessibility of the Goal.
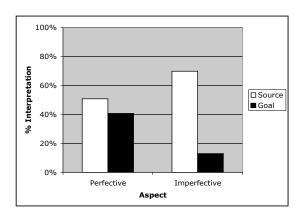

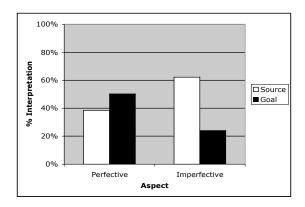Figure 3: No significant preference in Class 1 perfectives

Figure 4: No significant preference in Class 2 perfectives

There was also a significant interaction of aspect and verb class ($F(2, 100)=4.44$, $p<0.01$), stemming primarily from the variation across classes in the perfective aspect.

In keeping with the event structure hypothesis, it appears that the lack of a co-located Goal for Class 3 verbs diminishes the salience of the individual associated with the end state, namely the Goal. All three classes consistently show a Source preference in the imperfective.

In fact, the closest we came to witnessing a Goal preference is in continuations following perfective Class 2 verbs.[2] The differences across verb classes suggest that much depends on the verbs chosen for the task. Just as pronoun interpretation appears to be sensitive to verb properties like the co-location of Source and Goal, one would expect that other properties of transfer verbs could influence the accessibility of each referent. For example, the verbs *tell* and *hand* both signal transfer, but they differ in the degree of affectedness of the Goal. A recipient that undergoes a change of state or is otherwise affected may draw more attention to the end state of that event.

To summarize, we see that differences emerge across fairly coarse-grained verbal categories. Furthermore, it was clear in doing the analysis that the properties of individual verbs matter as well, even for verbs from the same class. As such, verbs influence pronoun interpretation by way of their lexical semantics. Next, we turn to discourse semantics, showing how the coherence relationships between clauses reflect the pronoun interpretation strategies at work.

Effects of Coherence

Consider the following completion from the corpus of participants' continuations:

(7) Miriam sent a fruitcake to Rachel. She <u>didn't want to eat it.</u>

Both judges categorized this example as ambiguous. Upon closer inspection, this ambiguity stems from how the clauses themselves are related to one another. If the second clause is interpreted as an explanation of the first – the 'diswanting' was the cause of the sending – then *she* will most likely be interpreted to refer to Miriam. If the second clause is taken to occasion the first – that is, the diswanting was connected to the sending but happened subsequently to it – *she* will most likely be interpreted to refer to Rachel.

Example (7) illustrates two types of inferential processing hearers use to establish relations between clauses in a discourse, as described in Kehler (2002). Kehler argued that

a variety of heuristic pronoun interpretation strategies that have been proposed in the psycholinguistic literature are largely side effects of the process of establishing these and other COHERENCE RELATIONS. We list below three relations with examples from the participants' story completions.

EXPLANATION: Infer *P* from the assertion of sentence S_1 and Q from the assertion of sentence S_2, where normally Q→P.

(8) Matt passed a sandwich to David. He <u>didn't want David to starve.</u> **[Explanation (*Source*)]**

PARALLEL: Infer a common or contrasting relation $p(a_1,a_2,...)$ from S_1 for entities a_i and infer $p(b_1,b_2,...)$ from S_2 for entities b_i where some property q_i holds of a_i and b_i for all *i*.

(9) Matt passed a sandwich to David. He <u>put fruit on his plate too.</u> **[Parallel (*Source*)]**

OCCASION: Infer a change of state for a system of entities in S_2, establishing the initial state for this system from the final state of S_1. (adapted from Hobbs 1990)

(10) Matt passed a sandwich to David. He <u>ate it up.</u> **[Occasion (*Goal*)]**

The inference processes that underlie the establishment of these relations are fundamentally different. Establishing an Explanation relation requires that the hearer draw a chain of cause-effect inferences that connect the two eventualities (i.e., events or states) that are being related. Such inference supports interpreting the pronoun in (8) to refer to (the subject Source) Matt. Establishing Parallel relations, on the other hand, is based on identifying points of similarity and contrast among the eventualities being related. Such inference supports interpreting the pronoun in (9) to refer to its (in this case, grammatically) parallel element, which here is again the subject Matt. Finally, establishing Occasion relations requires that a state of affairs be inferred as a point of connection between the eventualities expressed by each clause, i.e., that the initial state of the second eventuality be identified with the final state of the first. Since the state of possessing something is a precondition to eating it, such inference supports interpreting the pronoun in (10) to refer to the (non-subject Goal) David.

Note that of these relations, only the Occasion relation directly encodes a bias toward focusing on the end state of the previous eventuality. As such, if Kehler (2002) is correct, we might expect to see evidence for a Goal preference only in those cases that are related by an Occasion relation.

We had our judges annotate all unambiguous responses with the coherence relation that held between the context sentence and the continuation. Judges resolved disagreements through discussion, following Stevenson, Knott, Oberlander, & McDonald (2000). We restricted the analysis to the perfective cases since only these are compatible with end-state focus. Five coherence relations

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[2] It is worth pointing out that although Stevenson et al. summarize their results in the text as a Goal preference, they also found some variation across different experimental conditions. For the Source-Goal stimuli in the condition that mirrors our stimuli, it appears from their Table 3 (p. 529) that there was actually a slight Source preference. (The positive 0.16 score for that condition indicates a preference for the Source, though they do not address whether it was statistically significant.) Nonetheless, the fact that the number of Goal interpretations rivals the number of Source interpretations is unexpected.

were annotated, including the three previously mentioned and two others (Result, another cause-effect-based relation, and Elaboration, which patterns most closely with Parallel).
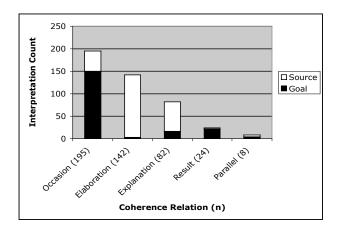

Figure 5: Pronoun interpretation across coherence relations for perfective verbs

We found that Occasion relations were dominated by continuations that refer to the Goal (χ^2=55.46, p<0.0001), while Elaborations and Explanations showed no evidence of the Goal preference; indeed these relations showed a Source preference following perfective context sentences (Elaboration: χ^2=131.18, p<0.0001; Explanation: χ^2=29.28, p<0.0001).[3] The restriction of the Goal preference to Occasion relations reinforces the conclusion that a generic thematic role preference is insufficient as a predictor of pronoun interpretation. Our results further suggest that the event structure bias itself is epiphenomenal, a consequence of the type of coherence relation that is inferred to hold between two clauses in a discourse.

Because our analysis was restricted to perfective verbs, the cases summarized in Figure 5 have an event structure with a salient endpoint. Crucially, though, it is the coherence relation that dictates whether that endpoint is relevant. Occasion relations show a clear preference for the Goal; they are precisely the relations that rely on the end state of an event in establishing coherence.[4]

Since Occasion relations attend to the end state of the previous event, it follows that context sentences that lack a salient endpoint will give rise to a different distribution of coherence relations. The continuations following imperfective context sentences did indeed have a significantly different coherence distribution from those following perfective context sentences (F(1,48)=30.949, p<0.0001). Imperfective context sentences yielded continuations that were dominated by a large proportion of Elaboration relations (49%) and a smaller proportion of Occasion relations (31%), whereas the perfectives yielded fewer Elaborations (31%) and more Occasions (43%).

This study is similar to one from Arnold (2001) in which continuations were classified using a three-way distinction (endpoint/cause/other). She found a similar correlation between Goal interpretations and endpoints. We agree with Arnold's proposal that expectations about where the discourse is going influence the likelihood that a referent is rementioned in participants' story continuations. The different distribution of coherence relations following perfective and imperfective context sentences attests to these discourse level biases.

Much more remains to be said about the relationship between coherence establishment and pronoun interpretation. This study, however, adds further support to our claim that surface-level heuristics like subjecthood, grammatical parallelism, and thematic-role preferences are not enough to explain the patterns one finds for pronoun interpretation. Instead, a much richer model of discourse processing is necessary (see also Wolf, Gibson, & Desmet 2004; Kertz, Kehler, & Elman 2006).

Conclusions

The results from our story continuation experiment support the conclusion that a previously observed thematic-role-level bias is a side effect of an event structure bias. Furthermore, the event structure bias is predictably associated with only certain types of coherence relations in the discourse. That is, the thematic-role bias depends on the availability of a salient Goal at the endpoint of the event, and similarly, the effects of the event-structure bias are contingent on the type of coherence relation at work. Given this, we argue that pronoun interpretation must be addressed within a broader theory of event structure and discourse comprehension rather than by appeal to superficial heuristics.

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[3] We also found a Goal bias for Result relations, but the small set of Result continuations (n=24) was very homogenous, more than half consisting of the form *X transfers Y to Z. Z thanks X.* The similarity of the continuations in our data makes extrapolation difficult. In any case, whereas Kehler's model of coherence would predict that causal inference plays a greater role in establishing Result relations than Occasion relations, the effect described by the second eventuality in a cause-effect sequence is often a direct result of the end state brought about by the first. It would perhaps not be surprising if the second eventuality in a cause-effect sequence exhibited a similar statistical bias toward focusing on the end state of the first.

There were likewise too few cases of Parallel relations (n=8) to support any conclusions.

[4] Stevenson et al. (2000) also report Occasion (or 'Narration' in their terminology) as the most common type of continuation in cases where the pronoun referred to the Goal. However, they do not report the number of Narrations with Source interpretations, and thus we cannot compare our results directly with theirs.

Acknowledgments

References

Arnold, J. E. (2001). The effects of thematic roles on pronoun use and frequency of reference. *Discourse Processes, 31(2)*, 137-162.

Chambers, G. C. & Smyth, R. (1998) Structural parallelism and discourse coherence: A test of Centering Theory. *Journal of Memory and Language, 39*, 593-608.

Crawley, R., Stevenson, R., & Kleinman, D. (1990). The use of heuristic strategies in the interpretation of pronouns. *Journal of Psycholinguistic Research*, *4*, 245-264.

Gernsbacher, M.A., & Hargreaves, D.J. (1988). Accessing sentence participants: The advantage of first mention. *Journal of Memory and Language, 27*, 699-717.

Gordon, P.C., Grosz, B.J. & Gilliom, L.A. (1993). Pronouns, names, and the centering of attention in discourse. *Cognitive Science, 17*, 311-347.

Hobbs, J. R. (1990) *Literature and Cognition*. CSLI Lecture Notes 21. Stanford, CA.

Kehler, A. (2002) *Coherence, reference, and the theory of grammar*. CSLI Publications, Stanford, CA.

Kertz, L., Kehler, A., & Elman, J. (2006) Grammatical and coherence-based factors in pronoun interpretation. In the *Proceedings of the 28th Annual Conference of the Cognitive Science Society* (this volume), Vancouver, July 26-29, 2006.

Moens, M. & Steedman, M. (1988). Temporal ontology and temporal reference. *Computational Linguistics*, *14(2)*, 15-28.

Smyth, R. H. (1994). Grammatical determinants of ambiguous pronoun resolution. *Journal of Psycholinguistic Research, 23*, 197-229

Stevenson, R., Crawley R., & Kleinman D. (1994). Thematic roles, focusing and the representation of events. *Language and Cognitive Processes*, *9*, 519–548.

Stevenson, R. Knott, A., Oberlander, J., & McDonald, S. (2000). Interpreting pronouns and connectives: Interactions among focusing, thematic roles, and coherence relations. *Language and Cognitive Processes*, *15(3)*, 225-262.

Wolf, F., Gibson, E. & Desmet, T. (2004) Coherence and pronoun resolution. *Language and Cognitive Processes*, *19(6)*, 665-675.

Appendix

Sentence-completion passages:
1. Ben chucked/was chucking a wrench to Mark. He _____
2. Rebecca flung/was flinging a frisbee to Hannah. She __
3. Nick kicked/was kicking a soccer ball to Justin. He ____
4. Charles lobbed/was lobbing a football to Jacob. He ____
5. Peter rolled/was rolling a toy truck to Jeremy. He _____
6. Jason threw/was throwing a hat to Andrew. He _____
7. Amanda tossed/was tossing a dish towel to Jenny. She _
8. John brought/was bringing a glass of water to Robert. He
9. Brian faxed/was faxing a resume to Adam. He _____
10. Angela forwarded/was forwarding a gossipy email to Kelly. She _____
11. Heather mailed/was mailing a letter to Amy. She _____
12. Miriam sent/was sending a fruitcake to Rachel. She ___
13. Katherine shipped/was shipping a package to Laura. She
14. Jane transmitted/was transmitting a message to Nicole. She ____
15. Richard wired/was wiring money to Fred. He _____
16. Sarah carried/was carrying a tray to Brittany. She ____
17. Roger delivered/was delivering a subpoena to Joe. He _
18. Elizabeth gave/was giving a sweater to Ruth. She _____
19. Mike handed/was handing a book to Josh. He _____
20. Matt passed/was passing a sandwich to David. He ____
21. Jessica served/was serving chili to Emily. She _____

Filler Sentences:
22. Pamela was stabbed by Colleen at midnight. Next ____
23. Keith poisoned Sally with cyanide. Next _____
24. Kevin was complaining about school. Brad _____
25. Brett was startled by Dan at the dance. As a result ____
26. Allison was approached by Tracy at a bar. Amazingly _
27. Paul blinded Greg with a flashlight. As a result _____
28. Ryan hugged Alice after the game. He _____
29. Carl was escorted to court by Frank. Next _____
30. Bill amazed Ken with a double back flip. Next _____
31. Craig was beaten by Beth in the race. He _____
32. Casey was interviewed by Joel. Next _____
33. Melissa murdered George at midnight. She _____
34. Tina arrived home late. Candice _____
35. Sandra was attacked on the street by Jared. He _____
36. Alan surprised Clara with flowers. Later _____
37. Scott was hitting Zack with a pillow. As a result _____
38. Tom was waiting after class. Kristy _____
39. Dawn confused Neal with bad directions. Afterwards _
40. Carolyn was worrying about finals. Henry _____
41. Ian found Jordan in an empty hallway. Quickly _____
42. Linda saw Becky through the window. Suddenly _____
43. Melanie helped Julia with the dishes. Next _____
44. Lisa was avoiding Mary after the party. As a result ___
45. Karen called Tiffany at home. Next _____
46. Margaret laughed out loud. Luis _____
47. Alyssa was deceived by Kim at a costume party. As a result _____
48. Katie answered Cindy with a smirk. As a result _____
49. Alicia was delayed by Monica on the way to school. As a result _____
50. Gina was followed by Susan. As a result _____