The effects of integrated knowledge on fact retrieval and consistency judgments: When does it help, and when does it hurt?

Lynne M. Reder
Carnegie-Mellon University

and

Brian H. Ross
Stanford University

To understand how we can easily retrieve facts from memory we must also understand the limitations of memory. Interference has been recognized for a long time as a major source of forgetting. More recently interference has also been shown to affect speed of retrieval. People are slower to recognize a studied fact when other studied facts share some of the same concepts (e.g., Anderson, 1974, 1976; Anderson & Bower, 1973; Hayes-Roth, 1977; King & Anderson, 1976; Lewis & Anderson, 1976; Thorndyke & Bower, 1974). This interference effect has been called the fan effect by Anderson (1974), because of the underlying representation he assumes to explain this interference phenomenon. Specifically, facts are assumed to be represented in a network structure where nodes in the network represent concepts, and links represent relations among concepts. Studied facts that share the same concepts would be represented as propositions with relational links fanning out of the same concept nodes. Time to retrieve any one fact depends on the time to activate the entire proposition. Activation spreads from various concept nodes until the entire proposition is activated, and it is slowed down when there are more links that divide the activation (see Anderson, 1976, or Collins & Loftus, 1975).

This robust fan effect has been under close scrutiny of late (e.g., McClosky & Bigler, 1980; Moeser, 1977, 1979; Smith, Adams, & Schorr, 1978) due to the paradoxical implications of the effect. The paradox is as follows: An expert knows more about the topic than a novice, and we would expect an expert to be able to answer questions about that topic faster than a novice. Yet according to the theory, the more one knows about a particular topic, the more potential interference to that topic, and the slower should be retrieval of any given fact.

Smith, Adams, and Schorr (1978) and Moeser (1977; 1979) partially demystified this paradox by showing that when the facts associated with the particular concept are themselves thematically related, there does not seem to be any interference among them with respect to time to verify the truth of one of these facts. Reder and Anderson (1980) showed that this attenuation of the fan effect only occurs when subjects can make plausibility judgments rather than explicit fact retrieval judgments (e.g., when foils are not thematically related to the facts studied). Reder and Anderson propose a propositional network with the additional assumption that related facts are stored in a subnode structure attached to individual nodes. Recognition and consistency judgments use the same representation and activation process, but require the subjects to use different criteria. When subjects are not forced to retrieve a specific fact, because the foils are not thematically related, subjects stop search at the appropriate thematic subnode. This subnode model accounts for another Reder and Anderson finding: Subjects were slower to verify a fact the more themes there were associated with the fictitious individual. The interference effects did not depend on the number of facts about the themes unrelated to the one specifically queried, only the number of irrelevant themes. This model also explains a similar result of McClosky and Bigler (1980). There is other empirical support for the notion that people will answer a question by judging plausibility, when asked to make recognition judgments, (Reder, 1980, 1981). In everyday situations, people make plausibility judgments rather than trying to decide if a specific fact has been presented to them. We usually do not have to discriminate something that was said to us from something that is true but is an inference or a paraphrase of something that we heard.

These earlier studies suggest the following tentative conclusions. Regardless of the nature of the foils, the fan effect is attenuated by the subnode structure afforded by thematically related material. That is, having subnodes speeds search by pruning search at inappropriate subnodes. Therefore, fan is not computed for the total number of facts learned about a concept. Moreover, when the foils are not thematically related to the learned facts, subjects can also stop search at the appropriate subnode, and circumvent the effect of "relevant fan" (the number of facts associated with the probed theme). However, regardless of whether subjects use a plausibility judgment or must retrieve a specific fact to answer a question, there is still a fan effect for the number of themes associated with a concept, i.e., the number of links from the concept node to the various subnodes.

There were two basic motivations for the research to be reported in this paper: The first is to extend and replicate previous research to insure that there really is a fan effect for number of themes. The second is to examine the effect of relevant fan when subjects are asked to make consistency judgments. We expect a negative fan effect in the consistency condition rather than an attenuation of the effect. The more relevant facts that are available from which to select in order to make a consistency judgment, the faster a subject can find enough information to make a judgment. The fact that there was only an attenuated fan effect with unrelated foils may reflect a mixture of plausibility judgments and direct retrievals when asked to make a recognition judgment.

In addition to the recognition blocks, (one block with thematically related foils and one with unrelated foils), and the consistency judgment blocks, we also included another kind of judgment which we call theme judgments. On these trials subjects see the fictitious individual's name (e.g., Marty) and a theme or topic name (e.g., ship-christening). We expect subjects to stop at the theme node for both types of judgments. The latter condition serves as a check on the processes used for consistency judgments.

Method

Procedural Overview[1]

There were two major phases in the experiment: study and test. In the initial study phase, subjects learned sets of facts about various characters. This phase included an initial presentation of facts for each character, organized by theme. Then subjects studied and were tested on the materials using two sets of dropout procedures, so that they could recall the facts studied about each character. Subjects with below a 90% criterion of final recall were excluded from the analyses.

In the critical phase, the test phase, reaction times to make various types of judgments about the learned material were collected, with each judgment type tested in a different block. The three judgments were recognition judgments with foils thematically related to the sentences actually studied about the probed character, recognition judgments with foils unrelated to the material studied about the probe character, and consistency judgments (whether the probe was consistent with what had been studied). Intermixed among these various test blocks were theme judgments, where subjects would see a character name and a theme name, rather than an entire sentence.

Both speed and accuracy were emphasized. Subjects were told to respond as fast as they could while remaining very accurate. Feedback was given after every trial.

[1] This description must be brief due to space limitations, for a fuller description, consult Reder and Ross (in preparation).

Table 1

Examples of Studied Facts and Test Questions

# of facts in the three themes	
3-2-1	Alan bought a ticket for the train. Alan heard the conductor call "All aboard". Alan arrived on time at Grand Central Station
	Alan added bleach to the rinse cycle. Alan sorted his clothes into colors and whites.
	Alan fell while skiing down the steepest stretch.
1-1-0	Brian watched the freaks in the side show.
	Brian wanted to major in psychology.
4-0-0	Steven called to have a phone installed. Steven read and signed the lease. Steven unpacked all of his boxes. Steven mailed out change of address cards.
3-3-0	James compared 5 different model cars. James paid the car dealer in cash. James put the license plates on his car.
	James checked the Amtrack schedule. James arrived on time at Grand Central Station. James watched the trains from the platform.

Recognition	Consistency	
Target	Target (Yes)	(3-2-1) Alan bought a ticket for the train.
Foil Unrelated	Inconsistent (No)	(1-1-0) Brian unpacked all of his boxes.
Foil Related	Thematic (Yes)	(3-3-0) James bought a ticket for the train.
Theme judgment (True)		(3-2-1) Alan train
Theme judgment (False)		(3-2-1) Alan circus

Design and Materials

Table 1 illustrates some of the material that a subject might see. There were several factors that define the condition within which a particular probe is tested: relevant fan (one to four facts related to the probe), theme fan (one to three themes learned about each character), and irrelevant fan (zero to five facts, irrelevant to the probe, that were also learned about the probed character).

The test variables were type of judgment required (recognition with related foils, with unrelated foils, consistency judgments, and theme judgments) and probe type (target, foils, and thematic, the latter defined only for consistency judgments). Some examples are illustrated in Table 1. Study and foil materials were constructed for each of the 33 subjects randomly.

Results

Reaction times were truncated to 5 seconds and missing cells replaced with RTs of 5 seconds. An analysis of variance was performed separately on each of the eleven task types because the variances are not the same in the different tasks. The data have been collapsed in different ways to analyze different aspects of the experiment, each of which can only be summarized here.

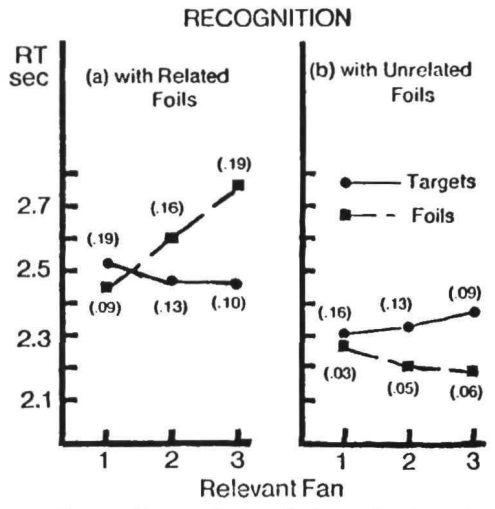

Figure 1. Mean reaction times (and proportion of errors) as a function of relevant fan in the recognition blocks.

First consider the recognition blocks, shown in Figures 1 and 2 (with the percent error listed above each point). There is no effect of relevant fan in the unrelated foil block. For the thematic foils, reaction time increased with relevant fan and, as in Reder and Anderson (1980), the targets in this block showed an effect of relevant fan on accuracy. As the number of themes associated with the probed character increased, reaction time increased for the targets in both recognition blocks, but not for the foils.

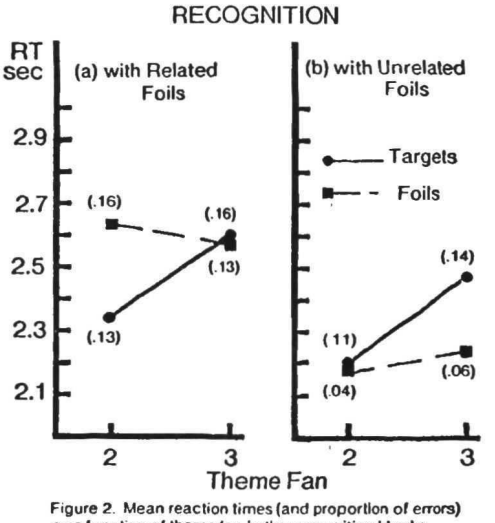

Figure 2. Mean reaction times (and proportion of errors) as a function of theme fan in the recognition blocks.

Now, consider the results from the consistency blocks of trials, shown in Figures 3a and 4a. Reaction times are plotted only for target (presented) sentences and for thematically related sentences that were not studied, because the unrelated statements cannot be plotted as a function of relevant fan. There is a significant negative fan effect for thematic statements, such that subjects are faster to make a consistency judgment the more facts they know on the relevant topic. Reaction times also decrease for targets in the consistency block. There is a significant effect for both targets and themes on accuracy, such that subjects are also more accurate the greater the relevant fan. The number of themes associated with the probed characters, collapsed over the three probe types, show a fan effect.

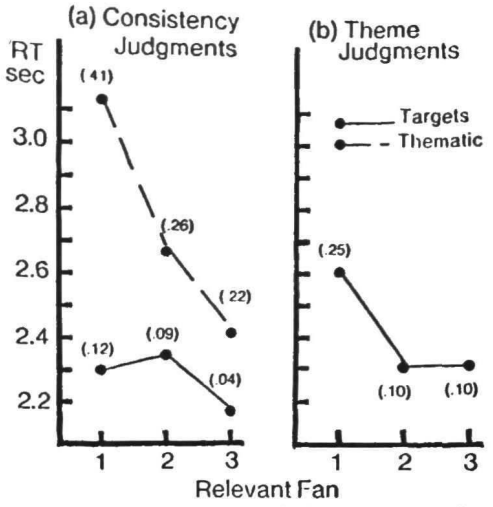

Figure 3. Mean reaction times (and proportion of errors) as a function of relevant fan in the consistency block and for the theme judgments.

Theme judgments (Figures 3b and 4b), like consistency judgments show a significant negative fan effect for the relevant theme for the positive judgments. There is a strong positive fan effect of number of themes. In no task was there an effect of the irrelevant fan on reaction time.

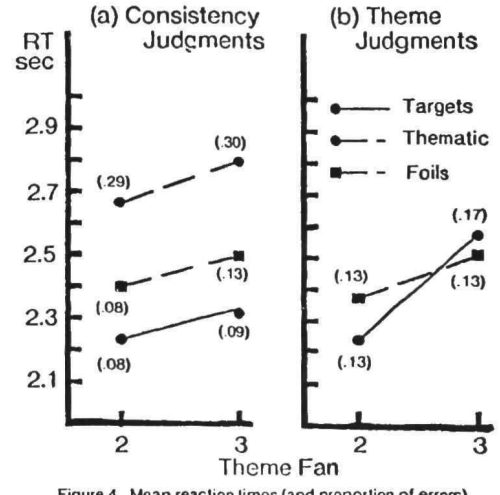

Figure 4. Mean reaction times (and proportion of errors) as a function of theme fan in the consistency block and for theme judgments.

Discussion

The conclusions that can be drawn from this pattern of data are straightforward. First, we have a better understanding of the conditions under which the fan effect is obtained. The fan effect is obtained only when subjects cannot use plausibility to answer the question, when subjects are asked to find a specific fact in memory and the foils are thematically related. In other situations, the strategy is to try to decide if a statement is true using consistency judgments, regardless of whether or not subjects are asked to make consistency judgments or in fact asked to make recognition judgments. This result has been found elsewhere (Reder, submitted; Reder & Anderson, 1980).

The suggestion of a fan effect due to the number of themes (McCloskey & Bigler, 1980; Reder & Anderson, 1980) has been confirmed and extended. We found, when controlling for total number of facts studied, that the number of themes associated with the character positively affects reaction time.

More important, perhaps, is the finding that fan facilitates question-answering when exact fact retrieval or recognition is not needed, in the consistency and theme judgments. This is a better resolution of the paradox of the expert than a finding that fan need not hurt retrieval time. Rather, we have found that knowing more actually speeds decision time in many situations. Our explanation for a negative fan effect (see Reder, submitted, and Reder & Ross, in preparation, for a more thorough explanation)is that the more facts attached to the subnode the stronger the link to that subnode. In other words, rate of activation is not only a function of the number of links to a concept but the relative strength of various links. Strength of a link is a function of its usage (usage depends on the frequency that the link is traversed), and recency of last usage. In fact, the experiments reported here manipulated strength independently, and found support for this notion of differential strength of arcs affecting response time. For space considerations, that result was not discussed here. Those results will be described in detail in Reder and Ross (in preparation).

In summary, we have learned that experts are not hampered by knowing too much for several reasons: first, experts organize their information into more specific subtopics. This is reasonable, because experts understand their topic area well enough to appreciate subcategories. Second, experts are not asked whether they recognize having been told a specific fact; rather, they are asked to judge whether something is true or something is plausible. Therefore, they can use their redundant knowledge in order to speed judgment.

References

Anderson, J.R. Retrieval of propositional information from long-term memory. Cognitive Psychology, 1974, 5, 451-474.

Anderson, J.R. Language, Memory, and Thought. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976.

Anderson, J.R., and Bower, G.H. Human Associative Memory. Washington: Winston & Sons, 1973.

Collins, A.M., and Loftus, E.F. A spreading-activation theory of semantic processing. Psychological Review, 1975, 82, 407-428.

Hayes-Roth, B. Evolution of cognitive structures and processes. Psychological Review, 1977, 84, 260-278.

King, D.R.W., and Anderson, J.R. Long-term memory search: An intersecting activation process. Journal of Verbal Learning and Verbal Behavior, 1976, 15, 587-606.

Lewis, C.H., and Anderson, J.R. Interference with real world knowledge. Cognitive Psychology, 1976, 7, 311-335.

McCloskey, M., and Bigler, K. Focused memory search in fact retrieval. Memory & Cognition, 1980, 8(3), 253-264.

Moeser, S.D. The role of experimental design in investigations of the fan effect. Journal of Experimental Psychology: Human Learning and Memory, 1979, 5, 125-134.

Reder, L.M. Plausibility Judgments vs. Fact Retrieval: Efficient Strategies for Question-Answering. Paper presented at meetings of the Psychonomics Society, Nov. 1980.

Reder, L.M., and Anderson, J.R. A partial resolution of the paradox of interference: The role of integrating knowledge. Cognitive Psychology, 1980, 12, 447-472.

Reder, L.M., and Ross, B. A resolution of the paradox of interference: The role of integrated knowledge in fact retrieval and consistency judgments. (In preparation.)

Smith, E.E., Adams, N., and Schorr, D. Fact retrieval and the paradox of interference. Cognitive Psychology, 1978, 10, 438-464.

Thorndyke, P.W., and Bower, G.H. Storage and retrieval processes in sentence memory. Cognitive Psychology, 1974, 5, 515-543.