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Focused search of semantic cases: The effects of question form and case status

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The present study was designed to identify and examine some of the variables that influence the focused search of semantic cases in question answering. Singer, Parbery, and Jakobson (1988) have previously reported that people can focus on the case interrogated by a question and can largely disregard irrelevant cases. In the present study, people learned facts, such as *the pilot painted the garage with the roller, the spraygun, and the brush.* One day later, they answered questions that focused on a particular case. For example, the question *did the pilot paint with a spraygun?* focuses on the instrument case. Experiment 1 revealed that people can focus on a particular case in response both to complete questions and to comparable word probes, such as "pilot spraygun." Therefore, the given-new structure of questions is not essential to focused search. Experiment 2 revealed that people have a difficult time ignoring the agent case, even when it is irrelevant to the question. This corroborates proposals that agent and action information are closely interrelated in the representation of a fact. These results help to delineate the phenomenon of the focused search of semantic cases.

Semantic cases play a central function in the representation of the meaning of discourse. By capturing the roles that nouns play in relation to the verbs of a sentence, such cases form an important component of the propositional idea units of a message. For example, underlying the sentence *the pilot painted the fence with the brush* is the proposition, (PAINT, AGENT:PILOT, PATIENT: FENCE, INSTRUMENT:BRUSH) (Kintsch, 1974). Theorists have identified numerous semantic case roles, including the *agent*, *patient*, *experiencer*, *instrument*, and *location* (e.g., Chafe, 1970; Fillmore, 1968; Jackendoff, 1972).

There is evidence that semantic cases constitute basic perceptual-cognitive categories available to both adults and children. Adults can make comparisons among semantic cases in a manner similar to the way they compare ordinary taxonomic categories (Chaffin & Herrmann, 1984; Shafto, 1973). The language of young children reflects their growing awareness of different semantic cases (Bowerman, 1973). In addition, children can make explicit classifications based on their knowledge of such cases (Braine & Hardy, 1982; Braine & Wells, 1978).

In a recent study, we examined people's ability to execute *focused memory searches* of semantic cases in complex facts (Singer, Parbery, & Jakobson, 1988). People learned facts such as the one expressed by Sentence 1a. Later, they were timed while they answered questions such as 1b and 1c:

(1a) The pilot painted the garage with the roller, the spraygun, and the brush.

(1b) Did the pilot paint a garage?

(1c) Did the pilot paint with a spraygun?

In Question 1b, it is given or presupposed that the pilot painted something. The question interrogates the accuracy of the "new" element, *garage*, which appears in the patient case (Clark & Clark, 1977; Clark & Haviland, 1977). Singer et al. (1988) proposed that people can focus their memory search on the case of the new question element, and disregard concepts in irrelevant cases. Therefore, according to the "focused search hypothesis," the answering of Question 1b results in an examination of the patient case in the representation of the antecedent fact in Sentence 1a, but not an examination of the instrument case.

The focused search hypothesis predicts that answer time will be mainly a function of the number of concepts in the relevant semantic case. For example, if we disregard the presupposed agent, Question 1b can be classified as a 1-relevant, 3-irrelevant (or 1-3) question with reference to Sentence 1a. This is because Sentence 1a includes one concept in the patient case, and three concepts in the instrument case. In contrast, Question 1c is a 3-1 question with reference to Sentence 1a: it interrogates the accuracy of spraygun, an instrument, and the fact in Sentence 1a includes three instruments and one patient. The focused search hypothesis predicts that 1-3 questions will be answered more quickly than 3-1 questions.

The data of three experiments provided clear support for this prediction (Singer et al., 1988). For example, averaging across the three experiments, mean answer times of 1,928 msec and 2,106 msec were measured for

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questions in the 1-3 and 3-1 conditions, respectively. Consistent with this outcome, the answer time to a question such as *does the dentist like Amsterdam?* is mainly determined by the number of facts associated with the relevant taxonomic category, namely "cities," and not by facts in irrelevant catetgories, such as "animals" (McCloskey & Bigler, 1980). Likewise, the answer time to theme-related questions such as *did Alan ride the chairlift?* is strongly influenced by the number of facts about Alan learned in the relevant theme, skiing, but not by the number of facts associated with an irrelevant theme, such as "the circus" (Reder & Anderson, 1980).

The data of Singer et al. (1988) also revealed that the number of concepts in the irrelevant case exerted a small but significant impact on answer time. The overall pattern of our data has been called "nonselective focused search" (McCloskey & Bigler, 1980). On the basis of these findings, we proposed that the concepts of a complex fact are organized under *case subnodes* (see also Reder & Anderson, 1980). Processing is hypothesized to proceed as follows:

First, the test question is propositionally encoded in such a way that the given and new components of the question are distinguished.

Second, activation spreads from the given concept predominantly to the subnode of the interrogated semantic case. This process has a high probability of retrieving the relevant case, and a small probability of retrieving the irrelevant case (see Reder, 1982; Reder & Anderson, 1980).

Third, the search of the retrieved semantic case, relevant or irrelevant, is exhaustive. As a result, answer time is affected by the number of concepts in both the relevant and the irrelevant semantic case. However, the effect of the number of relevant concepts is much greater, because the relevant semantic case is retrieved more often than the irrelevant one. Whether, after searching the irrelevant semantic case, the answerer proceeds to search the relevant one, does not exert much impact on the data. This is a result of the hypothetically small proportion of trials on which the irrelevant semantic case is retrieved.

A counterexplanation of the results described above is that the concepts *garage*, *roller*, *spraygun*, and *brush* in Sentence 1a are segregated on the basis of either their taxonomic or syntactic categories, rather than semantic cases. To address this possibility, Singer et al. (1988, Experiment 3) asked people to learn complex facts that linked an agent to concepts in two semantic cases but only one taxonomic category. One such fact was *The tailor used the francs to buy the rubles, the marks, and the pesos.* Suppose that people organize these concepts according to their taxonomic category, "currencies," rather than their semantic cases. Then, answer times for questions classified as 1-3 (relevant-irrelevant) and 3-1 on the basis of case relevance should be equal. This is because both would result in the examination of a list of four currencies. However, Singer et al. (1988, Experiment 3) reported that the answer times for 3-1 questions exceeded 1-3 answer times by a magnitude comparable to those observed in their other experiments. This discounts the possibility that the latency patterns of Singer et al. (1988, Experiments 1 and 2) were due to the taxonomic-category organization of the learned concepts.

In the sentence *The tailor used the francs to buy the rubles, the marks, and the pesos*, both the instrument and the patients function as surface-structure direct objects. Therefore, the results of Singer et al. (1988, Experiment 3) also partly addressed the possibility that the answer-time profiles were due to syntactic organization rather than case-role function. A complete deconfounding of semantic case and syntactic category might be achieved by the examination of cases that are not signaled by characteristic words or grammatical structures, such as the goal and the experiencer (see Healy & Levitt, 1978; Singer et al., 1988, p. 155).

The present study was designed to examine the conditions that permit and constrain the focused search of semantic cases. In Experiment 1, we examined the impact of the form of the test question on focused search. Then, in Experiment 2, we addressed the issue of whether or not different cases have equal status in the organization of complex facts.

EXPERIMENT 1

In the study of fact retrieval, investigators have used test probes of different forms. These have included probes consisting of word pairs (*word probes*) such as "editor bears" (Anderson, 1976, p. 295; McCloskey & Bigler, 1980); assertive sentences, such as *a lawyer is in the park* (Anderson, 1974; Reder & Anderson, 1980); and ordinary questions, such as *did the dentist repair a bus?* (Singer et al., 1988).

Experiment 1 was designed to compare the influence of word probes and ordinary questions on the focused search of semantic cases. The rationale for this endeavor is that the syntatic form of questions conveys a clear distinction between given and new information (Clark & Haviland, 1977; Haviland & Clark, 1974; Hornby, 1974). Following the given-new strategy (Clark & Haviland, 1977), this distinction ought to promote memory search proceeding from the given element toward the new element, focusing on the case of the new question element. In contrast, because word probes have no syntactic form to distinguish given from new information, test items of this form might restrict focused memory search. Existing evidence about this issue is ambiguous. Using word probes, Anderson (1976) reported that retrieval time varied as a function of the concepts associated with every concept in the probe. This outcome, the classic fan effect, is the antithesis of focused search. McCloskey and Bigler (1980), however, reported that people executed focused searches of taxonomic categories when presented with word probes. No direct comparison of word probes and questions has previously been reported.

In Experiment 1, we compared question probes such as *did the dentist repair a bus?* with word probes, such as "dentist bus." If the use of question probes by Singer et al. (1988) was instrumental in guiding focused search, there should be greater evidence of focused search with question probes than with word probes.

It is useful to provide an overview of the methods used in both experiments of this study, which were close variations of those of Singer et al. (1988). In the present experiments, each participant learned a unique set of 12 or 16 complex facts, such as that underlying Sentence 2:

(2) The pilot painted the fence, the garage, and the steps with the brush.

Each fact linked the name of a profession with concepts in either one or both of two other semantic cases, such as the patient and the instrument, or the patient and the location. As a result, every learned fact could be classified with regard to the number of concepts that appeared in the two semantic cases (disregarding the profession name). For example, facts in the 1A condition linked a profession name to one concept in one semantic case only. A 1A-3B fact linked a profession to one concept in one semantic case and three concepts in another. Sentence 2 above contains an example of a 1A-3B fact.

Twenty-four hours after learning, the participants answered test questions about the facts that they had learned. Every test question such as *did the pilot paint a garage?* linked one of the studied profession names with a single concept. The case of that concept was always among the semantic cases that had been linked to the profession name during learning. Every question could be classified according to the notation *x-y*, called its *probe type*. The symbols *x* and *y* referred respectively to the number of concepts that were learned in the relevant semantic case (the case of the new question element) and in the irrelevant one. For example, *did the pilot paint a garage?* asks about the accuracy of *garage*, a patient. As discussed earlier, this question is in the 3-1 condition with reference to Sentence 2, because the fact in Sentence 2 included three patients and one instrument. The focused search hypothesis states that answer time will be mainly a function of *x*, the number of concepts in the relevant semantic case.

Method

Materials

The materials consisted of sets of 12 statements of fact, plus corresponding test probes. Each fact comprised a profession name plus concepts in the patient case, the instrument case, or both. There was a unique set of materials for each of 12 participants. Eleven of the sets were those used in Experiment 1 of Singer et al. (1988), and one additional set was constructed using the procedure of that experiment. The precise facts and the pairing arrangement in each set were determined by random selection and assignment from a master list of 20 profession names and eight pairs of fact frames (Singer et al., 1988, Appendix A).

Each set of 12 statements of fact included two pairs of facts in each of the conditions 1A, 1A-3B, and 4A. An example of a pair of 1A-3B facts is *the dancer repaired the car with the pliers, the wrench, and the vise* and *the grocer destroyed the boat with the crowbar, the hammer, and the drill.*

The test probes corresponding to the 12 facts appeared in the probe-type conditions 1-0, 1-3, 3-1, and 4-0. For example, as discussed earlier, 1-0 means that the corresponding fact included one concept in the relevant semantic case and no concepts in the irrelevant one. The test probes all linked a profession name to a concept in either the patient case or the instrument case. It is important to note that the manipulated variable *probe type* is based on the classification of the probe (e.g., 3-1) and not of the original fact (e.g., 1A-3B).

For each set of facts, both question probes and word-pair test probes were constructed. The question probes were the 48 yes/no questions of Singer et al.'s (1988) Experiment 1, such as *did the pilot paint a fence?* The word probes consisted simply of the nouns of the corresponding questions, such as "pilot fence."

The distribution of the 48 test probes across probe-type conditions is shown in Table 1. There were one yes and one no probe for each 1A fact, one yes and one no probe for the A term of each 1A-3B fact, two yes and two no probes for the B term of the 1A-3B facts, and two yes and two no probes for each 4A fact. The foil words for the no probes were drawn from the facts that acted as companions in the fact pairs. This resulted in semantically sensible foils, such as *did the grocer destroy a car?* The precise rationale for the choice of probe distribution and the construction of the foils is provided by Singer et al. (1988).

Subjects

Twelve female and male students of introductory psychology at the University of Manitoba participated in Experiment 1 for course credit. All participants were native speakers of English.

Procedure

Learning. The participants were tested individually. During the learning session, each subject was handed a shuffled deck of 12 fact cards. The subject studied each card for as long as was desired, and then placed it face down on the table. After the entire deck had been studied, a cued recall test was administered. The cue for each fact was the profession name, and the subject was asked to provide all of the information that had accompanied that profession. The answer was scored as correct if it included, in any order, precisely those patient and instrument concepts associated with that profession.

At the end of the study-test sequence, the card deck was reshuffled and another learning-test trial was administered. Beginning with the second sequence, cards were removed from the deck if the subject was correct on a fact for two trials in a row. Once the deck was depleted, the entire deck was reshuffled and the subject received one more study-test sequence. If, on this trial, any facts were missed, the subject received additional sequences, following the "double-dropout" procedure.

Test. Twenty-four hours later, the subject returned for testing. At the outset of testing, the subject received one study-test sequence

Table 1
Selection of Probe Types and Corresponding Facts in Experiments 1 and 2 (*ns* in parentheses)

Experiment	Probe Type	Corresponding Fact
1	1-0* (8)	1A (4)
	1-3 (8)	1A-3B (4)
	3-1 (16)	1A-3B†
	4-0 (16)	4A (4)
2	1-0 (8)	1A (4)
	2-0 (16)	2A (4)
	1-3 (8)	1A-3B (4)
	3-1 (16)	1A-3B†

Note—For all probe types, half the items were in the "yes" condition and half in the "no" condition. *Probe type *x-y* means that there were *x* concepts in the relevant case and *y* concepts in the irrelevant case. †The 3-1 probes asked about the same 1A-3B facts as did the 1-3 probes.

on the full set of facts. Any facts that were missed were restudied to the double-dropout criterion.

The subject next received 48 trials of pressing the response button corresponding to the words *yes* and *no* as they appeared on the screen of a computer-controlled video monitor. The subjects were randomly assigned to use the right or left index finger for "yes."

Finally, the subjects received two blocks of question probes (Q) and two blocks of word probes (W). The subjects were instructed to respond "yes" in two circumstances: first, if a question such as *did the pilot paint a fence?* expressed an accurate fact; and second, if a word probe, such as "pilot fence," mentioned two concepts that had been connected in a learned fact. There were six distinct orders in which the blocks could be presented: QQWW, QWQW, QWWQ, WWQQ, WQWQ, and WQQW. The 12 subjects were randomly assigned to these block orders, with the constraint that each order be used for exactly 2 subjects.

On each test trial, a fixation point appeared on the screen for 500 msec, followed by the probe. The subject had 4 sec in which to answer, by pressing the "yes" or "no" button. After a 2-sec intertrial interval, the fixation point reappeared. The instructions stressed that the participant maintain a high degree of accuracy during testing.

Results

Learning

The subjects needed an average of 6.3 trials ($SD = 2.1$) to learn the facts to criterion. Relearning on the following day required an average of 2.3 trials ($SD = 1.3$).

Test

Answer times. The mean correct response latencies and corresponding error proportions of Experiment 1, collapsing across response and semantic case, are shown in Table 2. Analysis of variance (ANOVA) applied to the RTs had four within-subject variables, namely probe type, probe form (question versus word), response, and semantic case. Because a unique set of materials was constructed for each subject, the analysis took both subject and item variability into account (Clark, 1973). An alpha level of .05 was used throughtout.

The ANOVA revealed a main effect of probe type [$F(3,33) = 19.0$, $MS_e = 176{,}565$]. Bonferroni *t* tests revealed that 1-0 RTs were faster than 1-3 RTs [$t(190) = 2.66$], and that 1-3 RTs were faster than 3-1 RTs [$t(190) = 3.81$]. The difference between the 3-1 RTs and 4-0 RTs did not approach significance. These results supported the main focused search hypothesis.

Of equal importance for the present concerns was that the probe-type × probe-form interaction did not approach significance [$F(3,33) < 1$]. Inspection of Table 2 reveals that the probe-type profile was similar for the question probes and the word probes.

The probe-form main effect was significant [$F(1,11) = 10.2$, $MS_e = 287{,}390$], reflecting the fact that word probes were answered 175 msec faster than the questions. Likewise, there was a significant effect of response [$F(1,11) = 39.4$, $MS_e = 128{,}859$]: the means for "yes" and "no" responses were 1,958 msec and 2,187 msec, respectively. Finally, the main effect of semantic case was not significant, nor were any of the interactions.

The absence of a significant interaction of probe type and probe form indicated that focused search was executed in response to both question probes and word probes. However, it is conceivable that the presence of the question blocks influenced the nature of the memory search used for the word blocks. To evaluate this possibility, an examination was made of the mean correct RTs measured in the first block of the 6 subjects who received a word block first. There was no possibility that the memory search strategy in an initial word block could be influenced by the processing that occurred in subsequent question blocks. An ANOVA applied to these scores revealed no significant effects, presumably as a result of the small number of measures. However, consistent with the overall analysis, the main effects of both probe type and response approached significance ($ps < .2$).

Of greatest concern in the subanalysis of initial word blocks is the comparison of the 1-3 and 3-1 probe-type conditions. Questions in both of these conditions refer to facts with precisely four concepts in two semantic cases linked to the profession name. The 3-1 probe RTs exceeded the 1-3 probe RTs by 164 msec, with means of 2,152 msec and 1,988 msec, respectively. This difference was similar in magnitude to the 3-1 versus 1-3 difference of 180 msec for all word blocks. Thus, there was little indication that it was the presence of the question blocks that induced the subjects to execute focused memory searches of semantic cases on the word blocks.

Errors. The mean error rate in testing was 9.9%. The correlation between the error rates and RTs in the 32 conditions was highly significant [$r(30) = .71$]. A positive correlation between error rates and RTs is a familiar feature of studies of this sort (e.g., Carpenter & Just, 1975; Reder & Anderson, 1980; Singer et al., 1988). This pattern discounts the possibility of a serious speed–accuracy tradeoff between RTs and errors (Clark & Chase, 1972, p. 487).

An ANOVA was applied to the error rates of the two experiments. Typically, these analyses revealed a subset of the significant effects of the RT analyses. Therefore, this presentation will emphasize only those significant effects of the error measure that did not appear in the RT ANOVAs.

The only such error effect in Experiment 1 was the response × probe-type interaction [$F(3,33) = 4.84$, $MS_e = .014$]. This interaction appears to reflect the fact that 4-0 error rates were higher than 3-1s for "no" responses, as predicted by the focused search hypothe-

Table 2
Mean Correct Response Latencies (in Milliseconds) and Error Rates, Collapsing Across Response and Case, in Experiment 1

Probe Type	Probe Form: Question	Word	Mean
1-0	1927 (.052)	1750 (.021)	1839 (.036)
1-3	2071 (.073)	1942 (.093)	2006 (.083)
3-1	2352 (.133)	2122 (.132)	2237 (.134)
4-0	2291 (.143)	2126 (.140)	2208 (.144)

Note—Error rates are given in parentheses.

sis, but lower than the 3-1s for "yes" responses. This might occur if the lengthy list of concepts that appeared in the referent (4A) facts of the 4-0 probes biased people to respond "yes." Reder and Anderson (1980, p. 460) likewise detected high error rates for distractor items with high fan.

Discussion

Experiment 1 was designed to examine the effect of probe form on the focused search of semantic cases. The results revealed similar patterns of response latencies for question and word probes. In fact, the probe-form variable entered into no significant interactions. Therefore, it does not appear that the given–new structure of questions is an essential factor in the focused search of semantic cases.

There are several reasons that word probes might initiate focused memory search. First, even word probes might be argued to make some distinctions between given and new information. In the word probes of Experiment 1, such as "pilot fence," the order of the nouns was the same as in the corresponding question, *did the pilot paint a fence?* Because given information usually precedes the new information of a sentence (Clark & Clark, 1977, p. 32; Halliday & Hasan, 1976), the form of the word probes may have suggested the importance of evaluating the accuracy of the second word. Second, the subjects may have mentally expanded word probes, such as "pilot fence," into complete questions, such as "did the pilot paint a fence?" (see McCloskey & Bigler, 1980, p. 255). This would result in processing similar to that obtained with question probes.

What factor other than probe form might account for people's ability to execute focused memory search, in contrast to the sort of "alogical" search documented by Anderson (1974, 1976)? One likely possibility is that the learning procedure common to studies of focused memory search (McCloskey & Bigler, 1980; Reder & Anderson, 1980; Singer et al., 1988) results in the topicalization of a central concept, such as the profession name in the present experiment. Furthermore, the given–new structures of the probes of Experiment 1 are "congruent" with this topicalization: that is, the given component of the probes coincided with the topic of the corresponding fact (Clark & Haviland, 1977; Yekovich, Walker, & Blackman, 1979). This may have made it particularly easy to execute a memory search that proceeded from the topic to the relevant semantic case.

The present answer-time data replicated all of the features of Experiment 1 in Singer et al. (1988), except in that Singer et al. measured a significant case × response interaction. Their data revealed a larger response effect for patient questions than for instrument questions. However, that pattern appeared neither in the present experiment nor in Experiment 2 in Singer et al., and it therefore does not appear to constitute a systematic feature of these data.

Two other aspects of the probe-type effect merit brief mention. First, the latency advantage of 1-0 probes over 1-3 probes is consistent with the nonselectivity of the focused search of semantic cases, as discussed at the outset of this paper (see also Singer et al., 1988, p. 152): That is, the number of irrelevant concepts in the learned fact exerts a small effect on answer time. Second, the fact that 4-0 RTs did not exceed those of 3-1 probes is consistent with the proposal, mentioned earlier, that a "yes" response bias exists for the 4-0 probes. "No" RTs were 44 msec slower for 4-0 than 3-1 probes, whereas "yes" RTs were 102 msec faster in the 4-0 than in the 3-1 condition.

Although the pairs of fact frames were randomly assigned to different experimental conditions for each subject, each resulting set of materials used six of the eight pairs of fact frames. Therefore, some caution about the item generality of these results should be exercised.

In their experiments, Singer et al. (1988) examined the focused search of the patient, instrument, and locative cases. Because these cases figure prominently in most linguistic and psychological analyses of semantic case, the results of Singer et al. appear to have at least moderate generality with respect to semantic cases. Experiment 2 was designed to determine whether people can execute focused searches of semantic cases when one of the competing cases is the agent.

EXPERIMENT 2

According to many analyses, the agent is the most important and prominent of all semantic cases (e.g., Braine & Wells, 1978; Chafe, 1970; Fillmore, 1968; Schank, 1972; Segalowitz, 1982). For this reason, it would be useful to extend the focused search finding to the agent case. That is, suppose that subjects learned facts such as those in Sentences 3 and 4:

(3) The wall was cleaned by the judge, the minister, and the butcher with the mop.

(4) The lettuce was harvested by the student with the rake, the pitchfork, and the shovel.

In corresponding questions, the agent case would constitute either the relevant or the irrelevant semantic case, rather than be part of the given question component. For example, in the question, *was the wall cleaned by a butcher?*, asked with reference to the fact in Sentence 3, the agent case is the relevant one.

Consideration of this problem suggested that contrasting the agent case with other semantic cases might reveal an asymmetry of focused search. Previous studies have shown that the agent is predominant in people's judgments of semantic cases. For example, Segalowitz (1982) performed a series of experiments in which people had to make judgments about concepts that functioned as agents or played other roles. In one experiment, Segalowitz's subjects viewed pictures that depicted one fish, the agent, biting another fish, the patient. People needed less time to locate the agent than the patient in this task. In another experiment, the subjects needed a longer delay between two pictures to indicate, with 100% accuracy, whether the two patients were identical, than to make similarly accurate judgments for agents.

Two pilot studies confirmed our expectation of an asymmetry between the agent and other semantic cases. In the pilot studies, the subjects learned facts that linked a patient with varying numbers of concepts in the agent and/or the locative cases. When the agent case formed part of the new question component, and was therefore the relevant semantic case, 1-3 RTs were faster than 3-1 RTs, as usual. However, for questions that focused on the locative case, there was no difference between 1-3 and 3-1 RTs. The latter outcome indicated that people have a difficult time ignoring the agent case and focusing on a competing one.

Our goal in Experiment 2 was to systematically examine people's ability to focus memory search on the agent and other competing semantic cases. To accomplish this, people were asked to learn facts that linked central concepts filling the patient case with concepts in the agent case and/or one other case. Then, they answered questions that focused on one case or the other. Replication of the main focused search result would reveal that answer time varied mainly as a function of the number of concepts in the relevant case. Suppose, however, that the agent has a privileged status in learned facts. When people are asked questions about the agent, it ought to be possible to focus on that case. However, when a question focuses on a competing case, such as the instrument or the location, it might be difficult to ignore concepts in the agent case. In this event, the answer time for agent questions will vary mainly as a function of the number of relevant concepts as usual, but the answer times for other questions will reflect both the number of relevant concepts and the number of irrelevant agents. Such an asymmetry would be reflected by the detection of a case × probe-type interaction.

Experiment 2 was conducted as two separate experiments, comparing the agent case with the instrument case and the location case, respectively. Because the two experiments used precisely the same design and revealed the same results, it will be convenient to combine them in this presentation.

Method

Materials. Each subject learned a unique list of 12 facts, and subsequently answered corresponding questions. These materials were constructed from two master lists of 16 fact frames each. The frames on the first master list linked a patient concept with three agents and three *locations*, and the frames in the second master list linked a patient concept with three agents and three *instruments*. As in Experiment 1, the frames in the master lists were organized in pairs, in order to provide a source of foil words that did not yield anomalous questions. The frames in the location and instrument master lists are illustrated by Sentences 5 and 6, respectively:

(5) The floor was waxed by the farmer/premier/jockey at the laundromat/gym/clinic.

(6) The lettuce was harvested by the dentist/merchant/student with the rake/pitchfork/shovel.

The learned facts were classified as 1A, 2A, or 1A-3B facts, following the scheme of Experiment 1. Each test question linked the patient from one of the learned facts to a concept filling one of the semantic cases that had been mentioned in the original fact. The patient concept always formed part of the given component of the question, and the other semantic case was part of the new component. Viewing, as usual, the "new" semantic case as the relevant one, it was possible to classify each question in terms of the number of relevant and irrelevant concepts that occurred in the corresponding fact. Questions about 1A facts were always in the 1-0 probe-type condition. Likewise, questions about 2A facts were 2-0 probes. Finally, questions about the 1A-3B facts could be either 1-3 probes or 3-1 probes, depending on which semantic case they examined. For example, with reference to the statement of fact *the poem was written by the pitcher, the mechanic, and the mayor at the university*, the question *was the poem written at a university?* is a 1-3 probe. In constrast, *was the poem written by a mayor?* is a 3-1 question.

Each set of materials was based on either the patient-agent-location or the patient-agent-instrument master list. The procedure of constructing the sets of materials was similar for the two lists. For convenience, this exposition will refer to the patient-agent-instrument list.

For each set, six of the eight pairs of facts were chosen at random. Then, two pairs were randomly assigned to each of the conditions 1A, 2A, and 1A-3B. Within each condition, the agent case was assigned as the A term for one of the pairs of facts, and the instrument was designated as the A term for the other pair. As a result, each set included two facts (one pair) in each of the following conditions: 1A (one agent), 1A (one instrument), 2A (two agents), 2A (two instruments), 1A-3B (one agent, three instruments), and 1A-3B (one instrument, three agents). All 1A-3B facts mentioned the agent case first.

Once a fact from the master list was assigned to its condition, the precise fact that the subject had to learn was constructed by taking as many agents and instruments as necessary from the master frame. For example, if the fact frame in Sentence 6 above was assigned to the 1A(instrument)-3B(agent) condition, the resulting fact was *the lettuce was harvested by the dentist, the merchant, and the student with the rake*.

For each set of materials, 48 test questions, such as *was the lettuce harvested by a student?*, were constructed. The distribution of questions across probe-type conditions is shown in Table 1. There were one yes and one no question about each 1A fact (a total of 8); two yes and two no questions about each 2A fact (a total of 16); one yes and one no question about the A term of each 1A-3B fact (a total of 8); and two yes and two no questions about the B term of each 1A-3B fact (a total of 16). Each question included the patient concept in its given component, and focused on one of the other semantic cases that was included in the corresponding fact: namely, the agent or the alternative case. A question was never directed toward a semantic case that had not been included in the corresponding fact.

Subjects. There were 24 participants, who were selected from the same pool as was used in Experiment 1.

Procedure. The procedure was identical to that in Experiment 1, except that RT testing consisted of three blocks of question probes, rather than two blocks each of question and word probes.

Results

During learning, the subjects took a mean of 5.5 trials (SD = 1.9) to learn the 12 facts. No subject failed to learn the set of facts. Relearning immediately prior to the RT test on Day 2 took a mean of 1.7 trials (SD = 1.1).

Table 3
Mean Correct Response Latencies (in Milliseconds) and Error Rates as a Function of Probe Type and Case in Experiment 2

"Other Case"	Case	Probe Type 1-0	2-0	1-3	3-1
Location	Agent	1733 (.027)	2046 (.111)	1849 (.056)	2182 (.089)
	Location	1976 (.077)	1930 (.072)	2240 (.132)	2275 (.128)
Instrument	Agent	1973 (.042)	2358 (.198)	2150 (.042)	2396 (.151)
	Instrument	2143 (.091)	2312 (.075)	2354 (.112)	2415 (.115)
Mean	Agent	1853 (.035)	2202 (.154)	1999 (.049)	2289 (.120)
	"Other case"	2060 (.084)	2121 (.074)	2282 (.122)	2345 (.121)

Note—Error rates are given in parentheses.

Table 3 shows the mean correct RTs and error rates, collapsed across response, for Experiment 2. In the ANOVA applied to the RTs, probe type (1-0, 2-0, 1-3, 3-1), response (yes, no), and semantic case (agent, other) were within-subject variables. There was also one between-subjects variable, called "other-case." This variable refers to whether the semantic case accompanying the agent was the location or the instrument.

The ANOVA revealed a main effect of probe type [$F(3,66) = 17.2$, $MS_e = 121{,}600$], reflecting means of 1,956 msec, 2,161 msec, 2,141 msec, and 2,317 msec for the 1-0, 2-0, 1-3, and 3-1 conditions, respectively. Bonferroni t tests revealed that there were significant differences between the following pairs of conditions: 1-0 and 1-3 [$t(190) = 4.08$]; 1-0 and 2-0 [$t(190) = 3.68$]; and 1-3 and 3-1 [$t(190) = 3.50$]. The 1-3 and 2-0 RTs did not differ significantly ($t < 1$).

The semantic case × probe-type interaction was significant [$F(3,66) = 5.31$, $MS_e = 118{,}391$]. Of particular concern was the comparison between probe types 1-3 and 3-1 for the agent case and the other semantic case, which appear as the four values in the bottom right-hand corner of Table 3. Tests of simple main effects revealed that 1-3 RTs were faster than 3-1s for agent questions [$F(1,23) = 8.08$, $MS_e = 119{,}996$], but not for questions about the other semantic cases [$F(1,23) = .33$, $MS_e = 119{,}996$]. This pattern was similar for both "other cases," the location and the instrument. These effects support the main hypothesis: in answering tasks that promote the focused search of semantic cases (cf. Anderson, 1976), it is difficult to focus on one semantic case when the competing semantic case is the agent.

There was a significant main effect of response [$F(1,22) = 20.8$, $MS_e = 62{,}257$], with means of 2,086 msec and 2,202 msec for "yes" and "no" responses, respectively. The semantic case main effect was also significant [$F(1,22) = 9.66$, $MS_e = 133{,}284$]. Mean RTs of 2,086 msec and 2,202 msec were measured for the agent and the "other case," respectively. By coincidence, these values were identical to the means observed for the levels of the response variable.

The only other effect to reach significance was the semantic case × response × probe-type interaction [$F(3,66) = 2.82$, $MS_e = 34{,}244$]. The means for this interaction are shown in Table 4. These scores reveal that the pattern of greatest interest in Experiment 2 was consistent across responses—that is, 1-3 RTs were appreciably faster than 3-1s for both responses in the agent condition, and for neither response in the "other-case" condition. What the semantic case × response × probe-type interaction appears to reflect is that 2-0 RTs exceeded 1-0s by at least 187 msec for every case × response combination except "other-case/no," for which 2-0s were 65 msec faster. We offer no explanation for this outcome.

Table 3 also shows the error rates for Experiment 2. The mean error rate was 9.5% ($SE = .75\%$). There was a significant positive correlation between error rates and RTs [$r(30) = .66$]. The ANOVA applied to the error rates revealed no effects that did not appear in the latency analysis.

Discussion

In most respects, the results replicated the findings in Experiment 1 and of Singer et al. (1988). Answer RT varied mainly as a function of the number of concepts in the relevant or focused semantic case. In particular, RTs in the 1-3 condition were faster than those in the 3-1 condition. "Yes" responses were faster than "no" responses, as Singer et al. (1988) detected throughout.

However, the present results deviated from the previous focused search results in an important way: namely, the impact of probe type was not equivalent for all of the semantic cases examined in the experiment. Whereas the usual 1-3 versus 3-1 RT difference was detected for agent questions, this difference did not appear for the "other case." This was true regardless of whether the "other

Table 4
Mean Correct Response Latencies (in Milliseconds) for the Case × Response × Probe-Type Interaction in Experiment 2

Probe Type	Agent Yes	Agent No	"Other Case" Yes	"Other Case" No
1-0	1810	1896	1952	2167
2-0	2140	2264	2139	2102
1-3	1946	2053	2215	2349
3-1	2193	2385	2291	2399

case'' was the instrument or the location. This asymmetry was reflected by the signifiant semantic case × probe-type interaction.

This result confirmed the prediction that it is difficult for people to disregard the agent case when asked a question that focuses on a competing semantic case. The prediction was consistent with theoretical observations concerning the ''two-way dependency'' between the agent and the action of a proposition (e.g., Schank, 1972, p. 558). Such a relationship may amount to an inherent tendency to topicalize agents. Given the present procedure, this might result in the search and evaluation of the agent, regardless of whether a question focused on the agent or the other case. Consistent with these observations, the number of ''irrelevant'' agent concepts exerted a large impact on the answer time for instrument and location questions in Experiment 2. This was true in spite of the fact that it was the patient and not the agent of the referent fact that functioned as the recall cue during learning, and as the given concept of the test questions.

Two counterexplanations of the present results might be proposed. First, it is possible that the present outcome was due to people's inability to focus memory search on the location and instrument cases, rather than to the privileged status of the agent. Alternatively, it might be argued that the present RT profile resulted from the fact that the agent case preceded the other semantic cases in the learned facts. However, the data of the present Experiment 1 and of Singer et al. (1988) refute both of these alternatives. Singer et al. reported that people can focus memory search on the location and the instrument cases when they compete with other cases, such as the patient case. Likewise, the data of Singer et al. clearly showed that focused memory search was independent of the order of semantic cases in the learned facts.

GENERAL DISCUSSION

In our earlier work, we found that the number of concepts in the semantic case relevant to a question exerts a large impact on answering time, and that the number of irrelevant concepts exerts a smaller though measurable effect (Singer et al., 1988). The present study was designed to inspect the factors that influence the focused search of the semantic-case components of stored facts. In Experiment 1, both question and word test probes were found to initiate focused memory searches. This reveals that the clear given-new structure of the questions is not essential for focused search. The reason for this may be that, using the present fact retrieval procedures, the central profession name (or patient concept in Experiment 2) becomes topicalized by its repeated appearance at the beginning of the learned facts, and by its presentation as the recall cue. Upon receiving the test probe, in the form of either a question or a word pair, the participant uses the topicalized concept to access the pertinent fact in memory. Once this is accomplished, the participant can proceed to retrieve the semantic case of the concept interrogated by the test probe and to search that case.

This proposal raises two issues. First, it may be that learning procedures that do not clearly topicalize one concept would diminish or eliminate the focused search result. Anderson's (1974, 1976) studies of fact retrieval are pertinent to this point. Across learning trials, Anderson used different concepts from a fact to cue the recall of the fact, rather than consistently using one cue. Anderson's retrieval-time data revealed comparable fan effects for all of the concepts in the test probe, rather than a larger fan effect for the relevant concept. To determine whether the form of the fact-learning procedure is crucial to the observation of focused search, it will be necessary to compare our procedure with that of Anderson in a single design.

Second, it is noted that the given-new form of the questions in the present experiments was always congruent with the hypothetical topic structure of the referent fact—that is, the given component of the question coincided with the fact topic (Clark & Haviland, 1977; Yekovich et al., 1979). However, we speculate that the presentation of incongruent questions would not alter the focused search result. The reason for this is that, upon detecting the incongruence, the answerer might ''reconstitute'' the given-new structure of the question (Clark & Haviland, 1977). Then, search and evaluation would proceed from the topic concept to the other semantic cases, in much the same way that they do for congruent questions. However, this remains a matter for empirical examination.

In Experiment 2, we examined people's ability to execute focused memory searches when one of the competing semantic cases is the agent case. The results revealed the usual focused search outcome for questions about the agent, but not for the cases competing with the agent case. This suggests that agent concepts are so integrated with the action concept of a fact that, upon receiving a question about a competing case, the answerer is unable to disregard agent concepts, even though they are irrelevant to the thrust of the question. This finding is consistent with the numerous theoretical and empirical arguments about the privileged status of the agent case. It also indicates that it will be important to make other comparisons among the semantic cases that play a prominent role in theoretical proposals. For example, Chafe (1970) proposed that the patient, like the agent, plays a fundamental role in relation to the action. The procedures of the present study offer a method of investigating proposals of this sort.

The findings in these experiments raise several questions of theoretical significance. Two in particular are of interest to us. First, the present methods provide an opportunity to scrutinize the structure of stored facts. In this regard, Singer et al. (1988) argued that people's ability to focus memory search on the relevant semantic case indicates that compound concepts are organized under fact subnodes, comparable to the theme subnodes of Reder and Anderson (1980). Many facets of this organization are in need of study. To cite one example, theorists disagree on the nature of the representation of a sentence such as *the doctor ate with a fork*. One possibility is that the representation includes an "indefinite" representation of the patient case, such as PATIENT:X (Carlson & Tanenhaus, in press). Alternatively, the representation might make no reference to the patient case (Cottrell & Small, 1983). If the "indefinite" view is accurate, then the representation of *the doctor ate with the fork* may be presumed to be the same as that of *the doctor ate something with the fork*. In this event, it would take the same amount of time to answer the "don't know" question, *did the doctor eat a steak?*, regardless of which of the latter two facts the subject had learned. We have begun a study, using the present fact-retrieval techniques, to address this issue.

Second, it will be important to extend the present findings to situations in which people have acquired facts from spoken and written discourse. We chose, in the present study, to examine overlearned facts, in order to ensure that the subject had a well-defined referent fact represented in memory. However, it still remains to be shown that memory search can likewise proceed in a focused manner when people acquire complex facts, either incidentally or intentionally, from ordinary messages. Extending these investigations to discourse contexts will raise a variety of problems. For example, the identification of the topic of a discourse is guided by a variety of complex and subtle factors (e.g., see Kieras, 1981), whereas the central concepts in the facts of the present experiments were identified by repeated presentation as recall cues. Similarly, in contrast to the fact-retrieval paradigm, the likelihood of effectively storing the ideas of a discourse varies as a function of the importance of those ideas (Kintsch & van Dijk, 1978). Therefore, the study of the structure of facts derived from complex discourse will have to take into consideration the factors that guide discourse comprehension.

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