A study investigated whether readers infer automatically highly likely consequences of a state modification, intentional (action) or non intentional (event), described in short texts. Subjects, 48 psychology undergraduates at Paris VIII University (France), read explicit, predictable, or control forms of short passages using a Rapid Serial Visual Presentation procedure, after which they answered a question about the sentence and made a lexical decision. The lexical decision task used two SOAs (Stimulus Onset Asynchrony): 400 ms and 800 ms. Results indicated that: (1) accuracy on the comprehension questions was 95% overall and did not vary as a function of condition; (2) the explicit condition produced a faster response than the predictive condition that, in turn, produced faster responses than the control condition; (3) the long SOA produced faster responses than the short SOA; (4) causal inference began to decline with a SOA equal to 800 ms; and (5) the decision latencies of inferences expressed by an action were significantly faster than the decision latencies of inferences expressed by an event. Findings suggest that inference about the likely consequences of events and actions are drawn while reading. (Contains 13 references. Appendixes present examples of sentences and final activation values of the propositions of the text base of the three forms of one of the passages.)

AUTOMATIC AND STRATEGIC ASPECTS OF INFERENCE PROCESSING DURING COMPREHENSION: THE CASE OF PREDICTABLE CONSEQUENCES OF EVENTS AND ACTIONS

by

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Automatic and strategic aspects of inference processing during comprehesion:
The case of predictable consequences of events and actions.

Objectives
This research asked whether readers infer automatically highly likely consequences of a state modification, intentional (action) or non intentional (event), described in short texts. If recent studies showed that people draw bridging inferences necessary to establish causal coherence (Keenan, Baillet, & Brown, 1984; Singer, Halldorson, Lear & Andrusiak, 1992); inferences about superordinate goals of a story character (Long, Golding, & Graesser, 1992; Long & Golding, 1993; Suh & Trabasso, 1993); the status of elaborative inferences on highly likely consequences of events is controversial: some authors concluded that they are not encoded (Potts, Keenan & Golding, 1988; Magliano, Baggett, Johnson, & Graesser, 1993) whereas some others claimed that they are minimally encoded (McKoon & Ratcliff, 1986) or temporally drawn and subsequently deactivated (Keefe & McDaniel, 1993). As Graesser & Kreuz (1993) pointed out, an adequate theory of inference generation should accurately predict whether particular classes of knowledge-based inferences are generated "on-line" during text comprehension" (p. 145). So, we addressed the following questions: are the inferences about likely consequences of events and actions automatically drawn while reading? How long they are activated? Did intentional and non intentional modifications of a state calls for same processes?

According to these objectives, we conducted an experiment with the main following characteristics. First, the Rapid Serial Visual Presentation procedure was used (with a 350 ms duration per word and a negligible interword delay, see Till, Mross & Kintsch, 1988) to prevent non controlled multiple readings of parts of the sentence that was displayed (see Magliano, Baggett, Johnson, & Graesser, 1993). Secondly, a lexical decision task was used with two SOAs: 400 ms (ISI= 50 ms) and 800 ms (ISI= 450 ms) to permit the study of automatic and deliberate generation of inference. Thirdly, a question that belonged to one of the 8 following types: Who? What Object? What Property? What event/action? Where? When? How? Why?, was immediately asked after each lexical decision. Fourthly, in addition to the predictive sentence condition, a control and an explicit sentence condition were included (see appendix 1). Control sentences included the maximum of words from the predictive condition thought to be related to the inference word but did not induce the inference. Explicit sentences were identical to the predictive sentences except that the explicit sentences specified the target event/action. Finally, the Construction-Integration model proposed by Kintsch (1988) was used to simulate the activation values of the propositions that composed the three forms of each sentence. By this way, the activation value of the inference proposition obtained in the Explicit, Predictive and Control conditions can be computed and compared to the experimental data (see Appendix 2).

1 We are grateful to Walter Kintsch for authorising us to use the Macintosh version of his Construction-Integration model of discourse comprehension written by E.F. Mross & J. O. Roberts (1991).
Hypothesis

H1a. If the inference about highly likely consequence of events and actions is automatically drawn while reading, then the decision latencies for the Explicit and the Predictable conditions would not differ and would be shorter than the decision latencies for the Control condition.

Explicit # Predictable > Control

H1b. If the inference is less activated in the Predictable condition than in the Explicit condition, then the reaction time would be longer in the Predictable condition than in the Explicit condition, while remaining shorter than in the Control condition.

Explicit > Predictable > Control

H1. If the inference is not automatically drawn while reading, the reaction times in the Predictable and the Control condition would be similar and both longer than in the Explicit condition.

H2. If the mental representation of an intentional modification of the normal course of events involve causal ground representation and the goal of the main character, then an inference about an intentional modification of this state of affairs expressed by an action would be more likely than an inference expressed by an event and describing a non intentional modification. Consequently, the reaction time after a verb of action would be shorter than after a verb of event.

H3. If inference is automatically drawn while reading and further deactivated, we would observe an interaction between SOA and Experimental condition (Explicit, Predictive and Control). The difference between the Explicit and Predictive conditions would be longer for the long SOA (800 ms) than for the short SOA (400 ms) and the difference between the Predictive and the Control conditions would be shorter with the long SOA (800 ms) than for the short SOA (400 ms).

Method
Subjects and Design
The subjects were forty-eight psychology undergraduates at Paris VIII University who were divided in two groups. SOA was a between-subjects variable (400 vs. 800 ms) and sentence form a within-subjects variable (Explicit, Predictable and Control forms). The dependent variable were the decision latency and the rate of correct response.

Material
A set of sixty sentences were used (many of which have been adapted from Potts2, Keenan, & Goding (1988) and McKoon and Ratcliff (1986)). Examples of the sentences are shown in Appendix 1. 12 sentences were used for practice, 24 sentences were used as fillers and 24 as experimental in the experiment proper, 12 actions and 12 events.

Scaling the "compellingness" of the inferences
To measure how compellingness each inference was, an independent group of 50 subjects read the predicted condition paragraph and were asked to produce a verb that expresses the most likely consequence. The mean percentage of production of the most frequent verb was equal to 78 and 76 % for actions and events and the standard deviation was 18. In a second preliminary task, another independent group of 50 subjects read the same sentences and chose the most highly likely consequence among the two verbs that were the most frequently chosen in the first experiment.

2 We are grateful to George Potts for sharing his stimulus material.
Lexical decision targets
All the inference words are verbs that were presented in the infinitive. The nonword target items were created by changing a vowel or consonant in an existing verb in order to make it a pronounceable pseudo-word and by conforming to the frequency of ending of verbs in French ("er", "ir", "oir", "re").

True-False test items
A false answer to each of the eight questions per sentence was constructed by replacing the correct word or phrase by a plausible one belonging to the same semantic field (i.e., chalet vs. bungalow, wall vs. ceiling, nail vs hook, etc.).

Procedure
Upon arrival, subjects were randomly assigned to one of the two SOA conditions. Subjects worked individually on personal computers. They were instructed that they would read a series of short passages presented to them via the RSVP procedure and that they would be asked to answer a question after they read each passage. They were also instructed that they were to make a lexical decision after each sentence. They were to press a computer key marked yes if the lexical target was a word and a computer key marked no if the lexical target was not a word. They were instructed to respond quickly and accurately. The words of a sentence appeared on a screen's computer for 350 ms, with a negligible delay between each, the final word in a sentence was always presented for 350 ms. After each sentence, there was a mask of either 50 or 450 ms, followed by a target item. To encourage subjects to read for understanding, the target word was followed by a question about the explicit content of the sentence they had just read. The subjects chose one of the two answers that were presented by pressing the same computer keys used in the lexical decision. Subjects received 12 practice trials, followed by two blocks of 48 test trials.

Results
Accuracy on the comprehension questions was 95% overall and also did not vary significantly as a function of condition (all F < 1).

Table 1 presents the mean reaction times on correct responses for the inference words as a function of SOA and inference condition. The error rate for lexical decisions was approximately 3%. Reaction times that were more than two standard deviations from the mean of a subject's data were replaced by the value of two standard deviations above the mean.

<table>
<thead>
<tr>
<th>SOA</th>
<th>Explicit</th>
<th>Predictive</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 ms (ISI=50 ms)</td>
<td>759 (91)</td>
<td>818 (106)</td>
<td>875 (109)</td>
</tr>
<tr>
<td>800 ms (ISI=450 ms)</td>
<td>676 (64)</td>
<td>718 (63)</td>
<td>751 (85)</td>
</tr>
</tbody>
</table>

The mean latencies were analyzed in ANOVA with inference condition (Explicit, Predictive, or Control) and nature of the modification (action vs event) as within-subject factors and SOA (400 vs. 800 ms) as a between-subjects factor. The two analyses that were performed, one using subjects as the random variable and one using stimulus items as the random variable, gave similar results.

The main effect of Inference condition was significant [F(2, 116) = 87,592, p < .01], with the Explicit producing faster responding than the Predictive [F(1, 116) = 49,074, p < .01] that, in turn, produced faster responding than the Control [F(1, 116) = 38,722, p < .01]. It would appear, therefore, that the causal consequences were generated on-line. The main effect of SOA was also significant [F(1, 58) = 27,903, p < .01], with the long SOA producing faster responses than the short
SOA: 818 vs 715 ms. A significant interaction Inference Condition * SOA was obtained \([F(2, 116) = 4.061, p < .05]\). The two degrees of freedom were decomposed by comparing Explicit vs. Predictive conditions and Predictive vs. Control conditions. The difference between the Explicit and Predictive conditions was greater for the short SOA: 59 vs 42 ms, respectively; and the difference between the Predictive and Control conditions was greater for the short SOA than for the long SOA: 57 vs 33 ms, respectively. It is possible to infer from this result that the causal inference began to decline with a SOA equal to 800 ms. Finally, the decision latencies of inferences expressed by an action were significantly faster than the decision latencies of inferences expressed by an event: 757 vs 776 ms, \([F(1, 58) = 15.544, p < .01]\).

**Discussion**

If lexical decision provides an appropriate test of on-line inferencing, then the present results would suggest that inferences about the likely consequences of events and actions are drawn while reading. The hypothesis proposed by Potts & al. (1988) by which "lexical decision may also involve backward context-checking at the time of test" (p. 414) is inconsistent with the results obtained by Keefe & al. (1993) who find evidence for forward inferencing (experiments 2 & 3) by using a naming task. How can we explain theses discrepancies? We can assume that causal consequences are generated on-line when the context is highly constrained by the passage content and word knowledge (i.e., only one or two outcomes are possible) or by the depth of processing asked to the reader.

Another problem lies in the time course of activation of causal inferences. Our results are not conclusive from this point of view and longer SOAs had to be used in the future (see Till & al., 1988) and related to precise analysis of text comprehension (Kintsch, 1988; Magliano & al., 1993).

**REFERENCES**


MAGLIANO, J. P., BAGGETT, W. B., JOHNSON, B. K., & GRAESSER, A. C. (1993). The time course of generating causal antecedent and causal


Appendix 1

Example of action (adapted from Potts, Keenan & Golding, 1988, paragraph 23)

Explicit:

**French**: Les contractions se faisant de plus en plus fréquentes, la femme qui venait de terminer un travail pénible, se rendit à la maternité et **accoucha**.

**English**: The contractions becoming more and more frequent, the woman who just finished a hard labor, went to the maternity hospital and **delivered**.

Predictive:

**French**: Les contractions se faisant de plus en plus fréquentes, la femme qui venait de terminer un travail pénible, se rendit à la maternité.

**English**: The contractions becoming more and more frequent, the woman who just finished a hard labor, went to the maternity hospital.

Control:

**French**: Lorsqu’elles arrivent à la soixantaine, **les femmes** qui ont eu de nombreuses maternités et qui ont exerçé des travaux pénibles, souffrent de plus en plus fréquemment de contractions musculaires.

**English**: When they are in their sixties, the women who had numerous pregnancies and had hard labor, suffered more and more frequently from muscular contractions.

**Inference test word**: French: accoucher, English: to deliver

Example of event

Explicit:

**French**: Le commandant de bord allait demander aux hôtesses d’annoncer aux passagers la traversée d’une zone de forte turbulence quand l’avion piqua brusquement vers le sol et **s’écraça**.

**English**: The captain was about to ask to the hostesses to announce to the passengers that they will pass trough a zone of strong turbulence when the plane suddenly go down to the ground and **crashed**.

Prédictive:

**French**: Le commandant de bord allait demander aux hôtesses d’annoncer aux passagers la traversée d’une zone de forte turbulence quand l’avion piqua brusquement vers le sol.

**English**: The captain was about to ask to the hostesses to announce to the passengers that they will pass trough a zone of strong turbulence when the plane suddenly go down to the ground and **crashed**.

Control:

**French**: Les hôtesses, excédées par la turbulence des passagers de l’avion, informant le **commandant de bord** qui piqua une colère et fit brusquement une annonce.

**English**: The air hostesses, who were exasperated by the turbulence of the passengers', informed the captain who threw a fit and suddenly advertise the passengers.

**Inference test word**: French: s’écraiser, English: to crash.
Final activation values of the propositions of the text base of the 3 forms of the "Captain" passage.

P1 cl 0.2040 Captain
P2 cl 0.2989 Hostesses
P3 cl 0.2184 Passengers
P4 cl 0.1630 Zone
P5 cl 0.0297 Turbulence
P6 cl 0.8283 Plane
P7 cl 0.4800 TOASK(Px1,Px2,P2)
P2 cl 0.5652 TOANNOUNCE(Topx2,Px3,P3)
P3 cl 0.9433 TOPASSTHROUGH(Px4,Px6)
P4 cl 0.1708 OF(Px4,Px5)
P5 cl 0.0297 STRONG(Px5)
P6 cl 0.2909 WHEN(Px1,P2)
P7 cl 0.9778 TOGODOWN(Px6,Px7)
P8 cl 0.2389 SUDENLY(Px7)
P9 cl 0.9158 INF-CAUSE(Px2,Px6)
P10 cl 1.0000 INF-CAPABLE(Px2,Px6)
P11 cl 0.9293 INF-PARTOF(Px3,Px6)
P12 cl 0.3547 CONSEQ(Px7,Px13)
P13 cl 0.9083 TOCRASH(Px6,Px7)

Criterion: 0.0010
Delta: 0.0007
Iterations: 7

"Captain". Explicit Form.
Argument Overlapping.
Starting activation value = 1

"Captain". Predictive Form.
Argument Overlapping.
P12 & P13: Starting activation value = 0

"Captain". Control Form.
Argument Overlapping.
P12 & P13: Starting activation value = 0

Note: Inference proposition is underlined.
Appendix 2b

Final activation values of the propositions of the text base of the 3 forms of the "Captain" passage.

**"Captain". Explicit Form.**
Minimal Predication.

Starting activation value = 1

**"Captain". Predictive Form.**
Minimal Predication.

P12 & P13: Starting activation value = 0

**"Captain". Control Form.**
Minimal Predication.

P12 & P13: Starting activation value = 0

Note: Inference proposition is underlined.