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DYNAMIC COMBINATION OF CONCEPTS DURING ON-LINE LANGUAGE COMPREHENSION

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DYNAMIC COMBINATION OF CONCEPTS DURING ON-LINE LANGUAGE
COMPREHENSION

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by

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Abstract

Knowledge of real-world events influences how people understand language. The present study examined whether conceptually-based expectations are generated rapidly from event knowledge. Specifically, instruments combined with specific actions to influence expectancies for ensuing patients, in contrast to Rayner, Warren, Juhasz, and Liversedge (2004). Instrument-verb-patient triplets were created from norms designed to directly tap event knowledge (Experiment 1). In self-paced reading (Experiment 2), participants read patient nouns such as *paper* faster when they were typical of the instrument-action pair (*Susan used the scissors* vs. *the saw to cut*). Experiment 3 showed that these results are not due to direct relations between instruments and patients. This research demonstrates that conceptual event-based expectations are computed rapidly and dynamically during on-line language comprehension. The results are discussed in terms of event spaces and verb sense, suggesting that instruments can alter the sense of a verb and thus expectations for ensuing patients.

Keywords: Event knowledge; Expectancy generation; Verb sense; Thematic roles

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Dynamic Combination of Concepts during On-line Language Comprehension

A common view within the sentence processing literature is that context exerts rapid influences on both semantic and syntactic processing during sentence comprehension. In terms of semantic information, a number of studies have demonstrated that words tend to be fixated for a shorter duration and skipped more frequently when they are congruent with and highly predictable from the preceding context, as in *stamp* following *He mailed the letter without a* (Rayner & Well, 1996; Frisson, Rayner, & Pickering, 2005). It has also been shown that readers rapidly interpret the context-appropriate sense of ambiguous words (*star* as a celestial body vs. a celebrity) when reading sentences that contain a biasing context (*The director knew the name of the star* vs. *The astronomer knew the name of the star;* Vu, Kellas, Petersen, & Metcalf, 2003). In terms of syntax, a large body of evidence suggests that comprehenders rapidly resolve temporary syntactic ambiguities associated with verbs when the preceding context supports a particular interpretation. For example, context can bias the interpretation of a verb toward its past tense usage, as in a main clause such as *The cop arrested the slimy politician*, or toward a passive participle usage, as in a reduced relative clause such as *The criminal arrested by the detective was guilty of taking bribes* (MacDonald, Pearlmutter, & Seidenberg, 1994; McRae, Spivey-Knowlton, & Tanenhaus, 1998; Trueswell, Tanenhaus, & Garnsey, 1994).

The goal of the present study was to investigate whether a specific type of contextual manipulation can drive expectations for upcoming concepts in a linguistic stream. Specifically, the present study examined whether an instrument that occurs early in a sentence can bias the class of events being referred to by an instrument-verb

combination, and thus bias semantic event-based expectations for specific patients. For example, I compared *Susan used the saw to cut* with *Susan used the scissors to cut* and tested whether readers preferred patients such as *the wood* versus *the paper* to follow the instrument-verb combinations. This is an interesting test of the use of context for a number of reasons. First, only two previous studies have tested whether instrument-verb combinations can produce such biases (Rayner, Warren, Juhasz, & Liversedge, 2004; Warren & McConnell, 2007). Second, and critically, in direct contradiction to research that has shown effects of various types of context, neither of these studies found rapid use of this type of event knowledge in language comprehension. Given the central role that knowledge of real world events plays in a number of theories of language comprehension, this is a surprising result that suggests a need for further investigation.

<div align="center">Event Knowledge, Verbs, and Thematic Roles</div>

Given that context can constrain sentence comprehension semantically and syntactically, a central issue concerns the aspects or types of context that can modulate expectations for semantic information or syntactic structure. That is, what types of knowledge underlie context effects? One candidate that has been studied in a number of experiments is people's knowledge of (common) events and situations. Much of language describes everyday events, and there exist various linguistic cues to event knowledge. For example, events are typically denoted by verbs, although nouns can also denote events (event nouns or *relational schema nouns*; Gentner & Kurtz, 2005, such as *accident*). Verbs play an influential role in imposing both semantic and syntactic constraints during on-line sentence comprehension (Boland, Tanenhaus, Carlson, & Garnsey, 1989; Carlson & Tanenhaus, 1988; Ferreira & Clifton, 1986; Ferretti, McRae, & Hatherell, 2001;

Frazier, 1987; Frazier, Clifton, & Randall, 1983; Rayner, Carlson, & Frazier, 1983). One

important role that verbs play is in terms of thematic role assignment (Altmann &

Kamide, 1999; Boland, Tanenhaus, Garnsey, & Carlson, 1995). Thematic role processing

involves assigning the nouns in a sentence to the parts that they play in the event or

situation being described. For example, in *Nancy ate the soup with a large spoon*, *Nancy*

is the agent of the eating event (she is doing the eating), the *soup* is the patient (it is being

eaten) and the *large spoon* is the instrument (it is being used to accomplish the eating).

According to McRae and colleagues (Ferretti et al., 2001; McRae, Ferretti, &

Amyote, 1997), thematic role assignment involves detailed experiential event knowledge

that can be activated by individual verbs (see also Kamide, Altmann, & Haywood, 2003;

Knoeferle, Crocker, Scheepers, & Pickering, 2005). Furthermore, these studies suggest

that relevant event-based knowledge is readily available and used rapidly during sentence

comprehension. In a series of short stimulus onset asynchrony (SOA: the time between

the onsets of a prime and target) priming studies, Ferretti et al. (2001) showed that verbs

in isolation can elicit rapid computation of situation-specific knowledge regarding the

typical agents (*arresting-cop*), patients (*serving-customer*), and instruments (*stirred-

spoon*) that are related to the specific activity. These results suggest that representations

activated from a verb include knowledge of the event that the verb denotes, and this event

knowledge then drives the priming of the nouns that express salient elements of the

denoted class of events.

Verbs, however, are not the only source of constraint. Verbs generally denote

actions or activities, and people organize their event memories in terms of these

components. However, other elements such as participants, objects, time, and location are

also important constituents of event memory (Lancaster & Barsalou, 1997). Recent research suggests that the typical components of an event can rapidly activate well-learned experiential event representations and this, in turn, can influence on-line processing of words and sentences. This has been shown by a series of short SOA priming studies in which typical thematic role fillers of an event were used to prime verbs that denote an activity (McRae, Hare, Elman, & Ferretti, 2005). That is, priming was obtained from typical agents (*waiter-serving*), patients (*guitar-strummed*), instruments (*chainsaw-cutting*), and locations (*cafeteria-eating*). Similarly, Hare, Thomson, Kelly, and McRae (2008) showed that event nouns and nouns that denote a common event location primed people (*sale–shopper* and *hospital–doctor*), and objects (*trip–luggage* and *barn–hay*) that commonly are part of those events or are found at those locations.

Evidence from sentence comprehension studies also demonstrates the importance of non-verb elements in the computation and use of event knowledge. Morris (1994), for example, found that the processing of patient nouns such as *mustache* is facilitated by an event-cuing agent, as in sentence fragments such as *The barber trimmed the* compared to *The person trimmed the*. Moreover, several studies that have used the visual world paradigm suggest a role for non-verb elements in generating expectancies. The visual world paradigm features the use of concurrent visual scenes depicting the objects and/or events denoted in a sentence to investigate how visual attention (measured via eye-movements) is shifted as participants hear sentences. For example, Kamide, Altmann, and Haywood (2003) presented participants with a picture that contained a girl, a man wearing a helmet, a carousel, and a motorcycle. It was found that the preferred patient for the verb *ride* depended on the agent noun phrase. Participants tended to look more at a

picture of a carousel upon hearing the verb in *The girl will ride...* but more at a picture of a motorcycle at the same position in *The man will ride...* In summary, these results suggest that thematic role knowledge plays an important role in generating expectancies about the associated event (e.g., expectancies for other thematic role fillers that are associated with the event).

Other sentential elements, such as grammatical aspect, also play a key role in computation of event knowledge and generating expectancies. In a follow-up study to Ferretti et al. (2001), in which they did not find verb-to-location priming (i.e., *skated* did not prime *arena*), Ferretti, Kutas, and McRae (2007) showed that verbs prime common locations (*arena*) when the verb is marked with imperfective (*was skating*) but not with past perfect aspect (*had skated*). They also used sentences that included verbs with these grammatical aspect markings followed by locative prepositional phrases (typical or atypical locations for the actions denoted by the verb) in an ERP study. Corresponding effects were found in the amplitude of the N400 (an index of semantic expectation violation or integration cost) at the sentence–final location nouns. Such patterns of results suggest that salience of location information differs as a function of an event's temporal properties (ongoing vs. completed) when they are cued by grammatical aspect. Furthermore, Altmann and Kamide (2007) highlighted similar points by showing that participants looked more to an empty wine glass upon hearing *The man has drunk all of,* and more to a full glass of beer upon hearing *The man will drink all of* in a visual world task. These results demonstrate that detailed and subtle knowledge of events and how they unfold over time can be quickly used when people comprehend language. In summary, the findings reviewed in this section combine to indicate that event knowledge

is quickly and dynamically computed upon encountering linguistic input that is not restricted to verbs, and that computation of event knowledge appears to facilitate the generation of expectancies for upcoming semantic information.

Verb Sense, Structure, and Event Knowledge

One important role of non-verb elements is in determining verb senses. Many verbs can be used to exhibit several different but related interpretations, or senses. Senses of verbs are highly context-dependent. A verb like *grasp*, for example, can imply a physical sense (*grasp a coffee cup*) or a mental event sense (*grasp a concept*) depending on the context (in this case the patient). Note that the two actions are similar because they both imply the act of taking hold of something. This suggests that differences in verb sense can be viewed as differences in the event or class of events described by the verb.

Studies have shown that verb senses can be closely tied with structural biases (Roland & Jurafsky, 2002). For example, Hare, McRae, and Elman (2003) found that verb sense plays a role in the resolution of the direct object versus sentential complement ambiguity in which the post-verbal noun phrase can either be a direct object of the verb (*They admitted a large number of freshmen*) or the subject of sentential complement (*They admitted a large number of freshmen had cheated on the entrance exams*). In analyses of large corpora, Hare, McRae, and Elman (2004) found that specific senses of a verb were correlated with structural biases. For example, when *admit* is used in its "let in" sense, it strongly tends to be used with a post-verbal direct object noun phrase. In contrast, when it is used in its "acknowledge" sense, a post-verbal noun phrase is usually the subject of an ensuing sentential complement. In a self-paced reading study, Hare et al. (2003) used full sentence contexts to bias the sense of the verb. For example, the

"acknowledge" sense of *admit* was cued by, *For over a week now, the trail guide had been denying any problems with the two high school students walking the entire Appalachian trail.* In contrast, the "let in" sense context was, *The two freshman on the waiting list refused to leave the professor's office until he let them into his class.* Both contexts were followed by a sentence containing a sentential complement, as in, *Finally, he admitted (that) the students had little chance of getting into his class* (or ... *little chance of succeeding*). Participants had more difficulty with the sentential complement when the direct object biased "let in" sense was cued by the context.

This cuing of verb sense can also be accomplished using intra-sentential thematic role based information. For example, Hare, Elman, Tabaczynski, and McRae (in press) made use of the fact that some verbs such as *collect* can be expressed in either transitive (*The children collected dead leaves*) or intransitive structures (*The rainwater collected in puddles*). In these cases, the transitive use is associated with a causative sense of the verb, in which the subject of the verb is an agent (*children*) that is causing a change of state in the patient (*dead leaves*, in this case). The intransitive usage is associated with an inchoative sense of the verb, in which the subject is undergoing the action (it is the rainwater that is collecting) and there is no explicitly mentioned or obvious causal agent. In a sentence completion study in which participants completed fragments containing just the initial noun phrase subject and the verb (*The children collected _____*), Hare et al. found that the causative/inchoative alternation could be strongly cued by the subject. The authors then used two self-paced reading studies to show that participants more easily read transitive sentences that began with a causative-biasing subject (*children*). Likewise, reading times were shorter for intransitive sentences that began with an inchoative-

biasing subject (*rainwater*). In summary, this study, along with those of, for example, Kamide, Altmann, and Haywood (2003) and Morris (1994), shows that semantic information associated with a noun phrase subject can be combined with a verb to produce semantic expectations for upcoming patients, as well as structural expectations.

Contradictory Results

Given the set of results reviewed above, it is surprising that Rayner et al. (2004) obtained results suggesting that people do not use event-based knowledge rapidly when comprehending language. The authors examined the effects of what they referred to as "plausibility" on eye movements in reading, and specifically, whether plausibility could inform early stages of language comprehension. They used sentences that contained an instrument, a verb, and a patient, and varied the plausibility of the patient by manipulating the instrument-verb combinations to examine how reading times at the patient noun were affected. Rayner et al. used three conditions. In their "anomalous" sentences, the patient noun did not fit the verb's patient thematic role, as in *John used a pump to inflate the large carrots for dinner last night*. That is, carrots cannot be inflated, regardless of what instrument is used to perform the inflating. In what they termed their "control" condition, the patient was a good fit for the instrument-verb combination, as in *John used a knife to cut the large carrots for dinner last night*. That is, it is common to cut carrots, to use a knife for cutting, and more specifically, to use a knife for cutting carrots. Finally, they included an intermediate "implausible" condition, as in *John used an axe to chop the large carrots for dinner last night*. In this condition, the patient fit the verb (it is common to cut carrots), the instrument fit the verb as well (an axe is used to cut

things), but the patient did not fit the instrument-verb combination (people do not usually cut carrots with an axe).

The key difference between the control and implausible conditions is the degree to which the instrument-verb-patient triplet fits people's knowledge of common events. Note that although Rayner et al. (2004) did not describe their conditions in terms of event knowledge, I do so here. In my view, the role of the instrument is to alter the class of events to which the verb refers. That is, the set of events in which knives are used for cutting differs from the set in which axes are used for cutting. To tie this more directly to the research reviewed above, verb sense is tied to the set of events that a verb denotes. In other words, instruments can subtly alter the sense of the verb: cutting with an axe is a slightly different sense than is cutting with a knife. Because the instrument-verb combinations cue different types of events, or senses of cutting in this case, certain patients should be more relevant, common, and expected given different combinations. Such differences in expectation should result in early reading time difference at the patient. However, this is not what Rayner et al. (2004) found. When the anomalous and control sentences were compared, a clear plausibility effect was found immediately at the patient (*carrots*), in that gaze durations were longer for the anomalous sentences. The same was found when the anomalous and implausible sentences were compared. Critically though, for the control versus implausible comparison, the plausibility effects were mixed and weak. There was no control-implausible difference in first fixation times or gaze durations at the patient, or even at the subsequent region (*for dinner*). There was a marginal difference at the patient and a significant difference in the post-target region in go-past reading times (which include all fixations starting from the first one in a region

and ending when the reader moves past the region; i.e., regressions from that region back to earlier parts of the sentence are included).

Given this pattern of results, Rayner et al. (2004) argued that the degree of plausibility violation represented by their implausible condition was not sufficiently severe to be detected quickly. They further argued that the early differences that were found when the control and implausible conditions were compared to the anomalous condition were due to a violation that depended solely on lexical information associated with the verb (i.e., a theta-assigning relation). Warren and McConnell (2007) have extended this line of argument by suggesting that selectional restrictions imposed by a verb – lexically encoded information regarding the types of arguments a particular verb can license – are privileged with respect to information cued by other sources such as contextual or event knowledge. That is, the lexical representation for the verb *inflate* might specify that the patient must denote an object that can be inflated, and this type of violation is detected rapidly and has an immediate influence on comprehension.

The results of, and arguments put forward by, Rayner et al. (2004) and Warren and McConnell (2007) are surprising for a few reasons. First, they are inconsistent with the results of similar studies in which a preverbal agent noun phrase combined with the verb to produce relatively specific expectations for patients (Bicknell, Elman, Hare, McRae, & Kutas, 2008; Kamide et al., 2003; Morris, 1994). However, differences between agents and instruments might be responsible for the agents being more potent. Agents play a more central role in the causal structure of events, and therefore it is possible that instruments are not as effective in cuing events. Second, these results are also surprising given other early effects of contextual predictability on eye-movement

patterns during reading (Frisson et al., 2005; Rayner & Well, 1996; Schwanenflugel & Shoben, 1985). It seems as though the typicality of an event and of particular fillers of thematic roles in a described event are some of the factors that can underlie predictability.

The Present Study

The present study further investigates the possibility that instrument-verb combinations can indeed produce differential expectations for ensuing patients. One potential reason why Rayner et al. (2004) failed to find early differences between their control and implausible conditions is that the manipulation that differentiated those conditions was not sufficiently strong. To establish the difference between these conditions, Rayner et al. conducted a plausibility rating study using the entire sentences as stimuli. There are two possible concerns. First, in their study, plausibility was rated over the sentence as a whole, rather than at the patient, even though this was the point at which the crucial test was conducted. Therefore, it is possible that the ratings may not accurately reflect plausibility at the patient because the post-patient continuations might have influenced participants' ratings (i.e., the continuation appears to fit the plausible sentences better than the implausible ones in a few items). From my perspective, ratings should directly tap people's event knowledge of the instrument-action-patient triplet. Second, although the difference among the plausibility ratings was statistically significant, the ratings for the control and implausible conditions overlapped. That is, the ratings for some of the implausible items were the same as for some of the control items.

To test the notion that dynamic conceptual combination produces event-based expectancies, I created new materials that I believed would be more effective than those of Rayner et al.'s (2004). In Experiment 1, I obtained people's offline expectancies for

patients in an event denoted by specific instruments and actions. Participants were asked to "List the types of things or people that have the following actions done to them with the specified instruments." For example, they were asked to list the types of things that you use scissors to cut. These norms are preferable to whole-sentence plausibility ratings because they directly index people's knowledge of potential patients given an instrument and an action denoted by a verb. That is, the probability of specific patients being produced is related solely to the instrument-verb combination, outside of any specific sentence context. The norms served two purposes. First, they were the basis for selecting the experimental items that were then used in a self-paced reading study (Experiment 2). Second, Experiment 1 also included Rayner et al.'s control items, which enabled a direct comparison with the items used in the self-paced reading experiment.

In Experiment 2, I directly tested the hypothesis that participants rapidly combine instruments and actions to generate expectations for different classes of patients. There were a few differences between Experiment 2 and Rayner et al.'s study. First, I crossed instruments and patients to balance materials. In other words, *Susan used a saw to cut* preceded both *the wood* (which I call the "typical" condition) and *the paper* (atypical). In addition, *Susan used scissors to cut* preceded both *the paper* (typical) and *the wood* (atypical). In this manner, reading times at the patient were compared across conditions in which it was preceded by identical material. Second, I omitted the anomalous condition. In an experiment in which the purpose is to investigate whether people use their knowledge of real world events when comprehending language, the use of a substantial number of sentences that do not make sense runs the risk of ostensibly informing participants that real-world knowledge is somewhat irrelevant in the

experimental context. In other words, as stated by Warren and McConnell (2007), the use of anomalous sentences might disrupt natural reading. I predicted faster reading times at the patient when it was typical and expected given the instrument-verb combination. Finally, in Experiment 3, I examined whether the results of Experiment 2, in which reading time differences were indeed obtained at the patient noun, might have been due to strong lexical associations or semantic relations that may exist between instruments and patients. This is important because my aim was to ensure that the instrument was combining with the verb to produce expectancies for the upcoming patient, rather than the instrument acting on its own.

<center>Experiment 1: Event Generation Norms</center>

Experiment 1 had two purposes. The first was to construct items for Experiment 2 using a methodology designed to directly tap into people's knowledge of the types of things that are acted upon using specific instruments. This provides an empirical basis for the distinction between the typical and atypical instrument-verb-patient triplets. The second purpose was to measure the strength of Rayner et al.'s (2004) plausibility manipulation. To do so, I included their control items in Experiment 1 and compared them with the items that I then used for Experiment 2.

Method

Participants. Eighty-four undergraduates at the University of Western Ontario participated for course credit. All participants were native speakers of English and had normal or corrected-to-normal visual acuity.

Material. Thirty action verbs were selected. For each verb, two to seven instruments ($M = 4$) that can be used to perform each action (e.g., eat with a fork or

spoon) were generated. In addition, the 29 instrument-verb pairs from Rayner et al.'s (2004) 30 control items were included (*cut-knife* was used twice). From the resulting total of 220 instrument-verb pairs, four lists were created so that no instrument-verb pair appeared twice on any list (two lists contained 56 items and 2 contained 54). If the same verb or semantically similar verbs (e.g., *cut* and *chop*) appeared in a list, they did not occur on the same page of the norming form. No list contained more than two occurrences of each verb. The task was administered in a pen-and-paper fashion, with nine instrument-verb combinations per page (with two lists containing the two additional items on the final page). Space for five responses was provided for each item.

Procedure. Participants were given a list of instrument-verb pairs, and were asked, for example, to "List the things or people that have the following actions done to them with the specified instruments." Each item was worded such as "cut using scissors". Participants were told to write down as many things or people they can think of in one minute for each item. The task took less than one hour to complete.

Results and Discussion

Responses were scored on the basis of their production order within a participant and on their production frequency across participants. That is, each response was given a score weighted by the number of participants listing it 1st, 2nd, 3rd, 4th, or 5th. A weighted score was calculated for each response by multiplying the frequency with which it was produced as the first response by 5, second by 4, and so on, and then summing those products.

Based on the weighted score, I selected 48 typical instrument-verb-patient triplets (24 unique verbs). Selection was based on the following criteria. First, whenever

possible, the typical patient was the response with the highest weighted score for an instrument-verb pair. Second, I chose typical items that allowed re-pairing of instruments between the two triplets that used the same verb (e.g., *saw-cut-paper* and *scissors-cut-wood* from *saw-cut-wood* and *scissors-cut-paper*) so that they were atypical but not anomalous. The atypical patient nouns had a low or zero weighted score for its instrument-verb pair, though these pairings were still conceivably possible. These criteria ensured that each triplet contained a typical and an atypical patient for the instrument-verb pair.

The typical patient nouns had weighted scores ranging from 13 to 101, with a mean of 59 (*SD* = 24) and a median of 53. The mean production probability was .64 (i.e., 64% of participants listed the patient in one of the five slots; *SD* = 23%). Among those items, two triplets (i.e., *net-catch-fish* and *hammer-hit-nail*) seemed to possess an overly strong relation between the instrument and patient. Indeed, these two instrument-patient pairs are highly associated (0.39 and 0.28 respectively) according to Nelson, McEvoy, and Schreiber's (1998) word association norms. Because the purpose is to argue that instruments and verbs combine to influence expectancies for ensuing patients in Experiment 2, I replaced the patient nouns for those items with a highly similar exemplar (*trout* for *fish*) and a near synonym (*spike* for *nail*) to obscure the normative association. After these items were altered, the mean weighted score was 55 (*SD* = 28), the median was 51, and the mean production probability was 0.61 (*SD* = 26). The patient nouns in atypical sets created by re-pairing of instrument-verb combinations had weighted scores ranging from 0 to 11, with a mean of 1 (*SD* = 3), a median of 0, and a mean production probability of .03.

In contrast, the weighted scores for Rayner et al.'s (2004) 30 control items ranged from 0 to 80, with a mean of 21 $(SD = 23)$, and a median of 14. The mean production probability was .24. Eight of the 30 items had a weighted score of zero, and 6 had a score between 1 and 5. That is, approximately half of their items are not at all what participants considered as typical patients in the type of event denoted by the instrument-action combination. These results are important because they show that the plausibility of the patients used by Rayner et al. in their control sentences is not particularly high. Certainly, the patients were, on average, not expected on the basis of people's event-based knowledge. This strongly suggests that the delayed effects found by Rayner et al. resulted from a weak manipulation of plausibility.

Given these data, the items selected based on the results of Experiment 1 should better reflect people's real-world knowledge and should be stronger than Rayner et al.'s (2004). An independent t-test assuming equal variance confirmed that the mean weighted score of the items used in Experiment 2 is significantly greater than Rayner et al.'s items, $t(76) = 5.23, p < 0.001$. If the event-knowledge based expectancy account is correct, early effects at the patient should be obtained with sentences created with these materials.

Experiment 2: Self Paced Reading

The purpose of Experiment 2 was to investigate whether a stronger manipulation of the plausibility of instrument-action-patient triplets would produce reading-time effects directly at the patient. The sentence frames (described in more detail below) were identical in form to those used in Rayner et al. (2004). I predicted that self-paced reading times would differ for the typical and atypical items at the critical patient noun.

Method

   Participants. Thirty-six native English-speaking students at University of Western Ontario with normal or corrected-to-normal vision participated for monetary compensation ($10).

   Materials. Using the 48 typical and atypical instrument-verb-patient triplets selected from Experiment 1, I constructed 96 sentences following Rayner et al.'s (2004) template. Two examples per condition are shown below.

Typical:

a Susan used the scissors to cut the expensive paper that she needed for her project.

b Susan used the saw to cut the expensive wood that she needed for her project.

Atypical:

a Susan used the saw to cut the expensive paper that she needed for her project.

b Susan used the scissors to cut the expensive wood that she needed for her project.

   The proper name, the verb *used*, the determiners for the instrument noun and for the patient noun phrase, the adjective preceding the patient noun, and at least two words after the patient noun were identical among the sentences that featured the same verb. The adjectives modifying the patient nouns were selected so that they did not bias the plausibility of the patient nouns systematically for the typical and atypical conditions. All target sentences were followed by a second sentence to increase the meaningfulness of the narrative. These second sentences were written so that all patient nouns in both conditions were plausible with respect to the discourse. All items are presented in the Appendix A.

The sentences were divided into four lists so that no participant saw any instrument, verb, or patient more than once. Each list contained 24 target sentences. Eighty-four filler sentence pairs with various constructions were added to each list in order to ensure that the targets never occurred adjacently nor appeared first in a list. An additional 16 sentence pairs were used for practice. Yes/no comprehension questions regarding the content of the sentences were created for each sentence pair. The proportion of "yes" and "no" responses were matched across lists and items to be 50%.

Procedure. The sentence pairs were presented on a 17-inch color CRT monitor using a one-word-at-a-time moving-window self-paced reading paradigm (Just, Carpenter, & Wooley, 1982), implemented in E-Prime (Psychology Software Tools, Inc.) on an AMD Athlon 64 Processor 3200+ computer. Texts were presented in 18 point Courier New. Each trial began with lines of dashes appearing on the screen, with each non-space character of the sentence pair replaced by a dash. Participants pressed the space bar on the computer keyboard to read each word, with each key press revealing the next word and reverting the previous word to dashes. After the second sentence was completed, participants answered a comprehension question by pressing the "F" button for yes and "J" for no. Reading latencies (in milliseconds) for each word and responses to the comprehension questions were recorded. Each session began with 16 practice items. Participants then read 108 experimental items, taking a break every 20 items. Each session lasted approximately half an hour.

Results

All participants scored better than 80% correct on the comprehension questions ($M = 92\%$, $SD = 3\%$). In addition to the patient nouns (*paper*), each of seven word

positions starting at four words prior to the patient noun (*to cut the expensive*) to the two

words that followed the patient noun (*that she*) were analyzed. The effects of typicality in

each region were examined in by-participants (F_1) and by-items (F_2) analyses of

variance. Table 1 displays mean reading latencies and the associated F-statistics at the

seven word positions.

There were no significant differences between typical and atypical conditions in

any of the four word positions prior to the patient noun. This was expected because,

across conditions, the sentences were identical to this point. No difference was greater

than 10 ms, and there was a 1 ms difference at the adjective preceding the patient.

A main effect of event typicality was found at the patient. The patient nouns were

read 29 ms faster when the concepts they represented were typical of the event described

by the instrument-verb combinations than when they were atypical. In the post-patient

regions, there was a significant 24 ms spill-over effect on the second word after the

patient noun (*she*), although only a 6 ms difference at the word directly following the

patient noun.

Table 1

Reading Latency (in ms) and F-statistics for Experiment 2

	Word						
	to	*cut*	*the*	*expensive*	*paper*	*that*	*she*
Latency							
Atypical	293	294	281	296	349	337	337
Typical	299	285	285	297	320	331	313
Difference	-6	9	-4	-1	29	6	24
F-test							
$F_1 (1, 35)$	1.12	1.40	0.25	0.02	6.68	0.30	4.11
$F_2 (1, 47)$	0.62	1.08	0.18	0.02	5.16	0.35	5.07
MSE_1	827	1714	194	22	15334	719	10438
MSE_2	1103	2285	258	30	20446	958	13917
p_1	.30	.24	.62	.88	.01	.59	.05
p_2	.44	.31	.67	.89	.03	.56	.03

Discussion

Experiment 2 used sentential stimuli created from the event generation norms, which reflect people's expectancies based on their event knowledge. This manipulation influenced reading latency at the critical point in time, that is, directly at the patient noun. Patients that are typical of the event denoted by instruments and verbs were expected from the context, and thus processed faster than those that are atypical and therefore less expected. This pattern of results cannot be explained by a strictly verb-based account (e.g., selectional restrictions) because the same verbs were yoked with the same two patients in both conditions. That is, *cut-paper* and *cut-wood* appeared in both conditions. What instead differed was the instruments that were paired with those verb-patient combinations. The results thus suggest that experiential event knowledge is a likely source of the observed effects.

In combination with the results of the norming study (Experiment 1), Experiment 2 suggests that the weak and delayed effect of plausibility obtained in Rayner et al. (2004) was due to a weaker manipulation of plausibility. In particular, Experiment 1 showed that their control items did not contain overly plausible patients. Further discussion of these results are deferred until the General Discussion.

There is one alternative explanation for the results of Experiment 2 that must be considered. It is possible that the difference between the typical and atypical items may reflect some form of lexical priming effect resulting from lexical associations directly from instruments to patients. Another way of stating this is that there may be strong semantic relations between them. Of course, semantic relations do exist between the instruments and patients. People do know that scissors are related to paper, and they can

tell you why (i.e., you use scissors to cut paper). Although the possibility of this sort of priming effect in sentence comprehension is often rejected on the argument that lexical association effects diminish across intervening words (Rayner et al., 2004; Murray, 2006), it seems prudent to rule out this possibility empirically.

Experiment 3: Short SOA priming and then reanalysis

To verify that the self-paced reading results are not due to semantic relations or lexical associations between instruments and patients, I conducted a 250 ms SOA priming task in which instruments (*scissors* vs. *saw*) were used to prime patients (*paper*). Given the temporal distance between instruments and patients in the Experiment 2 sentence materials (mean reading latency that would correspond to an inter-stimulus interval of 1165 ms), it may on the surface seem appropriate to use a longer SOA. However, word-word priming differs from a situation in which there are multiple intervening words, as there were in Experiment 2. In a long SOA word-word priming study in which nothing intervenes between prime and target, participants are free to use strategies such as trying to guess the identity of the target given the prime. Therefore, this suggests that it is not appropriate to use an SOA that mimics the temporal parameters of the reading time experiment. If the instruments do indeed directly prime the patients used in the sentences of Experiment 2, a short SOA such as 250 ms should be sufficient to show any such priming effect.

Methods

Participants. Forty students from the University of Western Ontario participated. They were native English speakers and had normal or corrected-to-normal vision.

Material and Procedure. I used the instruments and patients from Experiment 2

as primes and targets. In priming studies, priming effects are determined by comparing

decision latencies for related prime-target pairs to those for unrelated pairs. In this

experiment, the related items were the instrument-patient pairs from the typical sentences

(*scissors-paper*), whereas the corresponding unrelated items were taken from the atypical

sentences (*saw-paper*). Therefore, there were 48 related and 48 unrelated pairs.

Items were divided into two lists so that no participant saw any word twice. Each

list contained 24 related and 24 unrelated instrument-patient pairs. Because no difference

between typical and atypical pairs was predicted, I included 32 prime-target pairs taken

from McRae and Boisvert (1998) that produced priming in that study. The purpose was to

establish that there was nothing odd about any aspect of the study, including the

participants, that might have produced a null difference for the instrument-patient pairs.

Thus, each list also included 16 semantically similar concrete noun pairs (*goose–turkey*)

and 16 semantically dissimilar pairs (*eagle–catapult*) from McRae and Boisvert. Both

lists also included 80 unrelated word-word pairs (*scarf–elevator*) and 160 word-nonword

pairs (*skate-dird*). Thus, there were 50% word targets and 50% nonword targets, and the

relatedness proportion was .25. Ten unrelated word-word pairs and ten word-nonword

pairs were presented first and thus served as the practice trials.

Each trial started with a fixation point (+) displayed for 250 ms, followed by the

prime for 200 ms, a blank screen for 50 ms, then the target word until the participant

responded. The inter-trial interval was 1,500 ms. Participants were instructed to read the

first letter string and then to make a lexical decision to the second letter string by pressing

a button on an E-Prime button box. The button corresponding to the "word" decision always corresponded to the participant's dominant hand.

Results and Discussion

The items from McRae and Boisvert (1998) and the instrument-patient pairs were analyzed in separate set of ANOVAs. Before each analysis, trials on which an error occurred were excluded. Lexical decision latencies greater than three standard deviations above the mean across all experimental trials were replaced by that cutoff value (< 2% of the scores). The decision latencies were examined in by-participants (F_1) and by-items (F_2) analyses of variance.

McRae and Boisvert (1998) Pairs. The decision latencies for semantically similar pairs ($M = 607$ ms; $SE = 12$ ms) were 17 ms shorter than for dissimilar pairs ($M = 624$ ms; $SE = 11$ ms), $F_1(1, 39) = 6.73, p < .02, F_2(1, 31) = 3.81, p = .06$. Thus, the McRae and Boisvert items elicited a priming effect.

Instrument-Patient Pairs. The decision latencies for typical instrument-patient pairs ($M = 560$ ms; $SE = 12$ ms) were a marginally significant 15 ms shorter than for atypical pairs ($M = 575$ ms; $SE = 12$ ms), $F_1(1, 39) = 3.13, p > .08, F_2(1, 47) = 2.77, p > .1$. The 15 ms difference was driven by three items that had notably large priming effects (*cauldron– potion* vs. *kettle – potion, band-aid – scrape* vs. *white-out – scrape*, and *payment – interest* vs. *shortcut – interest*). I removed those items along with the ones that were symmetrically paired with the same instruments to retain proper counterbalancing. Without those items, there was a 1 ms priming effect (typical: $M = 563$ ms; $SE = 12$ ms; atypical: $M = 564$ ms; $SE = 12$ ms), $F_1(l, 39) = 0.003, p > .9, F_2(1, 39) = 0.03, p > 0.8$.

Reanalysis of self-paced reading results. I reanalyzed the self-paced reading data

of Experiment 2 after removing the items that were responsible for the marginal

instrument-patient priming effect. The original Experiment 2 data and the reanalyzed data

are presented for comparison in Figure 1. The re-analysis revealed the same pattern of

results. There was a 34 ms main effect of event typicality at the critical patient noun,

$F_1(1, 35) = 7.84, p < .008, F_2(1, 41) = 5.66, p < .02$, and a slightly diminished and now

marginal 22 ms spill-over effect two words after the patient noun, $F_1(1, 35) = 3.60, p <$

$.07, F_2(1, 41) = 3.43, p < .08$. No significant difference was found at any other word

position.

These analyses show that the self-paced reading results are not driven by direct

priming from instruments to patients. Crucially, it is combination of the instrument and

verb that alters the class of events referred to by the verb, and thus alters expectations for
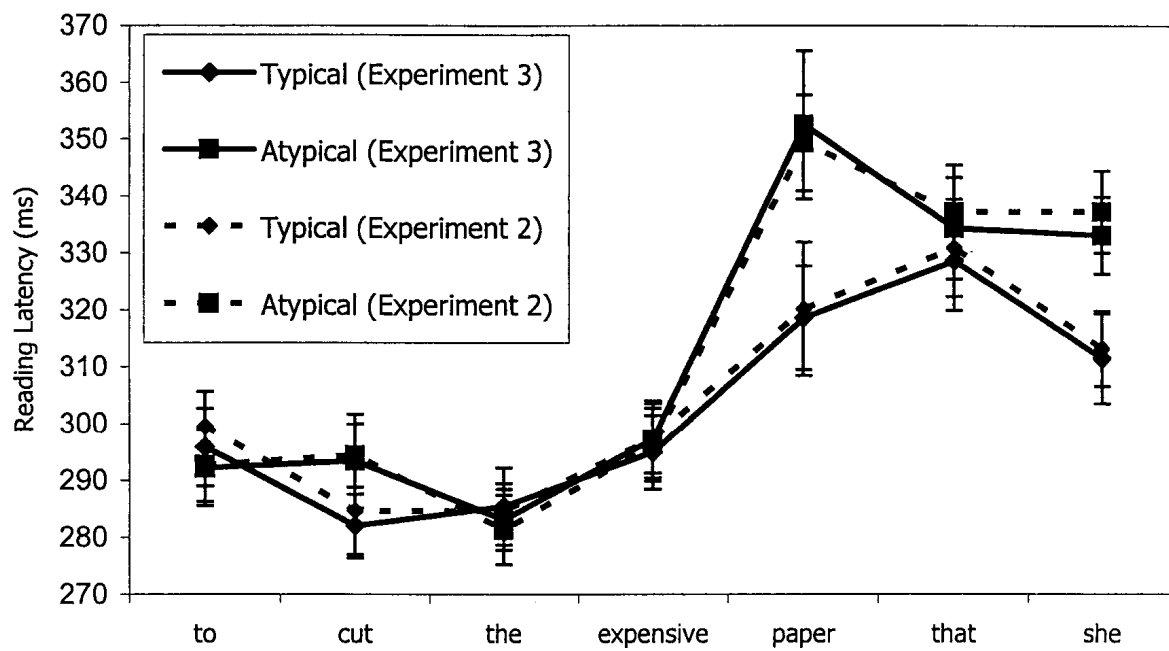
ensuing patients.

Figure 1. Comparison of reading latencies at each of six word positions in Experiment 2 (dotted lines) with those in after removing the items showing priming in Experiment 3 (solid lines)

General Discussion

The purpose of this research was to examine the idea that higher-order representations such as event knowledge are an integral component of on-line language comprehension, and that they immediately influence language comprehension. This position directly contrasts with the claims of Rayner, Warren, and colleagues (Rayner et al., 2004; Warren & McConnell, 2007) who argued that only purely lexical information, such as selectional restrictions, influences rapid conceptual computation during on-line language comprehension.

In three experiments, I demonstrated that combining instruments and actions produce expectancies for different classes of patients. In Experiment 1, event generation norms were used to construct materials that reflect people's offline event-based knowledge. I also used those data to assess concerns regarding the manipulation strength of Rayner et al.'s (2004) items, showing that many of their control items may not have been representative of people's expectations based on event knowledge. The results strongly suggest that their weak, delayed effects of plausibility were likely due to a weak manipulation. Note that my norming methodology differed from theirs due to differences in theoretical perspective. Rayner et al. were primarily interested in the effect of plausibility, and their presentation reflected this. My interest is somewhat broader. I was interested in the ability of different instruments, used with the same verb, to indicate different types of real-world events and thus to generate different sorts of expectancies. The goal of my study was thus to test whether instruments can alter the space of events denoted by the verb, changing expectations about subsequent patients.

In the self-paced reading study of Experiment 2, the stronger manipulation of event-based typicality influenced reading times at the critical patient noun, as predicted by an account in which people's knowledge of common events and situations influences expectancy generation. Participants read a patient noun (*paper*) more quickly when it was typical of the event described by the instrument and action (an event in which scissors are used for cutting) compared to when it was atypical (an event in which a saw is used for cutting). These results cannot be explained by a selectional restriction account (Rayner et al., 2004; Warren & McConnell, 2007) because the restrictions imposed by the verb are equivalent in both cases. In addition, as shown using re-analysis based on the priming results of Experiment 3, the reading time results are not driven by direct relations between the instruments and patients. Instead, they support the hypothesis that comprehenders generate conceptual expectancies based on event knowledge computed from context (i.e., instruments and actions in this case).

Expectancy Generation

There is a growing consensus that sentence comprehension involves some form of anticipation for forthcoming inputs at various levels of representation (Arnold, in press; Kutas & Federmeier, 2000; Pickering & Garrod, 2007; Spivey, 2006), and empirical evidence in favor of this view is emerging. For example, in a recent ERP study by DeLong, Urbach, and Kutas (2005), participants read sentences such as *The day was breezy so the boy went outside to fly a kite/an airplane*. As in other similar studies that investigated the effect of contextual predictability (i.e. cloze probability), they found a larger N400 amplitude elicited at the target word when its predictability was low (*airplane*) compared high (*kite*). What makes this study particularly interesting was the

pattern of negativity at the article (*a* vs. *an*) preceding the target. They found a significant

negative correlation over specific sites between cloze probability of the article (expected

on the basis of the subsequent noun) and the N400 amplitude, such that the N400 was

larger for the article that agreed with the less predictable target (*an* for *airplane*) than

with the more predicable target (*a* for *kite*). Such data suggest contextually–based

anticipation of upcoming words' phonological form because it was the target nouns'

phonological form that determined whether or not the article is expected. Van Berkum,

Brown, Zwitserlood, Kooijman, and Hagoort (2005) demonstrated similar results in the

auditory domain using Dutch grammatical gender marking of pre-nominal adjectives.

That is, expectancy–based effects were obtained at the adjective that preceded an

expected noun phrase and were based on the congruency of the case marking on the

adjective. Corresponding results, but with a different component (P600, an index of

grammatical violation), have also been found with gender agreement in Spanish

sentences (Wicha, Moreno, & Kutas, 2004). All of these results strongly suggest that

expectancy generation is a component of normal language comprehension.

Based on this evidence, it is also likely that the results of the current experiment

are due to expectancy generation. The studies cited above used highly constraining

contexts. It is likely that, in general, the contexts used in Experiment 2 were not so highly

constraining, in that participants probably did not expect one specific lexical item (see the

range of weighted scores for the items). Instead, the instrument-action combinations

presumably resulted in expectations for a reasonably small set of concepts. By choosing

patient nouns based on high weighted scores in the production task of Experiment 1,

salient expected concepts were used in the typical condition. The self-paced reading

results demonstrate that the typical patient concepts were indeed more expected than the atypical ones. That is, contexts up to the verb syntactically and conceptually cued a small set of typical or salient constituents of the type of event they denoted. Thus, it is likely that computation of event knowledge is an integral component in generating expectancies during on-line sentence processing.

Verb Sense and Event Representation

In the Introduction, I described studies in which extra-sentential and intra-sentential context alters the sense of a verb and thus alters structural expectancies for postverbal material (Hare et al., 2003, 2004, in press). Of course, it is not possible to alter structural expectancies without also altering conceptual ones. It is interesting to consider the role of verb sense in the present study. One way to think about senses of verbs is that each sense of a verb is associated with a different class of events. In this way, the present study manipulates verb sense and ensuing semantic expectancies. That is, cutting with scissors brings to mind a different set of events or scenarios than does cutting with a saw. In this view, the current results demonstrate that instruments altered the sense of the verb (the class of events to which it refers), which then changed expectations for upcoming patients.

Note that this is a somewhat different view of verb sense than is sometimes used in the lexical semantics literature. That is, in many cases, such as that with *cut*, this sort of sense difference is subtle, as compared to, for example, the physical and mental senses of *grasp*. This may seem problematic given a traditional view of the lexicon because such a definition of sense might be viewed as requiring an ever increasing number of lexical entries for the same verb. Instead, the view pursued here is that words and syntax serve as

a set of cues for trajectories or movement through state space, and different verb senses entail different trajectories (see Elman 2004, in press, for a full discussion of this view). In this type of view, words serve as cues and the generation of meaning is always context-dependent. Thus, different senses correspond to different trajectories through state space, and the question of the number of lexical entries is not relevant (i.e., there are no lexical entries, at least in the traditional sense of the lexicon).

This view of verb sense also can be seen as having a close link to theories that advocate perceptual simulations. In this view, word and sentence representations are dynamically computed and instantiated through simulations or reenactment of situation-specific somatosensory experiences (or 'perceptual symbols', Barsalou, 1999). These are computed as patterns of neural activation formed from direct interaction with the world (see Kemmerer, in press; Zwaan & Madden, 2005; for a review). This idea is rooted in a theory that has been employed to explain various cognitive phenomena (see Barsalou, Breazeal, & Smith, 2007; Gallese, 2007; Hesslow, 2002; Smith, 2005, for a review). Applied to the domain of language, the simulation framework suggests that the meaning of a word is context-dependent or situation-dependent and computed representations of language reflect mental states instantiated during the actual experience of an event.

Various behavioral and neuroimaging studies have demonstrated that when understanding sentences, comprehenders represent the implied objects' shapes (Sato & Schafer, 2008; Zwaan, Stanfield, & Yaxley, 2002), colors (Connell, 2007), orientations (Stanfield & Zwaan, 2001), implied physical effort (Moody & Gennari, 2008), and implied direction or spatial schema of motion (Glenberg & Kaschak, 2002; Kaschak et al., 2005; Richardson, Spivey, Barsalou, & McRae, 2003; Zwaan, Madden, Yaxley, &

Aveyard, 2004), to list a few. For example, Zwaan et al. (2002) demonstrated that

participants respond more quickly (both in recognition tests and naming) to a picture of

an eagle with folded wings compared to a picture of an eagle with outstretched wings

after reading a sentence such as *The ranger saw the eagle in its nest* versus *The ranger*

saw the eagle in the sky. This pattern of results suggest that participants re-enacted their

real-world knowledge of, or experience with, the referent as they read the sentence, and

their representations reflect the particular shape of the referent in a specific situation.

Such simulation is incremental and rapidly modified as salient cues become available and

are combined (Sato & Schafer, 2008). Interestingly, several neuroimaging studies have

revealed that comprehending sentences (or words under certain contexts) that describe a

particular somatosensory experience recruit an overlapping neural substrate for the actual

perceptual experience or execution of actions, and the pattern of activation differs when

contexts differ (Gennari, MacDonald, Postle, & Seidenberg, 2007; Moody & Gennari,

2008).

While many of these studies have dealt mainly with (features of) entities denoted

by nouns, the same theoretical view may apply to events denoted by verbs. Because an

event consists of multiple participants and elements, and because processing of a verb

activates salient constituents of events denoted by the verb (Ferretti et al., 2001), it is

likely that simulations cued by action verbs involve experiential traces of mental states

tied to those elements. For example, a verb like *spread* may cue situations that include

things like a pastry chef, a knife, and jam, or conversely include a gardener, a shovel, and

dirt. When the sense of a verb is constrained by context, the corresponding simulation

would differ accordingly to reflect the situation-specific representation. That is, *A pastry*

chef spread would activate concepts such as jam or butter, whereas *The gardener spread* would activate concepts such as dirt or mulch. In summary, the results of Experiment 2 could be viewed as using instruments to systematically change the types of simulations cued by the verb.

Event Simulation and Expectancy Generation

In combination with an expectancy generation account, simulation theory suggests that when comprehending the instruments and verbs, participants re-enacted the experiential representation of the denoted event, and expectancies for patients emerged as a result of such re-enactment or simulation. Variations of this account can also explain studies in which expectations regarding the probable patient were altered by a specific agent (Kamide et al., 2003; Bicknell, Elman, Hare, McRae, & Kutas, 2008) or reversed by a more extensive discourse context (Race, Klein, Hare, & Tanenhaus, 2008). Extending this line of logic, it is probable that words that denote other salient constituents of an event, such as time and location, could also be used to influence simulations of event representations and corresponding generation of expectancies. In fact, locations were key to Race et al.'s manipulation. Likewise, manipulating additional elements that are salient to an event, such as agents in addition to instruments and actions (*The lumberjack used a saw to cut* vs. *The butcher used a saw to cut*), could result in simulation of different classes of events (or verb senses) and produce differential expectancies for patients (e.g., *log* vs. *bone*). One avenue for future research is to investigate language comprehenders' ability to dynamically and rapidly combine greater numbers of concepts in this manner.

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APPENDIX A

Sentences used in the self-paced reading (Experiment 2) and their weighted scores in the

event generation norms (Experiment 1)

Sentences	Condition	Weighted score
Jessie used a payment to avoid the annoying interest because he heard that rates were going up. He had the money anyway, and he figured that he could save more by paying now rather than later.	typical	13
Jessie used a shortcut to avoid the annoying interest because he heard that rates were going up. He had tried to cook up a number of complicated schemes, but in the end, he simply paid it from his chequing account.	atypical	0
Jessie used a shortcut to avoid the annoying traffic because he heard that there had been an accident on his usual route. He was in a hurry to get to work because he had an important meeting that morning.	typical	29
Jessie used a payment to avoid the annoying traffic because he heard that the freeway was jammed. He hated paying tolls, but he was in a hurry to get to work that morning.	atypical	0
Linda used a cauldron to brew the medicinal potion for her twelve year old daughter. Her daughter had been home sick for two days now, and Linda was hoping this would help.	typical	51
Linda used a kettle to brew the medicinal potion for her twelve year old daughter. Her daughter had been home sick for two days now, and Linda was hoping this would help.	atypical	0
Linda used a kettle to brew the medicinal tea for her twelve year old daughter. They often had tea as soon as Linda got home from work.	typical	86
Linda used a cauldron to brew the medicinal tea for her twelve year old daughter. They had just moved to a new apartment, and couldn't find the kettle anywhere.	atypical	3
James used a glove to catch the elusive baseball before it fell into someone else's hands. He couldn't believe that he had caught Vernon Wells' home run.	typical	72
James used a net to catch the elusive baseball before it fell into someone else's hands. His buddies had laughed at him for bringing it, but now he was really happy that he did.	atypical	4

James used a net to catch the elusive trout before it fell back into the water. It must have weighed at least 5 pounds.	typical	93
James used a glove to catch the elusive trout before it fell back into the water. He had been told by his guide that when handling a trout, big thick gloves are required.	atypical	0
Nancy used the dye to color her beautiful hair a bright shade of red. This was the fifth time in the last 6 months that she had changed hair color.	typical	64
Nancy used the crayons to color her beautiful hair a bright shade of red. She was trying to imitate her big sister who had just dyed her hair.	atypical	0
Nancy used the crayons to color her beautiful picture a bright shade of red. For some reason, she just felt red that day.	typical	51
Nancy used the dye to color her beautiful picture a bright shade of red. Her art project was supposed to be experimental, and she was trying silk screening for the first time.	atypical	0
John used a joystick to control the brand-new game that he bought yesterday. He had to stop using the regular controller because of the blisters on his both thumbs.	typical	62
John used a remote to control the brand-new game that he bought yesterday. He is now getting used to the non-traditional controller, and enjoying every moment of it.	atypical	0
John used a remote to control the brand-new television that he bought yesterday. He was very happy to see that his old universal remote works perfectly with his new TV.	typical	87
John used a joystick to control the brand-new television that he bought yesterday. He is a heavy gamer, and likes to control everything with his joystick.	atypical	0
Leslie used the white-out to cover the minor error after she had discovered the misspelling. She was too lazy to correct it and print it out again.	typical	89
Leslie used the band-aid to cover the minor error after she had cut her leg while shaving. She vowed to get a better razor as soon as possible because she was tired of cutting herself.	atypical	0
Leslie used the band-aid to cover the minor scrape after she had stopped the bleeding. She couldn't believe that a relatively small scrape would bleed that much.	typical	32
Leslie used the white-out to cover the minor scrape after she had picked up her resume in the parking lot. Luckily, she had some whiteout in her purse, because she didn't have time to	atypical	0

print her resume again before the interview.

Susan used the scissors to cut the expensive paper that she needed for her project. She was making a poster for her Grade 11 geography class.	typical	98
Susan used the saw to cut the expensive paper that she needed for her project. She purposely wanted to create ragged edges on her background.	atypical	0
Susan used the saw to cut the expensive wood that she needed for her project. She was known as one of the best cabinet makers in the city.	typical	83
Susan used the scissors to cut the expensive wood that she needed for her project. The wood that she used for her art was thin and had to be handled with care.	atypical	0
Betty used a fork to eat the homemade pasta that was stuffed with large pieces of crab. She absolutely loved it.	typical	37
Betty used a spoon to eat the homemade pasta that was stuffed with large pieces of crab. She absolutely loved it.	atypical	3
Betty used a spoon to eat the homemade soup that was stuffed with large pieces of crab. She absolutely loved it.	typical	72
Betty used a fork to eat the homemade soup that was stuffed with large pieces of crab. She absolutely loved it.	atypical	5
Helen used a bottle to feed the adorable infant who was born just two weeks ago. She didn't want to do it, but she had been having trouble breastfeeding.	typical	101
Helen used a bucket to feed the adorable infant who was born just two weeks ago on her father's farm. She was worried that the pig wasn't eating well, so she fed him separately from the other pigs.	atypical	0
Helen used a bucket to feed the adorable pig who was born just two weeks ago. She was worried that he wasn't eating well, so she fed him separately from the others.	typical	52
Helen used a bottle to feed the adorable pig who was born just two weeks ago. She was worried that he wasn't gaining weight, so she was giving him some special treatment.	atypical	0
Sandra used a fireplace to heat the frozen cabin that her grandma left to her. She went there every Christmas holiday and skied at the local hill.	typical	23
Sandra used an oven to heat the frozen cabin that her grandma left to her. Her ski chalet had a beautiful old wood burning	atypical	0

oven in the middle of it.

Sandra used an oven to heat the frozen pie that her grandma made for her. Her grandma always makes more than Sandra's family can eat.	typical	39
Sandra used a fireplace to heat the frozen pie that her grandma made for her. Her grandma always made food for her to take to the cabin by the ski hill.	atypical	0
David used a bat to hit the dirty baseball really hard while playing in the backyard. Unfortunately, he broke the neighbour's window.	typical	44
David used a hammer to hit the dirty baseball really hard while holding a beer in his other hand. They were playing the game that his brother had invented, and that they called "hammerball."	atypical	0
David used a hammer to hit the dirty spike really hard while holding a beer in his other hand. He and his friends were pretty irresponsible.	typical	89
David used a bat to hit the dirty spike really hard while playing in the backyard. He stupidly put a large dent in his brand new bat.	atypical	0
Brian used a frame to hold the antique photograph during his art class. They were having an exhibition at his high school.	typical	94
Brian used a clamp to hold the antique photograph during his art class. They were having an exhibition at his high school.	atypical	0
Brian used a clamp to hold the antique wood during his art class. He had almost finished making his picture frame, and he was now painting it.	typical	50
Brian used a frame to hold the antique wood during his art class. For his project, he had painted a nature scene on barn board.	atypical	0
Joseph used a rifle to kill the unfortunate deer that they had been pursuing for an hour. It's the third deer that he and his father had caught so far.	typical	50
Joseph used a harpoon to kill the unfortunate deer that they had been pursuing for an hour. The bullets had not killed it, and they wanted to put it out of its misery.	atypical	11
Joseph used a harpoon to kill the unfortunate whale that they had been pursuing for three hours. It was his first catch since he had become the captain of an Inuit whaling crew.	typical	66

Joseph used a rifle to kill the unfortunate whale that they had been pursuing for three hours. It was his first catch since he had become the captain of an Inuit whaling crew.	atypical	0
Jamie used a match to light the cheap cigarette in the motel near the airport. She had just flown to Mexico from Detroit, and the US airport security had taken her lighter away.	typical	41
Jamie used a lantern to light the cheap cigarette in the motel near the airport. She had just flown to Mexico from Detroit, and the US airport security had taken her lighter away.	atypical	0
Jamie used a lantern to light the cheap room in the motel near the airport. The power had gone out, and the manager had brought everyone a lantern.	typical	34
Jamie used a match to light the cheap room in the motel near the airport. The power had just gone out, and she was trying to find her way around.	atypical	0
Willie used the scissors to open the old package that he found in the basement. After opening it, he realized it was a present that his parents bought for him for this coming Christmas.	typical	87
Willie used the can-opener to open the old package that he found in the basement. The can-opener was the only sharp thing he could find.	atypical	0
Willie used the can-opener to open the old soup that he found in the basement. It was one of those types without an easy-to-open pull tab on the lid.	typical	50
Willie used the scissors to open the old soup that he found in the cabin. He had been lost for two days and had just happened to see the cabin from the top of a nearby hill.	atypical	0
Casey used an alarm to protect the precious car that she purchased a month ago. She had learned recently that she could get a discount on her auto insurance by installing an anti-theft device.	typical	48
Casey used a fence to protect the precious car that she purchased a month ago. Some one had key-scratched her car in her open front yard a week ago, and it wasn't going to happen again.	atypical	0
Casey used a fence to protect the precious property that she purchased a month ago. Given her recent celebrity status, she was worried about stalkers and people coming onto the property.	typical	49
Casey used an alarm to protect the precious property that she	atypical	5

purchased a month ago. She had heard about a number of recent burglaries in the neighbourhood.

Thomas used a horse to pull the old-fashioned carriage from the barn to the park. He felt privileged to chauffeur the Mayor in the annual parade.	typical	64
Thomas used a pick-up truck to pull the old-fashioned carriage from the barn to the park. The city asked him to display the 100-year old carriage in the annual parade.	atypical	0
Thomas used a pick-up truck to pull the old-fashioned trailer from the barn to the market. He's selling pumpkins and apples at the farmers' market.	typical	43
Thomas used a horse to pull the old-fashioned trailer from the barn to the park. Being Amish, he wasn't allowed to use gasoline powered vehicles.	atypical	0
Rene used the coins to purchase the hand-made candy at the farmers' market. She had a pocket full of dimes that her mother had given to her.	typical	29
Rene used the credit card to purchase the hand-made candy at the farmers' market. She couldn't believe how many chocolate bars she was buying for Halloween.	atypical	0
Rene used the credit card to purchase the hand-made clothes at the farmers' market. She got her first ever credit card this morning and went directly for the dress she's been keeping her eyes on.	typical	68
Rene used the coins to purchase the hand-made clothes at the farmers' market. She had a pocket full of townies and wanted to get rid them.	atypical	5
Rick used a rope to secure the large boat properly so that no strong winds would blow it away from the dock. The weather report called for an overnight storm.	typical	32
Rick used a lock to secure the large boat properly so that no one would break into his house boat while he walked around town. He had a lot of booze, plus his laptop, along with him on his week long trip.	atypical	0
Rick used a lock to secure the large door properly so that no one would break into his shed. He had stored both his and his wife's new racing bikes in there for the winter.	typical	61
Rick used a rope to secure the large door properly so that it wouldn't fall over in his truck on his way home. There were two large windows in it, and he didn't want any broken glass.	atypical	6

Jimmie used a dish to serve the fabulous dessert following the main course last night. He had artfully decorated a tiramisu, garnished it with a dusting of cocoa powder and with shaved semisweet chocolate and raspberries.	typical	17
Jimmie used a mug to serve the fabulous dessert following the main course last night. His kids always loved chocolate pudding.	atypical	0
Jimmie used a mug to serve the fabulous tea following the main course last night. He used a special blend of spices to make a delicious chai tea.	typical	71
Jimmie used a dish to serve the fabulous tea following the main course last night. His Chinese platter could hold four cups and was a nice touch when he was having company.	atypical	0
Terry used a shovel to spread the fresh dirt all around the flower bed so that it made a nice mound. This was the year that he was finally going to plant perennials in the front yard.	typical	65
Terry used a knife to spread the fresh dirt all around his terrarium. His lizards liked it when he made a little hill in the middle.	atypical	0
Terry used a knife to spread the fresh jam all around his toast so that it covered the whole thing. He also always made sure that there was at least one strawberry in each quadrant.	typical	53
Terry used a shovel to spread the fresh jam all around the world's largest loaf of bread. The Guinness representatives had already come and gone, and they were celebrating their new world record.	atypical	0
Donna used the hose to wash her filthy car after she came back from the beach. The strong and humid wind had covered her car with sand and salt.	typical	91
Donna used the shampoo to wash her filthy car after she came back from the beach. The strong and humid wind had covered her car with sand and salt.	atypical	8
Donna used the shampoo to wash her filthy hair after she came back from the beach. Her hair was covered with sand, and she wanted to wash it out.	typical	99
Donna used the hose to wash her filthy hair after she came back from the beach. Her hair was covered with sand, and she wanted to wash it out.	atypical	0
Kelly used a rag to wipe her greasy counter which became	typical	49

really dirty while she was making pancakes. It was first time
cooking by herself, and she had a hard time mixing the batter.

Kelly used a kleenex to wipe her greasy counter which became really dirty while she was making pancakes. It was first time cooking by herself, and she had a hard time mixing the batter.	atypical	10
Kelly used a kleenex to wipe her greasy nose which became really dirty while she was cleaning the garage. It was extremely dusty in there.	typical	91
Kelly used a rag to wipe her greasy nose which became really dirty while she was cleaning the garage. It was extremely dusty in there.	atypical	0
Mary used the paper to wrap the wonderful gift for her daughter who was coming to dinner that night. She was excited about her kid's twenty-fifth birthday.	typical	44
Mary used the tinfoil to wrap the wonderful gift for her daughter who was coming to dinner that night. She was excited about her kid's twenty-fifth birthday.	atypical	0
Mary used the tinfoil to wrap the wonderful leftovers for her daughter who was going back to her apartment. This was a Sunday ritual and Mary always tried to help her daughter as much as possible.	typical	31
Mary used the paper to wrap the wonderful leftovers for her daughter who was going back to her apartment. This was a Sunday ritual and Mary always tried to help her daughter as much as possible.	atypical	4

APPENDIX B

Ethics approval form for Experiment 1 through 3

Department of Psychology The University of Western Ontario
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Use of Human Subjects - Ethics Approval Notice

Review Number	07 03 09	Approval Date	07 03 21
Principal Investigator	Ken McRae/Kazunaga Matsuki	End Date	07 08 31
Protocol Title	Testing expectations in sentence processing		
Sponsor	n/a		

This is to notify you that The University of Western Ontario Department of Psychology Research Ethics Board (PREB) has granted expedited ethics approval to the above named research study on the date noted above.

The PREB is a sub-REB of The University of Western Ontario's Research Ethics Board for Non-Medical Research Involving Human Subjects (NMREB) which is organized and operates according to the Tri-Council Policy Statement and the applicable laws and regulations of Ontario. (See Office of Research Ethics web site: http://www.uwo.ca/research/ethics/)

This approval shall remain valid until end date noted above assuming timely and acceptable responses to the University's periodic requests for surveillance and monitoring information.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the PREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of research assistant, telephone number etc). Subjects must receive a copy of the information/consent documentation.

Investigators must promptly also report to the PREB:
a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to the PREB for approval.

Members of the PREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the PREB.

Clive Seligman Ph.D.

Chair, Psychology Expedited Research Ethics Board (PREB)

The other members of the 2006-2007 PREB are: Mike Atkinson, Bertram Gawronski, Rick Goffin, Jim Olson, and
Matthew Maxwell-Smith

CC: UWO Office of Research Ethics

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