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The Time Course of the Influence of Implicit Causality Information: Focusing versus Integration Accounts

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We report four self-paced reading experiments that investigate the influence of implicit causality information on anaphor resolution. Specifically, we test whether the processor uses implicit causality information to focus an antecedent for an anaphor or to facilitate integration. Previous work has produced data supporting conflicting positions (Garnham, Traxler, Oakhill, & Gernsbacher, 1996; Greene & McKoon, 1995; McDonald & MacWhinney, 1995). A range of findings concerned with the processing of pronouns versus names, the resolution of ambiguous and unambiguous pronouns, and the effects of a depth-of-processing manipulation suggest that effects of implicit causality occur during integration and that there is no evidence for effects during focusing. © 2000 Academic Press

Key Words: implicit causality; pronoun; anaphor; verb; language comprehension.

The way in which people ascribe causes to events depends on the way in which a particular event is described. Thus, people normally ascribe the cause of *John questioned Mary* to the referent of the subject noun phrase (henceforth *NP1*), *John,* rather than the referent of the object noun phrase (henceforth *NP2*), *Mary.* Conversely, they normally ascribe the cause of *John praised Mary* to NP2, *Mary,* rather than NP1, *John.* For example, after *John questioned Mary because . . . ,* the most likely continuation is a statement about John (e.g., *he wanted to learn the truth*); but after *John praised Mary because . . . ,* the most likely continuation is a statement about Mary (e.g., *she was responsible for the successful campaign*) (Garvey & Caramazza, 1974; Garvey, Caramazza, & Yates, 1976). Such verbs have an *implicit causality bias:* The verb *question* is NP1-biasing, whereas *praise* is NP2-biasing.

This bias has an influence on language comprehension. Its effects emerge in the resolution of ambiguous anaphors such as pronouns. For example, Caramazza, Grober, Garvey, and Yates (1977) had participants read sentences such as (1) which contained NP1-biasing verbs and sentences such as (2) which contained NP2-biasing verbs. The continuation (or *explicit cause*) was either congruent with the implicit cause, as in (1a) and (2a), or incongruent with it, as in (1b) and (2b):

1a. Roy questioned Anthony because he wanted to learn the truth.

1b. Bob questioned Timothy because he hadn't told the truth.

2a. Susan praised Diane because she was responsible for the successful campaign.

2b. Michelle praised Lucy because she was pleased with the successful campaign.

Participants took longer to read the sentence and name the referent of the pronoun when the sentence was incongruent than when it was congruent. Similar effects occurred when the pronoun was gender-disambiguated. We term this pattern of results the *causality congruency effect* (see also Ehrlich, 1980; McKoon, Greene, & Ratcliff, 1993; Garnham & Oakhill, 1985; Stevenson, Crawley, & Kleinman, 1994).

We can regard implicit causality as a constraint that affects sentence comprehension. An important question about any constraint is the time course of its application. On one account, processing might be affected by the constraint

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as soon as it becomes available. In (1a), it becomes likely that the sentence will be concerned with the cause of the act of questioning after *because* is encountered. The implicit causality associated with *questioned* makes it likely that the continuation will refer to *Roy*. If the processor rapidly becomes sensitive to this constraint (as may be the case with constraints in parsing: e.g., MacDonald, Pearlmutter, & Seidenberg, 1994; Trueswell, Tanenhaus, & Garnsey, 1994), then it might use this information to focus its attention on the likely cause. It would then be likely to assume that the antecedent of *he* is *Roy* in (1a) soon after encountering the pronoun. Following Garnham et al. (1996), we call this the *Focusing* account of the implicit causality bias.

Alternatively, implicit causality information might only affect later stages of processing, during or after the process of assigning the explicit cause, and at the point when the interpretations of the two clauses are integrated into a single interpretation for the sentence as a whole. If so, implicit causality information would not affect initial processing of the pronoun *he* in (1a). (The pronoun might be assigned an antecedent by some other strategy or not be assigned an antecedent at all at this point.) Again following Garnham et al. (1996), we call this the *Integration* account. A final possibility is that implicit causality influences processing associated with both focusing and integration: We call this the *Mixed* account. The main goal of this paper is to determine which account is correct.

Three recent papers have addressed the question of the time course of the use of implicit causality information (Garnham et al., 1996; Greene & McKoon, 1995; McDonald & MacWhinney, 1995). However, their data appear to clash, and they come to incompatible conclusions: Garnham et al. supported the Integration account, whereas Greene and McKoon and McDonald and MacWhinney argued for the Focusing account. This state of affairs is perhaps particularly surprising because they employed similar methods: probe tasks in which participants responded to the question of whether a particular word had appeared in the sentence.

McDonald and MacWhinney (1995) used a cross-modal probe task involving auditory presentation of a sentence like (3) and visual presentation of probe word:

(3) Beth disappointed Pam bitterly because she was so hard hearted at the anniversary party.

In Experiment 1, the probe was positioned (i) 100 ms after the second name, (ii) immediately after the pronoun, (iii) 200 ms after the pronoun, or (iv) at the end of the sentence. For NP1-biasing verbs, NP1 was processed faster than NP2 at all probe points. This may reflect the first-mention advantage commonly found with the probe task (Gernsbacher, 1989; Gernsbacher & Hargreaves, 1988). For NP2-biasing verbs, NP1 was processed faster than NP2 at points (i) and (iii), but at points (ii) and (iv), reaction times were similar for both NP1 and NP2. McDonald and MacWhinney argued that implicit causality information affected pronoun resolution at points (ii) and (iv). Because the effect occurred immediately after the pronoun, this result provides some evidence for the Focusing account, though it is very unclear why the effect disappeared at point (iii).

Greene and McKoon (1995) had subjects read three-sentence passages in which the third sentence was similar to (1)–(3) above. They probed after the second sentence and just before the pronoun in the third sentence (and therefore after the verb). For NP2-biasing verbs, they found an interaction, with the reduction in reaction time to probe words presented after the verb in comparison to before the verb being greater for NP2 probe words than NP1 probe words. This can be interpreted as indicating that NP2-biasing verbs immediately focus attention on NP2. But there is an alternative explanation: The NP2 probe occurs fairly soon after the NP2 name at the second probe position, unlike the first probe position. Participants may simply be responding faster to a fairly recent probe. In addition, they did not find a comparable interaction with NP1-biasing verbs. However, inspection of the means indicates that this difference is most likely due to the fact that there was no first-mention advantage at the first probe position, which has no obvious explanation, and

the data for the second probe position were similar to those for NP1-biasing verbs. Thus, their experiments do not provide convincing evidence for the Focusing account.

Garnham et al. (1996) employed an all-visual probe task, and tested before and after the pronoun and at the end of the sentence. The first three experiments employed two names of the same gender. These experiments revealed a first-mention advantage at all probe points and an effect of congruency. There were no consistent effects of whether the probe referred to the antecedent of the pronoun or not (probe reference). The lack of an immediate effect of probe reference is some evidence against Focusing account (and appears to clash with McDonald & MacWhinney, 1995), and the finding of a congruency effect supports the Integration account. However, the lack of a sentence-final probe reference effect may be worrying for this explanation. Garnham et al. argued that the final clause might have activated both the antecedent and the nonantecedent, but it is hard to see why no effects of reactivation were detected at any point. The results suggest a problem with the task itself, because congruency indicates that the pronoun must have been resolved, but the lack of any effect of probe reference suggests that the task is not always sensitive to the establishment of coreference. We return to this below.

Garnham et al.'s (1996) pattern of data is made more complex by their fourth experiment, which employed gender as well as plausibility to disambiguate sentences. It showed no straightforward effect of congruency, but did show an advantage for the pronoun's referent. However, this advantage might have been due to gender match between the pronoun and the probe word rather than reactivation of the antecedent. Overall, Garnham et al.'s data provide no support for the Focusing account. They are more consistent with the Integration account, though there may be alternative explanations of some aspects of their data.

Let us consider why McDonald and MacWhinney (1995) and Garnham et al. (1996) came to such different conclusions. First, processing might be more difficult when the tasks in which participants have to engage occur in the same modality compared to different modalities. A higher processing load in Garnham et al.'s experiments may have resulted in a general decrease in reading performance, thus removing any early influence of implicit causality information and weakening its influence at later probe points.

Another difference lies at the level of experimental design and suggests a possible problem with McDonald and MacWhinney's (1995) study. Most experiments on implicit causality, including those of Garnham et al. (1996), have employed a crossed design that includes both NP1- and NP2-biasing verbs, together with explicit causes disambiguated to NP1 or NP2. Hence there are two congruent and two incongruent conditions. In contrast, McDonald and MacWhinney's studies contained only congruent conditions. Au (1986) found that participants displayed sensitivity to implicit causality biases when asked to sort verbs into categories. If participants can access this information during processing, then they could use it to predict the explicit cause strategically. In response to this argument, McDonald and MacWhinney found no impact of implicit causality information at any probe point in sentences like (4):

(4) John amazed Bill time after time at the juggling competition.

Hence, they concluded that anaphor resolution itself produced their effects. However, this argument is weak, because (4) does not contain the connective *because*, which Ehrlich (1980) demonstrated was needed for implicit causality information to affect processing.

There are, however, more general concerns with the probe task. People do not, of course, normally perform this kind of secondary task during reading, and the appropriate response strategy (remembering the form of the sentence) is not part of normal processing. Indeed, some evidence suggests that the level of information accessed by the task may not reflect that used in comprehension (Cloitre & Bever, 1988; Garrod, Freudenthal, & Boyle, 1994; Gordon & Hendrick, 1998). Additionally, it may not be particularly sensitive to the time course of processing,

TABLE 1

Example Items Used in Experiments 1–3

Anaphor	Implicit cause	Congruency	Example
Name	NP1	Congruent	Daniel apologised to Arnold (profusely) because Daniel had been behaving selfishly.
		Incongruent	Daniel apologised to Arnold (profusely) because Arnold didn't deserve the criticism.
	NP2	Congruent	Jean congratulated Rita (vigorously) because Rita had won the championship.
		Incongruent	Jean congratulated Rita (vigorously) because Jean was very impressed.
Pronoun	NP1	Congruent	Daniel apologised to Arnold (profusely) because he had been behaving selfishly.
		Incongruent	Daniel apologised to Arnold (profusely) because he didn't deserve the criticism.
	NP2	Congruent	Jean congratulated Rita (vigorously) because she had won the championship.
		Incongruent	Jean congratulated Rita (vigorously) because she was very impressed.

Note. The NP1-biasing conditions make up one item, and the NP2-biasing conditions make up another item. The parenthesized material occurred in Experiment 2.

as Garnham et al.'s results suggest. For example, Greene, McKoon, and Ratcliff (1992) found no facilitation of antecedents immediately after a pronoun using the probe task, but eye-tracking studies have found that pronouns can be interpreted immediately (e.g., Garrod et al., 1994). Likewise, Millis and Just (1994) used probe-task data to argue that integration of two clauses is delayed until the second one has been fully read. But Traxler, Bybee, and Pickering (1997) found eye-tracking evidence that integration occurred incrementally during the second clause. Hence reading-time measures may be more appropriate than the probe task for examining the time course of comprehension. These points raise major worries over the reliability of the data on which evidence for the Focusing and Integration accounts has been based.

We therefore employed self-paced reading to test among the Focusing, Integration, and Mixed accounts in the experiments reported below. Let us outline our approach using examples from Experiment 1 (see Table 1). We manipulated information about the implicit cause (verb bias) and information about the explicit cause. If implicit cause and explicit cause were in agreement, a sentence was congruent; if not, it was incongruent. Finally, the anaphor could be a name (e.g., *Daniel*) or a pronoun (e.g., *he*). The names were unambiguous, whereas the pronouns were ambiguous, as both names were of the same gender (*he* could in principle refer to Daniel or Arnold). Experiments 1–3 used this contrast, whereas Experiment 4 contrasted unambiguous with ambiguous pronouns.

Full noun phrases or (proper) names can be used to refer to antecedents that are no longer in focus and indeed are often used for that purpose. Names can also be used to serve additional discourse functions, such as signaling a change in the theme in a text (Marslen-Wilson, Levy, & Tyler, 1982; Vonk, Hustinx, & Simons, 1992). In contrast, pronouns preferentially refer to antecedents that *are* focused (Gordon, Grosz, & Gilliom, 1993; Gordon & Hendrick, 1998; Hudson, Tanenhaus, & Dell, 1986; Sanford, Moar, & Garrod, 1988). Hence pronouns are more sensitive indicators of states of focus than name or full noun phrase anaphors. For instance, Hudson et al. showed that pronominal references were processed more readily when made to focused (centered in the terms of Grosz, Joshi, & Weinstein, 1983) than

to nonfocused characters. In contrast, when proper names were used as anaphors, this pattern did not occur, and there was some evidence for a reversal of the effect. Likewise, Sanford et al. found that anaphors which referred to highly focused proper names (like *John*) were processed more quickly than those which referred to somewhat less focused full noun phrases (like *the secretary*), provided the anaphor was a pronoun. But if a repeated name or repeated full noun phrase was used, no difference was found. (It is also worth noting that the most versions of the probe task use proper names as probes, which might therefore not be sensitive to differences in focus; this is another concern with the probe task.)

Hence the Focusing model predicts the causality congruency effect with pronouns but not with names. In other words, it predicts an interaction between congruency and anaphor type. In contrast, no such difference is predicted by the Integration account. As the mixed model allows for an influence of implicit causality during both the stages of focusing and integration, it predicts a congruency effect for both types of anaphor, but a reduced effect when repeated names are used.

The models make the same predictions for another reason as well. Because the pronouns were ambiguous, the Focusing account predicts that the processor should determine the antecedent of the ambiguous pronoun on the basis of the implicit causality bias of the verb. If this assignment ran counter to the explicit cause (i.e., the sentence was incongruent), then Focusing predicts that readers should experience difficulty with sentences containing ambiguous pronouns. In contrast, difficulty should not emerge in sentences containing unambiguous repeated names.

Experiment 1 used whole-sentence presentation. Experiment 2 addressed the same question, but used materials that were more similar to those employed by McDonald and MacWhinney (1995) and presented sentences in two parts. In Experiment 3, we manipulated the depth of processing used by participants, by varying the type of question participants were required to answer. Our argument was that integration effects should be influenced by depth of processing, whereas focus effects should not. In Experiment 4, we employed ambiguous and unambiguous pronouns. If the congruency effect resulted entirely from focus, then there should be a larger congruency effect for ambiguous than unambiguous pronouns.

EXPERIMENT 1

Method

Participants. Thirty-two English-speaking participants from the student population at the University of Glasgow took part.

Stimuli. Participants were presented with 48 items (see Table 1 and Appendix A). These were constructed on the basis of verb bias and plausibility pretests reported below. The stimuli were based on 24 verbs, 12 of which were NP1-biasing and 12 NP2-biasing. There were four versions of each item, defined by the combination of two factors: Anaphor (pronoun vs. repeated name) and Congruency (congruent vs. incongruent). A third factor, Implicit Cause (NP1- vs. NP2-biasing verb), was manipulated between items. All items consisted of a main clause and a subordinate clause connected by *because.* The main clause contained two proper names of the same gender which served as subject and direct object of an active transitive past-tense verb. The subordinate clause began with a pronoun or a repeated name subject and a predicate. Items were matched for length across conditions.

To produce six data points per condition, each verb was used twice. Thus for NP1-biasing verbs, the 12 verbs were divided into four sets of 3. (Exactly the same held for NP2-biasing verbs.) A group of 3 verbs was allocated to each of the four conditions to create a single list. By rotating the allocations, four files were created, such that each verb appeared in each of the conditions over the experiment. Within a given list, if a verb appeared in the pronoun-congruent condition, then it was later presented in the name-incongruent condition and vice versa; if it appeared in the pronoun-incongruent condition, then it was later presented in the name-congruent condition and vice versa. Thus a single

complete list had each verb appearing twice, but in different conditions. When a verb was used a second time, a different item was generated for that verb by changing the names, so that the only overlap between the two items using a particular verb was the verb and the word *because*. This procedure led to 48 items. The first occurrence of each verb was in the first half of the experiment, and the second occurrence in the second half.

Versions of a comprehension question were included with each item (e.g., *Who had been behaving selfishly?*) and required participants to press one of two buttons corresponding to the names. This question always made reference to the subordinate clause and required resolution of the pronoun in the pronoun conditions.

Verb-bias pretest. To make sure that our verbs were strongly biased, we conducted a sentence-completion pretest. Twenty-four further participants completed sentence fragments like *John blamed Bill because . . .*, where the verb was one of 50 taken from the literature on implicit causality and the two noun phrases were proper names. Continuations were scored on the basis of whether the first word following the connective referred to NP1, NP2, or neither. All our verbs were strongly biased (see Appendix B).

Plausibility pretest. We tried to equate the plausibilities of the two versions of each item as far as possible. Implausible sentences, in general, take longer to read than plausible sentences (e.g., Garrod et al., 1994; Murray & Rowan, 1998; Traxler & Pickering, 1996). Twenty-four participants rated the 48 items for plausibility on a scale from 0 (very implausible) to 7 (very plausible); see Appendix B. For each item, they rated the repeated name version of each item (e.g., *Daniel apologised to Arnold because Daniel had been behaving selfishly*). All conditions were rated highly plausible: The congruent conditions for the NP1- and NP2-biased verbs had mean ratings of 6.5 and 6.5, respectively; the incongruent conditions had mean ratings of 6.0 and 6.0. This difference is very small, but a plausibility difference does exist. Although we cannot completely rule out the influence of plausibility, we attempted to reduce its influence as much as we could. In any case, a very likely explanation for the small plausibility difference between conditions is that it really reflects the difficulty that people have integrating incongruent sentences, even when the situation they describe is highly plausible, compared with the ease of integrating congruent sentences.

The participants also rated an "incorrect" version of the item with the other name repeated (e.g., *Daniel apologised to Arnold because Arnold had been behaving selfishly*). This was intended to be implausible, but it is possible that differences in the degree of implausibility of the alternative analysis might affect processing difficulty. On this analysis, all conditions were rated highly implausible: The congruent conditions for the NP1- and NP2-biased verbs had mean ratings of 2.1 and 2.2; the incongruent conditions had mean ratings of 1.5 and 1.8.

Procedure. Participants were randomly assigned to one of the four lists. Each list was presented along with 96 filler sentences of various types (similar in form to the experimental sentences), plus associated questions, in an individually randomized order.

The experiment was run on an Apple Macintosh computer using the PsyScope experimental software (Cohen, MacWhinney, Flatt, & Provost, 1993). A button box was connected to the computer which recorded participants' responses with millisecond accuracy. A fixation point appeared on the left-hand side of the screen. Participants were first provided with both verbal and written instructions and 10 practice trials. They pressed a button on the button box to remove the fixation point and present the sentence. A second press removed the sentence and presented a comprehension question. The two halves of the experiment were divided by an enforced break of at least 30 s. The experiment lasted roughly 35 min.

Results

Sentence reading times. Reading times that were below 500 ms or above 25 s were removed (based on clear discontinuities in the data). This accounted for 1.3% of the data. Outliers, defined as times falling more than 2.5 *SD* from the

TABLE 2

Experiment 1 Reading Times in Milliseconds for Sentences and Questions (with Response Accuracy Expressed as Percentage Correct)

Anaphor	Implicit cause	Congruency	Sentence	Question (%)
Name	NP1	Congruent	4702	1673 (98.9)
		Incongruent	4701	1775 (93.6)
	NP2	Congruent	3946	1677 (98.4)
		Incongruent	4654	1732 (96.3)
Pronoun	NP1	Congruent	4760	1902 (87.4)
		Incongruent	5601	2317 (74.3)
	NP2	Congruent	4327	1748 (97.4)
		Incongruent	4837	2066 (91.1)

mean for each participant, were then replaced by the cutoff value for that participant. This accounted for 2.5% of the data. For the question response data, times below 500 ms or above 25 s were removed. This accounted for 1.3% of the data. Outliers accounted for 2.9% of the data.

Table 2 presents the mean reading times and question response times for the different experimental conditions. We conducted 2 Anaphor (pronoun vs. repeated name) $\times$ 2 Implicit Cause (NP1- vs. NP2-biasing verb) $\times$ 2 Congruency (congruent vs. incongruent) ANOVAs, treating participants ($F1$) and items ($F2$) as random factors.

These analyses revealed a main effect of Congruency, with congruent sentences (4434 ms) being read faster than incongruent ones (4948 ms) ($F1(1,31) = 51.05$, $p < .0001$, $MSe = 331{,}936$; $F2(1,46) = 27.75$, $p < .0001$, $MSe = 486{,}021$). However, there was no reliable interaction between Anaphor and Congruency ($F1(1,31) = 2.448$, $p > .1$; $MSe = 679{,}917$; $F2 < 1.1$), though there was a trend toward the effect being smaller in the case of the repeated name anaphors (354 ms) than it was in the pronoun case (675 ms). Tests of simple effects demonstrated a reliable effect of Congruency for the pronoun conditions ($F1(1,31) = 21.50$, $p < .0001$; $F2(1,46) = 9.29$, $p < .005$) and an effect of Congruency for the repeated name conditions that was reliable by participants ($F1(1,31) = 5.87$, $p < .05$; $F2 = 2.64$, $p < .12$).

The analyses also revealed main effects of Implicit Cause, with sentences containing NP2-biasing verbs (4441 ms) being read faster than those containing NP1-biasing verbs (4941 ms) ($F1(1,31) = 19.01$, $p < .0001$, $MSe = 841{,}524$; $F2(1,46) = 17.68$, $p < .0001$, $MSe = 692{,}576$) and of Anaphor, with sentences containing a repeated name anaphor (4501 ms) being read more quickly than those containing a pronoun (4881 ms) ($F1(1,31) = 10.59$, $p < .005$, $MSe = 874{,}191$; $F2(1,46) = 6.07$, $p < .05$, $MSe = 1{,}052{,}406$). The only other effect that approached significance was a marginal three-way interaction of Anaphor, Implicit Cause, and Congruency, significant only by participants ($F1(1,31) = 5.51$, $p < .05$, $MSe = 786{,}187$, $F2(1,46) = 2.56$, $p < .12$, $MSe = 1{,}255{,}386$).

Question response data. We conducted three-way ANOVAs on question response times and accuracy. A full report is omitted for reasons of space. The most important finding was a main effect of congruency on both measures, with questions about congruent sentences being answered faster and more accurately than questions about incongruent sentences. The effects were more pronounced for the pronouns than for the repeated names.

Discussion

The causality congruency effect emerged strongly in the sentence reading time data. The effect was numerically smaller in the repeated name than in the pronoun conditions, but this difference was not reliable. The results offers no support for the Focusing account, which predicted an elimination of the congruency effect. Instead, these results are consistent with implicit causality exerting its influence during integration, in the same manner for pronouns and repeated names. However, the numerical trend is compatible with focus exerting some influence (i.e., the Mixed account). Our claim at this stage is that an important part of the congruency effect is mediated by integration. The congruency effect in the question response data sug-

gests that readers constructed a more stable representation when the implicit and explicit causes were congruent than when they were incongruent and is in accordance with many previous studies. The stronger effect in the pronoun conditions may reflect the fact that readers need not have paid attention to the main clause in the repeated name conditions. This may also explain why the sentences were read faster in the repeated name conditions.

EXPERIMENT 2

Experiment 1 provides some evidence for integration but no clear evidence for focusing (though it is possible that this is due to insufficient power). This runs counter to the conclusions of Greene and McKoon (1995) and McDonald and MacWhinney (1995). However, apart from the tasks involved, McDonald and MacWhinney's experiments differed in one important way from ours: They employed an additional phrase at the end of the main clause, prior to the connective *because*. Greene and McKoon's studies also included an additional phrase which followed the connective *because.*

It is not immediately clear why this phrase should have an effect. First, Garnham et al. (1996) used similar phrases and found no evidence of focusing. Second, in McDonald and MacWhinney's (1995) experiments the phrase comes before the connective. As Ehrlich (1980) and McDonald and MacWhinney showed, implicit causality effects do not appear to occur in the absence of the connective *because.* If it is simply a question of the phrase giving the processor more time to begin focusing, then it appears that the phrase comes too early (it would need to appear between *because* and the anaphor). However, it is possible that the critical property of the additional phrase is not to introduce more time. Instead, it may cause the processor to focus on the appropriate referent for reasons associated with the attributions that a reader might make on the basis of the additional information provided by the phrase (e.g., Rudolph & Forsterling, 1997). We therefore conducted an experiment using an additional phrase before the connective. The items were otherwise identical to those in Experiment 1 (see Table 1).

A possible concern with Experiment 1 was the use of the whole-sentence presentation method. Although it has the advantage of naturalness, it may be insensitive, and it does not allow us to localize effects. In Experiment 2, we therefore presented the sentences in two parts: the first up to and including the pronoun or repeated name subject of the subordinate clause and the second containing the rest of the sentence.

Our main interest is in the reading time to the second fragment. According to the Integration account, a similar congruency effect should emerge in both the pronoun and repeated name conditions. According to the Focusing account, congruency should emerge with pronoun anaphors, but not with repeated names. Because of the additional phrase and the presentation procedure, a lack of interaction between pronoun and repeated name conditions would provide strong evidence in favor of the Integration account.

Reading times to the first fragment may also be of interest. Repeated name conditions are disambiguated by the repeated name, which occurs in the first fragment. The Focusing account might therefore predict an effect of congruency on reading time to the first fragment in the repeated name conditions. However, a problem is that repeated names are not normally used to refer to a focused antecedent, as discussed above. If so, the most natural prediction of the Focusing account would be that the repeated name would have no effect.

Method

Participants. We employed 32 further participants.

Stimuli. We constructed 48 items, by adding an additional phrase into the items from Experiment 1 (see Table 1 and Appendix A). The average length of these phrases was 1.38 words and 9.42 letters, compared with the phrases used in the McDonald and MacWhinney study (1.91 words and 9.72 letters, though their sentences were spoken). There were four versions of each item, defined by the combination of two factors:

TABLE 3

Experiment 2 Reading Times in Milliseconds for Sentence Fragments and Questions (with Response Accuracy Expressed as Percentage Correct)

Anaphor	Implicit cause	Congruency	Fragment 1	Fragment 2	Question (%)
Name	NP1	Congruent	3711	1555	2026 (91.0)
		Incongruent	3396	1633	2009 (92.1)
	NP2	Congruent	3287	1620	1889 (95.8)
		Incongruent	3550	1696	2011 (93.8)
Pronoun	NP1	Congruent	3183	1825	2666 (75.6)
		Incongruent	3354	1991	3132 (51.1)
	NP2	Congruent	3201	1803	2460 (80.6)
		Incongruent	3457	1931	2740 (78.6)

Anaphor (pronoun vs. repeated name) and Congruency (congruent vs. incongruent). A third factor, Implicit Cause (NP1- vs. NP2-biasing verb) was manipulated between items.

Procedure. The procedure was the same as that of Experiment 1, except that the sentences were presented as two fragments, with the split occurring immediately after the pronoun or repeated name. Pressing the button revealed the first fragment; pressing it again removed the first fragment and replaced it with the second fragment.

Results and Discussion

For the first fragment, we removed 1.2% of the data (times below 300 ms or above 16 s). We then removed outliers, accounting for 2.1% of the data. For the second fragment, we removed 1.4% of the data (times below 300 ms or above 11 s) and 2.8% of the data (outliers). For the question response time, we removed 0.5% of the data (times below 300 ms or above 13 s) and 3.3% of the data (outliers).

Table 3 presents the mean reading times and question response times for the different experimental conditions. We conducted 2 Anaphor (pronoun vs. repeated name) $\times$ 2 Implicit Cause (NP1- vs. NP2-biasing verb) $\times$ 2 Congruency (congruent vs. incongruent) ANOVAs. Anaphor and Congruency were within-participants and within-items factors; Implicit Cause was within-participants but between-items.

First fragment reading times. These revealed a main effect of Anaphor ($F1(1,31) = 9.42$, $p < .005$, $MSe = 238{,}051$; $F2(1,46) = 4.74$, $p < .05$, $MSe = 351{,}983$), with fragments containing pronouns being read more quickly (3299 ms) than those containing repeated names (3486 ms), and an interaction between Implicit Cause and Congruency, significant only by participants ($F1(1,31) = 6.39$, $p < .05$, $MSe = 274{,}850$; $F2 < 2$). Because all four conditions containing pronouns were identical, a more valid comparison considers only the repeated name level of the Anaphor factor. Two-way ANOVAs revealed an interaction of Implicit Cause and Congruency that was marginal by items ($F1(1,31) = 8{,}81$, $p < .01$, $MSe = 302{,}489$; $F2(1,46) = 3.28$, $p < .08$, $MSe = 561{,}425$) and no hint of any main effects (all Fs < 1.1). This interaction suggests that fragments containing a name that repeated NP2 (3342 ms) were read faster than fragments containing a name that repeated NP1 (3631 ms). Note, however, the lack of any effect of implicit causality on this fragment.

Second fragment reading times. There was a main effect of Congruency ($F1(1,31) = 7.09$, $p < .05$, $MSe = 113{,}487$; $F2(1,46) = 4.87$, $p < .05$, $MSe = 111{,}975$), with congruent fragments (1701 ms) being read faster than incongruent fragments (1813 ms). As in Experiment 1, there was no significant interaction between Anaphor and Congruency (both Fs < 1), but the congruency effect was numerically smaller for the repeated name anaphors (77 ms) than the pronouns (147 ms). Although unreli-

able, this effect is in the same direction as that obtained in Experiment 1. Tests of simple effects demonstrated a reliable effect of Congruency for the pronoun conditions ($F1(1,31) = 6.43$, $p < .05$; $F2(1,46) = 6.00$, $p < .05$) but not for the repeated name conditions ($F1(1,31) = 1.76$, $p < .20$; $F2 = 1.61$, $p < .22$). These results are consistent with an account that ascribes congruency to integration, though the numerical effect suggests that we cannot rule out a minor role of focus.

Analyses also revealed a main effect of Anaphor ($F1(1,31) = 19.99$, $p < .0001$, $MSe = 218{,}452$; $F2(1,46) = 25.76$, $p < .0001$, $MSe = 128{,}775$), with sentences containing repeated names (1626 ms) being read faster than sentences containing pronouns (1888 ms).

Question response data. The most important finding was an effect of congruency on both response time and accuracy measures. This effect emerged in the pronoun conditions but not the repeated name conditions.

Discussion

Essentially, the study replicated Experiment 1. There was an effect of congruency and no reliable interaction between anaphor type and congruency in the critical fragment. However, the effect was numerically larger for the pronoun anaphors in Experiment 2, just as in Experiment 1. This evidence suggests that integration is an important factor in the congruency effect, but does not rule out an influence of focusing.

The data from the first fragment warrant some discussion. In particular, participants appeared to spend longer reading a repetition of the first mentioned character's name than the second mentioned character's name. This can be interpreted as a repeated name penalty, as proposed within Centering Theory (Gordon et al., 1993). On this account, the first mentioned character is focused (probably because it is mentioned first: Gernsbacher, 1989; Gernsbacher & Hargreaves, 1988), and the processor has difficulty referring to the focused character with a repeated name. However, an alternative explanation is that the effect is due to lexical priming from the second mentioned character's name. The following experiments help us distinguish these possibilities. Note that there was no effect of congruency on the first fragment. In other words, readers did not notice any conflict between having an NP1-biasing verb and a name repeating NP2 or vice versa.

EXPERIMENT 3

The questions that participants were required to answer in Experiments 1 and 2 related to the interpretation of the anaphor. Thus, in the pronoun conditions, a question could be successfully answered only if participants had appropriately integrated the information between the clauses. Also, because each sentence was followed by a question, readers would be aware that deep processing would be necessary for all sentences. In Experiment 3, we contrasted conditions using *deep-processing* questions with conditions using *shallow-processing* questions such as *Did Daniel apologise to Arnold?* which can be answered without integrating the interpretations of the clauses. Additionally, the conditions using shallow-processing questions employed questions on only one third of trials, and different groups of participants were exposed to the different question types. Hence, the participants in the shallow-processing conditions would not be encouraged to conduct extensive integrative processing (though they would still have to pay some attention to the sentences).

By manipulating type of question, we sought to manipulate participants' depth of processing. If the Integration or Mixed account is correct, the degree to which participants engage in integrative processing should affect the magnitude of the congruency effect. The less integrative processing carried out, the weaker should be the influence of any factor that is brought into play during this processing. Thus these accounts predict that the type-of-question manipulation would affect the magnitude of the congruency effect: A larger effect is predicted in the deep-processing than the shallow-processing conditions. In contrast, the Focusing account does not predict that depth of processing will affect the congruency effect. Because focus within the reader's discourse model changes continuously as a text is being read, a measure that requires

TABLE 4

Experiment 3 Reading Times in Milliseconds for Sentence Fragments

Question type	Anaphor	Implicit cause	Congruency	Fragment 1	Fragment 2
Shallow	Name	NP1	Congruent	2366	1624
			Incongruent	2069	1668
		NP2	Congruent	2012	1562
			Incongruent	2273	1621
	Pronoun	NP1	Congruent	2041	1617
			Incongruent	2117	1910
		NP2	Congruent	2032	1594
			Incongruent	2028	1618
Deep	Name	NP1	Congruent	3086	2078
			Incongruent	2793	2299
		NP2	Congruent	2648	1915
			Incongruent	2976	2418
	Pronoun	NP1	Congruent	2799	2238
			Incongruent	2713	2794
		NP2	Congruent	2639	2375
			Incongruent	2714	2386

inspection of the discourse model at a later point should not be influenced by temporary focusing and refocusing that may occur during the reading of a sentence.

Method

Participants. We employed 64 further participants.

Stimuli. The same 48 items as Experiment 1 were used (see Table 1). Each item was paired with a deep-processing question, which was the same as Experiment 1. One third of the items were paired with a shallow-processing question (see Appendix A). For example, *Barry fascinated Derek because he performed magic tricks* was followed by the deep-processing question, *Who performed magic tricks?* or the shallow-processing question, *Did Barry fascinate Derek?*. As in Experiment 1, the factors of Anaphor (pronoun vs. repeated name) and Congruency (congruent vs. incongruent) were manipulated within items, and Implicit Cause (NP1- vs. NP2-biasing verb) was manipulated between items. Additionally, a fourth factor, Type of Question (deep vs. shallow processing) was manipulated between participants.

Procedure. Participants were randomly assigned to one of eight lists. Each sentence was presented as two fragments, with the split occurring immediately after the anaphor [*he* in (6) above], as in Experiment 2. The filler and practice sentences in the lists that contained the deep-processing questions had the same questions as in Experiment 1; the filler and practice sentences on the lists that contained the shallow-processing questions were associated with questions on one third of the trials. In other respects, the procedure was identical to that of Experiment 1.

Results and Discussion

For the first fragment, we removed 1.6% of the data (times below 200 ms or above 17 s). We then removed outliers, accounting for 5.9% of the data. For the second fragment, we removed 0.8% of the data (times below 200 ms or above 15 s) and 5.6% of the data (outliers). For the question response time, we removed 3.3% of the data (outliers).

Table 4 presents the mean reading times for the different experimental conditions. We conducted 2 Anaphor (pronoun vs. repeated name) $\times$ 2 Implicit Cause (NP1- vs. NP2-biasing verb) $\times$ 2 Congruency (congruent vs. incongruent) $\times$ 2 Type of Question (deep vs. shallow processing) ANOVAs. Anaphor, Im-

plicit Cause, and Congruency were within-participants; Type of Question was between-participants. Anaphor, Congruency, and Type of Question were within-items; Implicit Cause was between-items.

First fragment reading times. Four-way ANOVAs revealed a main effect of Type of Question ($F1(1,62) = 8.46$, $p < .005$, $MSe = 6{,}978{,}596$; $F2(1,46) = 300.83$, $p < .0001$, $MSe = 147{,}374$), with participants taking longer to read this fragment in the deep-processing conditions (2796 ms) than the shallow-processing conditions (2117 ms), and a marginal effect of Anaphor ($F1(1,60) = 5.43$, $p < .05$, $MSe = 479{,}597$; $F2(1,46) = 3.22$, $p < .08$, $MSe = 1{,}844{,}973$), which suggested that participants took longer to read fragments containing repeated names (2528 ms) than fragments containing pronouns (2385 ms). There was also an interaction of Implicit Cause and Congruency ($F1(1,62) = 24.38$, $p < .0001$, $MSe = 129{,}835$; $F2(1,46) = 8.30$, $p < .01$, $MSe = 291{,}104$) and a marginal three-way interaction of Implicit Cause, Congruency, and Anaphor ($F1(1,62) = 10.01$, $p < .005$, $MSe = 241{,}132$; $F2(1,46) = 3.52$, $p < .07$, $MSe = 506{,}943$).

As the conditions containing pronouns remained ambiguous for the first fragment, we conducted analyses on the repeated name level of the Anaphor factor alone. These revealed a main effect of Type of Question (deep processing: 2876 ms; shallow processing: 2180 ms) ($F1(1,62) = 9.20$, $p < .005$, $MSe = 3{,}367{,}379$; $F2(1,46) = 189.16$, $p < .0001$, $MSe = 122{,}915$) and an interaction of Implicit Cause and Congruency ($F1(1,62) = 29.48$, $p < .0001$, $MSe = 188{,}404$; $F2(1,46) = 9.96$, $p < .005$, $MSe = 419{,}375$): Fragments containing a name that repeated NP2 (2381 ms) were read faster than fragments containing a name that repeated NP1 (2675 ms). Note, however, the lack of any effect of implicit causality on this fragment (both Fs < 1). These results are therefore similar to those found in Experiment 2.

Second fragment reading times. There was a main effect of Congruency (congruent: 1875 ms; incongruent: 2089 ms) ($F1(1,62) = 41.80$, $p < .001$, $MSe = 140{,}356$; $F2(1,46) = 18.98$, $p < .0001$, $MSe = 237{,}060$), which was modified by an interaction of Congruency and Type of Question ($F1(1,62) = 10.83$, $p < .005$, $MSe = 140{,}356$; $F2(1,92) = 5.64$, $p < .05$, $MSe = 201{,}034$). As predicted by the Integration model, the congruency effect was weaker for second fragments in the conditions where participants had to respond to a shallow-processing question (105 ms) than in the conditions where participants had to respond to a deep-processing question (323 ms). The congruency effect in both conditions was significant, however [shallow processing: $F1(1,31) = 5.49$, $p < .05$, $MSe = 128{,}735$; $F2(1,46) = 7.70$, $p < .01$, $MSe = 72{,}452$; deep processing: $F1(1,31) = 43.95$, $p < .0001$; $MSe = 151{,}977$; $F2(1,46) = 13.88$, $p < .0005$, $MSe = 365{,}643$]. There was no interaction between Congruency and Anaphor (both Fs < 1). The congruency effect was 207 ms for the name conditions and 221 ms for the pronoun conditions. Tests of simple effects demonstrated that both of these were significant (all ps < 0.01).

The analyses also revealed an effect of Type of Question ($F1(1,62) = 13.94$, $p < .0005$, $MSe = 4{,}016{,}906$; $F2(1,46) = 355.25$, $p < .0001$, $MSe = 118{,}306$), with fragments in the shallow-processing conditions (1652 ms) being read faster than those in the deep-processing conditions (2313 ms). There were also an effect of Anaphor ($F1(1,62) = 17.30$, $p < .0001$, $MSe = 209{,}871$; $F2(1,46) = 13.64$, $p < .001$, $MSe = 201{,}379$), with fragments following pronouns (2067 ms) being read more quickly than fragments following repeated names (1898 ms), and an interaction of Anaphor and Type of Question ($F1(1,60) = 6.41$, $p < .05$, $MSe = 209{,}871$; $F2(1,46) = 7.09$, $p < .05$, $MSe = 134{,}577$), suggesting that this was largely restricted to the deep-processing conditions. There was also an interaction of Anaphor, Implicit Cause, and Congruency ($F1(1,60) = 15.73$, $p < .0005$, $MSe = 156{,}592$; $F2(1,46) = 6.69$, $p < .05$, $MSe = 269{,}352$), suggesting that following a name referring to either the first or second mentioned character, integration is equivalently fast; but

following a pronoun, integration is faster following reference to the first mentioned character than reference to the second. We did not analyze participants' responses to the questions as those presented to one group of participants were very different from those presented to the other group (and occurred only on a third of the trials).

Experiment 3 replicated the pattern of results found in Experiments 1 and 2. Importantly, there was no interaction of Anaphor and Congruency (both Fs < 1). In fact, the congruency effect was almost identical with pronouns and repeated names. In accord with the Integration account, but not the Focusing or Mixed models, the second fragment data indicate that a similar congruency effect occurred whether the subordinate clause contained an ambiguous pronoun or a repeated name. The data from the first fragment provide further support for this account. Additionally, the congruency effect *was* affected by the type of question asked, with a more substantial effect occurring when participants were asked deep-processing questions after every sentence than when they were asked shallow-processing questions after one third of sentences. These findings accord with the Integration account but run contrary to the predictions of the Focusing account.

EXPERIMENT 4

So far we have contrasted ambiguous pronouns with unambiguous repeated names. Hence there are two differences between the pronoun and repeated name conditions: ambiguity and type of anaphor. Experiment 4, in contrast, looked at the effects of ambiguity alone by contrasting ambiguous pronouns with pronouns disambiguated by gender.

The Focusing, Mixed model, and Integration accounts make different predictions as to how gender information might interact with implicit causality information. The critical point is that gender can be used to provide immediate disambiguation of the antecedent of the pronoun. The following argument relies on the assumption that pronoun resolution can occur immediately and that gender information can be used immediately. Good evidence for these assumptions comes from reading-time experiments (Garnham, Oakhill, & Cruttenden, 1992; Garrod et al., 1994) and cross-modal priming (Marslen-Wilson, Tyler, & Koster, 1993). Some probe task experiments do not support this finding (e.g., Greene et al., 1992; MacDonald & MacWhinney, 1990; Stevenson & Vitkovitch, 1986), but this discrepancy is probably related to the nature of the task employed. In any case, the evidence suggests that gender information can be used immediately in the task employed here: Garnham et al. (1992) showed that when the experimental task demands immediate resolution of a pronoun, gender information does have a quick influence. In Experiment 4 every sentence was followed by a deep-processing question, which required pronoun resolution, and hence gender information should be used immediately.

Experiment 4 used sentences like those in Table 5. Since pronouns prefer focused antecedents, the Focusing account predicts that pronouns should be easier to process if they refer to the focused noun phrase. Thus, after *Daniel apologised to Joanne because he . . .* , the pronoun *he* refers to Daniel, who should be focused by the implicit-causality information associated with the NP1-biasing verb *apologised.* But after *Joanne apologised to Arnold because he . . .* , the pronoun *he* refers to Arnold, who should be out of focus. Hence, the Focusing account makes the prediction that there will be difficulty with the first fragment if verb bias and gender information conflict (assuming pronouns are resolved immediately). There might be some "spillover" to the second fragment, but the difficulty should occur mainly on the first fragment.

More crucially, the Focusing account also makes a prediction for the second fragment similar to that made in Experiments 2 and 3: The congruency effect ought to occur in sentences that contain ambiguous pronouns, but not in sentences that contain unambiguous pronouns. After *Daniel apologised to Arnold because he . . .* , readers should employ verb bias to initially interpret *he* as referring to Daniel. If the sentence continues *had been behaving* selfishly, this interpretation of the pronoun is felic-

TABLE 5

Example Materials Used in Experiment 4

Pronoun	Implicit cause	Congruency	Example
Ambiguous	NP1	Congruent	Daniel apologised to Arnold because he had been behaving selfishly.
		Incongruent	Daniel apologised to Arnold because he didn't deserve the criticism.
	NP2	Congruent	Jean congratulated Rita because she had won the championship.
		Incongruent	Jean congratulated Rita because she was very impressed.
Unambiguous	NP1	Congruent	Daniel apologised to Joanne because he had been behaving selfishly.
		Incongruent	Joanne apologised to Arnold because he didn't deserve the criticism.
	NP2	Congruent	John congratulated Rita because she had won the championship.
		Incongruent	Jean congratulated John because she was very impressed.

itous. But if the sentence continues *didn't deserve the criticism*, it turns out that the pronoun felicitously refers to Arnold. Hence, readers would then have to perform costly reanalysis during this second fragment. Because the effects with the unambiguous pronouns should mainly be confined to the first fragment, the effects should be larger for the ambiguous than the unambiguous pronouns in the second fragment.

In contrast, the Integration account does not predict any difference in the magnitude of the congruency effect as a function of the informativeness of gender information. Under the Integration account, the congruency effect arises only during integration and is separate from any aspect of processing associated with focusing on the appropriate referent. Hence its main prediction is a congruency effect on the second fragment that is unaffected by whether the pronoun is ambiguous.

With respect to the first fragment, the Integration account makes one of two predictions. Recall that repeated name in Experiments 2 and 3 was read faster if it corresponded to NP2 than NP1. If this is due to a first mention effect, with a preference for a name to refer to an unfocused antecedent, then the fact that pronouns preferentially refer to a focused antecedent might predict that a fragment containing an unambiguous pronoun would be read faster if it referred to NP1 than NP2. But if the effect is due to lexical priming, then no effects are predicted. The critical point, however, is that the Integration account predicts no effects of congruency on this fragment.

Method

Participants. We employed 32 further participants.

Stimuli. The 48 sets of items were the same as those in Experiment 1, except that one name in the main clause was replaced by a name of the opposite gender, and the repeated names were replaced by unambiguous pronouns (see Table 5 and Appendix A). There were four versions of each item, defined by the combination of two factors: Pronoun (unambiguous vs. ambiguous pronoun) and Congruency (congruent vs. incongruent). A third factor, Implicit Cause (NP1- vs. NP2-biasing verb) was manipulated between items.

Procedure. The procedure was identical to that of Experiment 2.

Results and Discussion

For the first fragment, we removed 2.0% of the data (times below 300 ms or above 15 s). We then removed outliers, accounting for 3.1% of the data. For the second fragment, we removed 2.6% of the data (outliers). For the question response time, we removed 1.2% of the data (times below 300 ms or above 15 s) and 2.7% of the data (outliers).

Table 6 presents the mean reading times and question response times for the different experimental conditions. We conducted 2 Pronoun (ambiguous vs. unambiguous pronoun) $\times$ 2 Im-

TABLE 6

Experiment 4 Reading Times in Milliseconds for Sentence Fragments and Questions (with Response Accuracy Expressed as Percentage Correct)

Pronoun	Implicit cause	Congruency	Fragment 1	Fragment 2	Question (%)
Ambiguous	NP1	Congruent	2379	1983	2312 (87.1)
		Incongruent	2157	2234	2813 (85.3)
	NP2	Congruent	2058	1919	2091 (93.6)
		Incongruent	2235	1893	2453 (90.1)
Unambiguous	NP1	Congruent	2112	1696	1810 (96.3)
		Incongruent	2176	1980	2156 (92.5)
	NP2	Congruent	2070	1641	1757 (99.0)
		Incongruent	2109	1769	1896 (93.8)

plicit Cause (NP1- vs. NP2-biasing verb) × 2 Congruency (congruent vs. incongruent) ANOVAs. Pronoun and Congruency were within-participants and within-items factors; Implicit Cause was within-participants but between-items.

First fragment reading times. Three-way ANOVAs revealed a marginal effect of Pronoun ($F(1,31) = 3.55$, $p < .07$, $MSe = 148{,}324$; $F2(1,46) = 3.01$, $p < .09$, $MSe = 118{,}784$), with fragments containing unambiguous pronouns (2117 ms) being read marginally faster than fragments containing ambiguous pronouns (2207 ms), and a marginal three-way interaction ($F(1,31) = 3.04$, $p < .1$, $MSe = 235{,}826$; $F2(1,46) = 4.72$, $p < .05$, $MSe = 141{,}942$). However, the more important two-way ANOVAs using just the unambiguous level of the Pronoun factor revealed no effects (all Fs < 1). This implies that the marginal three-way interaction is spurious, as it depends upon differences between identical conditions. Thus there is no effect of either first mention or implicit causality on first fragment reading time.

Second fragment reading times. There was a main effect of Congruency ($F1(1,31) = 24.36$, $p < .0001$, $MSe = 66{,}487$; $F2(1,46) = 10.23$, $p < .005$, $MSe = 148{,}046$), with congruent fragments (1810 ms) being read faster than incongruent fragments (1969 ms). The effect of congruency was not influenced by whether the pronoun was ambiguous (both Fs < 1.2). Furthermore, the causality congruency effect was numerically smaller with ambiguous pronouns (113 ms) than unambiguous pronouns (206 ms). Tests of simple effects demonstrated that this effect was reliable for unambiguous pronouns ($F1(1,31) = 11.17$, $p < .005$; $F2(1,46) = 9.72$, $p < .005$) and marginal for ambiguous pronouns ($F1(1,31) = 3.32$, $p < .08$; $F2(1,46) = 2.88$, $p < .1$). These results are not consistent with the Focusing and Mixed accounts, but are consistent with the Integration account.

The analyses also revealed a main effect of Pronoun ($F1(1,31) = 12.50$, $p < .005$, $MSe = 284{,}041$; $F2(1,46) = 19.20$, $p < .0001$, $MSe = 167{,}485$), with fragments following unambiguous pronouns (1772 ms) being read more quickly than fragments following ambiguous pronouns (2007 ms). This is consistent with the idea that a gender cue serves to facilitate reference resolution. There was also an effect of Implicit Cause ($F1(1,31) = 9.53$, $p < .005$, $MSe = 188{,}474$; $F2(1,46) = 6.51$, $p < .05$, $MSe = 212{,}302$), with fragments following NP2-biasing verbs (1806 ms) being read more quickly than fragments following NP1-biasing verbs (1973 ms).

Question response data. The effect of Congruency emerged in the response times and on the participants' analysis of the accuracy data. Type of pronoun did not have any effect (perhaps because pronoun resolution is always necessary to answer the question).

Discussion

The results of this experiment provide probably the strongest support for the Integration model. We found evidence of the congruency

effect in the reading time data for the second fragment, for both the ambiguous and unambiguous cases. Both the Focusing and Mixed accounts predicted that if implicit causality information was used to focus on one character over another, then the congruency effect arising during reading of the second fragment should be reduced when gender information is available. Contrary to this, the congruency effect was nonsignificantly increased in the presence of gender information.

We found no evidence of an effect of congruency in the data for the first fragment. This provides additional evidence against the Focusing and Mixed accounts and in favor of the Integration account. Note that the lack of a first-mention effect suggests that the finding in Experiments 2 and 3 may well have been due to lexical priming. The suggestion that fragments containing ambiguous pronouns were read faster than fragments containing unambiguous pronouns, if real, may have been due to a preference for reading fragments containing two names of the same gender over fragments containing two names of different genders. Overall, it is not safe to conclude that there were any theoretically interesting effects on the first fragment in any of the experiments.

GENERAL DISCUSSION

The results of the experiments reported above support the Integration account. Although we regularly found the causality congruency effect in our reading time data, we never found an interaction between the causality congruency effect and the type of anaphor, and there is no consistent trend toward such an interaction. Such an interaction is predicted by both the Focusing account and the Mixed account.

In Experiments 1–3 we found a causality congruency effect with repeated name anaphors. This is contrary to the predictions of the Focusing model. Experiment 4 found a main effect of congruency that was unaffected by whether the pronoun was ambiguous and no effect of a mismatch between verb bias and gender cue in the first fragment. These results provides further support for the Integration account. Contrary to the findings of Greene and McKoon (1995) and of McDonald and MacWhinney (1995) we found no evidence of an early influence of implicit causality. Experiment 2 demonstrated that the differences could not be due to the presence of extra words in the earlier studies. We found further evidence supporting the Integration account in Experiment 3, where our depth of processing manipulation resulted in a reduction in the magnitude of the congruency effect under shallow-processing conditions. Again, this is contrary to the predictions of the Focusing model.

All of the data reported in this paper are consistent with the account outlined in Garnham et al. (1996). Their position was based on inconclusive data, however. They failed to find any clear difference between antecedent and nonantecedent activation levels using the probe task in the context of implicit causality information (although they did find such a difference when a gender cue was present). Additionally, their experiment adopted the probe task, which may be inappropriate for monitoring language comprehension online. As our findings are based on an alternative methodology and are consistently clear, they strengthen Garnham et al.'s (1996) conclusion that the influence of implicit causality occurs during integration. However, we cannot completely rule out some small influence of implicit causality during focusing.

In conclusion, our results suggest that implicit causality information is employed by the language processor during integration. Implicit causality does not focus the processor on the potential referent consistent with the direction of the implicit causality bias. Rather, it facilitates the process of combining clauses to produce a coherent semantic representation.

APPENDIX A: ITEMS FROM EXPERIMENTS 1–4

Items 1–12 contain NP1-biased verbs. Items 13–24 contain NP2-biased verbs. The second set of 24 items were used for the second presentations of each verb. Thus Items 25–36 contain the same verbs and endings as Items 1–12 but different proper names. Similarly, Items 37–48 contain the same verbs and endings as Items 13–24 but with different proper names. For each item, the subordinate clause within the first set of parentheses is congruent with the verb's bias,

and the subordinate clause within the second set is incongruent. In Experiment 1 the names of the characters in the main clause were of the same gender and occur before the slash. The anaphor in the subordinate clause was either an ambiguous pronoun or a repetition of the name of one of the characters in the main clause. The items used in Experiment 2 were identical to those used in Experiment 1, with the exception of the presence of additional words prior to the connective (indicated in parentheses). The items in Experiment 3 were the same as those in Experiment 1 (with an additional manipulation of Question Type). In Experiment 4 the characters in the main clause were either of the same or a different gender. Thus the first name in NP1 position (*Daniel* in Example 1) was paired with the either the first or second name in NP2 position (*Arnold* or *Joanne* in Example 1). Each item is shown with the versions of a deep-processing question and the versions of a shallow-processing question (in that order). (A shallow-processing question follows each item because, although each participant saw such questions after only one third of the items, different participants saw questions after different thirds.)

1. Daniel/Joanne apologised to Arnold/Joanne (profusely) because (Daniel/he had been behaving selfishly.)/(Arnold/he didn't deserve the criticism.)

Who had been behaving selfishly?/Who didn't deserve the criticism?
Did Daniel/Joanne apologise to Arnold/Joanne?

2. Philip/Tracey confessed to Callum/Tracey (right away) because (Philip/he had stolen the money.)/(Callum/he would not be judgmental.)

Who had stolen the money?/Who would not be judgmental?
Was it a cheque book that had been stolen?

3. Barry/Lydia fascinated Derek/Lydia (lots and lots) because (Barry/he performed magic tricks.)/(Derek/he was easily entertained.)

Who performed magic tricks?/Who was easily entertained?
Did Barry/Lydia fascinate Derek/Lydia?

4. Ann/Ben infuriated Liz/Ben (greatly) because (Ann/she had broken the promise.)/(Liz/she hated being deceived.)
Who had broken the promise?/Who hated being deceived?
Did Liz/Ben infuriate Ann/Ben?

5. Rose/John disappointed Joan/John (deeply) because (Rose/she failed to appear.)/(Joan/she had high standards.)

Who had failed to appear?/Who had high standards?

Did Rose/John disappoint Joan/John?

6. Amy/Tim troubled Sue/Tim (enormously) because (Amy/she was starting to behave rather strangely.)/(Sue/she hated seeing others feeling very sad.)

Who was starting to behave rather strangely?/Who hated seeing others feeling very sad?
Did Sue/Tim trouble Amy/Tim?

7. Henry/Carol inspired Terry/Carol (intensely) because (Henry/he had managed to beat the odds.)/(Terry/he needed someone to look up to.)

Who had managed to beat the odds?/Who needed someone to look up to?
Did Henry/Carol inspire Terry/Carol?

8. Jake/Nancy telephoned Luke/Nancy (straight away) because (Jake/he wanted to ask a favour.)/(Luke/he wouldn't remember to call.)

Who wanted to ask a favour?/Who wouldn't remember to call?
Did Luke/Nancy telephone Jake/Nancy?

9. James/Donna amused Craig/Donna (a lot) because (James/he performed hilarious impressions.)/(Craig/he was very easily entertained.)

Who performed hilarious impressions?/Who was very easily entertained?
Were the impressions hilarious?

10. Susan/Terry concerned Carol/Terry (a great deal) because (Susan/she was starting to behave erratically.)/(Carol/she hated seeing friends in trouble.)

Who was starting to behave erratically?/Who hated seeing friends in trouble?
Was the behaviour predictable?

11. Caroline/Jonathon amazed Florence/Jonathon (completely) because (Caroline/she passed the exam.)/(Florence/she was easily impressed.)

Who passed the exam?/Who was easily impressed?
Did Caroline/Jonathon amaze Florence/Jonathon?

12. Diana/Craig called Nancy/Craig (quickly) because (Diana/she had found the telephone number.)/(Nancy/she couldn't make outgoing calls.)

Who had found the telephone number?/Who couldn't make outgoing calls?
Did Nancy/Craig call Diana/Craig?

13. Jean/John congratulated Rita/John (vigorously) because (Rita/she had won the championship.)/(Jean/she was very impressed.)

Was was very impressed?/Who had won the championship?
Did Rita/John congratulate Jean/John?

14. Michael/Kathryn appreciated Richard/Kathryn (very much) because (Richard/he had offered to help.)/(Michael/he needed the extra help.)

Who needed the extra help?/Who had offered to help?
Did Richard/Kathryn appreciate Michael/Kathryn?

15. Trevor/Phoebe detested Gordon/Phoebe (utterly) because (Gordon/he was completely unreliable.)/(Trevor/he hated being taken advantage of.)

Who hated being taken advantage of?/Who was completely unreliable?
Did Trevor/Phoebe detest Gordon/Phoebe?

16. Jack/Mary liked Tony/Mary (considerably) because (Tony/he was full of incredibly helpful advice.)/(Jack/he was made to feel quite at home.)

Who was made to feel quite at home?/Who was full of incredibly helpful advice?
Was the advice incredibly helpful?

17. Catherine/Jonathon despised Elizabeth/Jonathon (passionately) because (Elizabeth/she seemed to lie constantly.)/(Catherine/she had felt very let down.)

Who had felt very let down?/Who seemed to lie constantly?
Did Catherine/Jonathon despise Elizabeth/Jonathon?

18. Cathy/Harry thanked Sally/Harry (wholeheartedly) because (Sally/she had brought the present.)/(Cathy/she had appreciated the present.)

Who had appreciated the present?/Who had brought the present?
Did Sally/Harry thank Cathy/Harry?

19. Mick/Lisa loathed Paul/Lisa (thoroughly) because (Paul/he had very little integrity.)/(Mick/he was starting to feel upstaged.)

Who was starting to feel upstaged?/Who had very little integrity?
Did Mick/Lisa loathe Paul/Lisa?

20. Ted/Sue praised Bob/Sue (enthusiastically) because (Bob/he behaved very courageously.)/(Ted/he was impressed by the project.)

Who was impressed by the project?/Who behaved very courageously?
Was the project unimpressive?

21. Ray/Liz scolded Rob/Liz (severely) because (Rob/he had damaged the mahogany table.)/(Ray/he was aware of the potential danger.)

Who was aware of the potential danger?/Who had damaged the mahogany table?
Did Ray/Liz scold Rob/Liz?

22. Anna/Bill noticed Emma/Bill (at once) because (Emma/she wore a remarkably colourful dress.)/(Anna/she was always exceedingly observant.)

Who was always exceedingly observant?/Who wore a remarkably colourful dress?
Did Emma/Bill notice Anna/Bill?

23. Gemma/Paul punished Ellen/Paul (harshly) because (Ellen/she had been very trying.)/(Gemma/she had had enough.)

Who had had enough?/Who had been very trying?
Did Gemma/Paul punish Ellen/Paul?

24. Emily/Grant admired Tracy/Grant (unreservedly) because (Tracy/she was very motivated.)/(Emily/she needed a role model.)

Who needed a role model?/Who was very motivated?
Did Tracy/Grant admire Emily/Grant?

25. Edward/Kirsty apologised to Justin/Kirsty (profusely) because (Edward/he had been behaving selfishly.)/(Justin/he didn't deserve the criticism.)

Who had been behaving selfishly?/Who didn't deserve the criticism?
Did Edward/Kirsty apologise to Justin/Kirsty?

26. Thomas/Daphne confessed to Johnny/Daphne (right away) because (Thomas/he had stolen the money.)/(Johnny/he would not be judgmental.)

Who had stolen the money?/Who would not be judgmental?
Was it a cheque book that had been stolen?

27. KevinPaula fascinated Peter/Paula (lots and lots) because (Kevin/he performed magic tricks.)/(Peter/he was easily entertained.)

Who performed magic tricks?/Who was easily entertained?
Did Kevin/Paula fascinate Peter/Paula?

28. Jan/Tom infuriated Meg/Tom (greatly) because (Jan/she had broken the promise.)/(Meg/she hated being deceived.)

Who had broken the promise?/Who hated being deceived?
Did Meg/Tom infuriate Jan/Tom?

29. Beth/Bill disappointed Ruth/Bill (deeply) because (Beth/she failed to appear.)/(Ruth/she had high standards.)

Who had failed to appear?/Who had high standards?
Did Beth/Bill disappoint Ruth/Bill?

30. Kay/Roy troubled Eve/Roy (enormously) because (Kay/she was starting to behave rather strangely.)/(Eve/she hated seeing others feeling very sad.)

Who was starting to behave rather strangely?/Who hated seeing others feeling very sad?
Did Eve/Roy trouble Kay/Roy?

31. David/Sarah inspired Simon/Sarah (intensely) because (David/he had managed to beat the odds.)/(Simon/he needed someone to look up to.)

Who had managed to beat the odds?/Who needed someone to look up to?
Did David/Sarah inspire Simon/Sarah?

32. John/Nora telephoned Noel/Nora (straight away) because (John/he wanted to ask a favour.)/(Noel/he wouldn't remember to call.)

Who wanted to ask a favour?/Who wouldn't remember to call?
Did Noel/Nora telephone John/Nora?

33. Grant/Kathy amused Keith/Kathy (a lot) because (Grant/he performed hilarious impressions.)/(Keith/he was very easily entertained.)

Who performed hilarious impressions?/Who was very easily entertained?
Were the impressions hilarious?

34. Trudy/John concerned Linda/John (a great deal) because (Trudy/she was starting to behave erratically.)/(Linda/she hated seeing friends in trouble.)

Who was starting to behave erratically?/Who hated seeing friends in trouble?
Was the behaviour predictable?

35. Kathleen/Joseph amazed Jennifer/Joseph (completely) because (Kathleen/she passed the exam.)/(Jennifer/she was easily impressed.)

Who passed the exam?/Who was easily impressed?
Did Kathleen/Joseph amaze Jennifer/Joseph?

36. Sarah/Robert called Donna/Robert (quickly) because (Sarah/she had found the telephone number.)/(Donna/she couldn't make outgoing calls.)

Who had found the telephone number?/Who couldn't make outgoing calls?
Did Donna/Robert call Sarah/Robert?

37. Gail/Karl congratulated Cath/Karl (vigorously) because (Cath/she had won the championship.)/(Gail/she was very impressed.)

Was was very impressed?/Who had won the championship?
Did Cath/Karl congratulate Gail/Karl?

38. Douglas/Gillian appreciated Stephen/Gillian (very much) because (Stephen/he had offered to help.)/(Douglas/he needed the extra help.)

Who needed the extra help?/Who had offered to help?
Did Stephen/Gillian appreciate Douglas/Gillian?

39. Norman/Hilary detested George/Hilary (utterly) because (George/he was completely unreliable.)/(Norman/he hated being taken advantage of.)

Who hated being taken advantage of?/Who was completely unreliable?
Did Norman/Hilary detest George/Hilary?

40. Alan/Mona liked Jeff/Mona (considerably) because (Jeff/he was full of incredibly helpful advice.)/(Alan/he was made to feel quite at home.)

Who was made to feel quite at home?/Who was full of incredibly helpful advice?
Was the advice incredibly helpful?

41. Kimberley/Sebastian despised Josephine/Sebastian (passionately) because (Josephine/she seemed to lie constantly.)/(Kimberley/she had felt very let down.)

Who had felt very let down?/Who seemed to lie constantly?
Did Kimberley/Sebastian despise Josephine/Sebastian?

42. Eliza/Derek thanked Doris/Derek (wholeheartedly) because (Doris/she had brought the present.)/(Eliza/she had appreciated the present.)

Who had appreciated the present?/Who had brought the present?
Did Doris/Derek thank Eliza/Derek?

43. Bill/Jill loathed Neil/Jill (thoroughly) because (Neil/he had very little integrity.)/(Bill/he was starting to feel upstaged.)

Who was starting to feel upstaged?/Who had very little integrity?
Did Bill/Jill loathe Neil/Jill?

44. Roy/Kay praised Ian/Kay (enthusiastically) because (Ian/he behaved very courageously.)/(Roy/he was impressed by the project.)

Who was impressed by the project?/Who behaved very courageously?
Was the project unimpressive?

45. Joe/Joy scolded Guy/Joy (severely) because (Guy/he had damaged the mahogany table.)/(Joe/he was aware of the potential danger.)

Who was aware of the potential danger?/Who had damaged the mahogany table?
Did Joe/Joy scold Guy/Joy?

46. Mary/Brian noticed Lisa/Brian (at once) because (Lisa/she wore a remarkably colourful dress.)/(Mary/she was always exceedingly observant.)

Who was always exceedingly observant?/Who wore a remarkably colourful dress?
Did Lisa/Brian notice Mary/Brian?

47. Chloe/Simon punished Norma/Simon (harshly) because (Norma/she had been very trying.)/(Chloe/she had had enough.)

Who had had enough?/Who had been very trying?
Did Norma/Simon punish Chloe/Simon?

48. Irene/Tim admired Rosie/Tim (unreservedly) because (Rosie/she was very motivated.)/(Irene/she needed a role model.)

Who needed a role model?/Who was very motivated?
Did Irene/Tim admire Rosie/Tim?

APPENDIX B: CONTINUATION AND PLAUSIBILITY PRETEST RESULTS

NP-1-Biasing Verbs

	NP1 continuations (of 24)	NP 2 continuations (of 24)	Plausibility of NP1 sentence (congruent)	Plausibility of NP2 sentence (incongruent)	Plausibility of "incorrect" version of NP1 sentence (congruent)	Plausibility of "incorrect version of NP2 sentence (incongruent)
Fascinated	21	0	6.417	5.667	3.000	1.292
Infuriated	22	0	6.583	5.375	2.625	1.625
Disappointed	21	0	6.458	6.292	3.083	1.208
Confessed to	22	0	6.542	6.304	1.042	1.167
Apologised to	21	1	6.565	6.500	2.042	0.667
Inspired	16	0	6.042	5.333	1.750	2.333
Troubled	19	1	6.500	5.875	2.792	1.708
Telephoned	20	1	6.542	6.292	0.500	2.522
Amused	19	1	6.250	5.833	2.583	1.083
Concerned	19	0	6.125	5.292	2.125	1.391
Amazed	18	1	6.292	6.125	2.458	1.000
Called	16	0	8.000	6.792	0.957	2.542
Mean	19.5	0.4	6.526	5.973	2.080	1.545

NP2-Biasing Verbs

	NP1 continuations (of 24)	NP2 continuations (of 24)	Plausibility of NP1 sentence (incongruent)	Plausibility of NP2 sentence (congruent)	Plausibility of "incorrect" version of NP1 sentence (incongruent)	Plausibility of "incorrect" version of NP2 sentence (congruent)
Admired	0	18	6.125	6.333	1.913	1.583
Appreciated	1	16	6.125	6.583	2.708	1.792
Praised	1	17	6.000	6.750	2.261	1.875
Despised	1	16	6.250	6.583	1.250	1.917
Liked	1	18	6.000	6.417	1.208	1.958
Noticed	0	17	6.042	6.625	1.375	2.000
Congratulated	1	21	5.875	6.833	1.083	2.000
Loathed	2	18	5.708	6.125	2.958	2.375
Punished	1	14	5.583	5.958	1.583	2.458
Scolded	1	17	5.958	6.500	1.250	2.625
Detested	1	19	6.042	6.375	2.292	2.958
Thanked	2	17	6.583	6.583	1.318	3.417
Mean	1.0	17.3	6.024	6.472	1.767	2.247

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