Do Baseball Fans Experience the Fan Effect?

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Abstract

A set of studies examines whether domain knowledge for baseball will enable participants to overcome the fan effect from baseball-related sentence sets. In a first study, neither high nor low knowledge participants overcame the fan effect when baseball positions and locations were randomly paired together. In a second study, when positions and locations were consistent with baseball expectations, both high and low knowledge participants overcame the fan effect on target sentences. However only high knowledge participants showed no effect on foils. The results suggest that prior knowledge can affect both representation and decision phases underlying recognition memory.

Domain-related Knowledge and Memory

Research on expertise has generally found that possession of domain-related knowledge or experience leads to superior problem solving, learning, and memory performance (see Feltovich, Prietula, & Ericsson, 2006 for review). The superior performance is thought to be due to extensive, easily accessible and well-connected knowledge structures in long-term memory (Bedard & Chi, 1992; Ericsson & Kintsch, 1995; Ericsson & Staszewski, 1989) which allows for more connections or associations to be made with incoming stimuli. Interestingly, another body of research suggests that increasing the number of associations among incoming stimuli can lead to a detriment in memory performance (See Reder et al., 2007 for review). This phenomenon, called the *fan effect*, refers to the slowdown in verification time that occurs as a function of the number of associations with a presented concept (e.g., Anderson & Bower, 1973; Lewis & Anderson 1976; Reder, Donavos, & Erickson, 2002).

What is the Fan Effect?

Typically the *fan effect* is demonstrated by having participants study sets of sentences that vary in the number of associations stated between concepts such as objects and locations (Anderson, 1974; Reder et al., 2007). The number of associations that each object or location is paired with is the "fan" size, and it usually varies between one and three.

For example, participants could be presented with the following sentences:

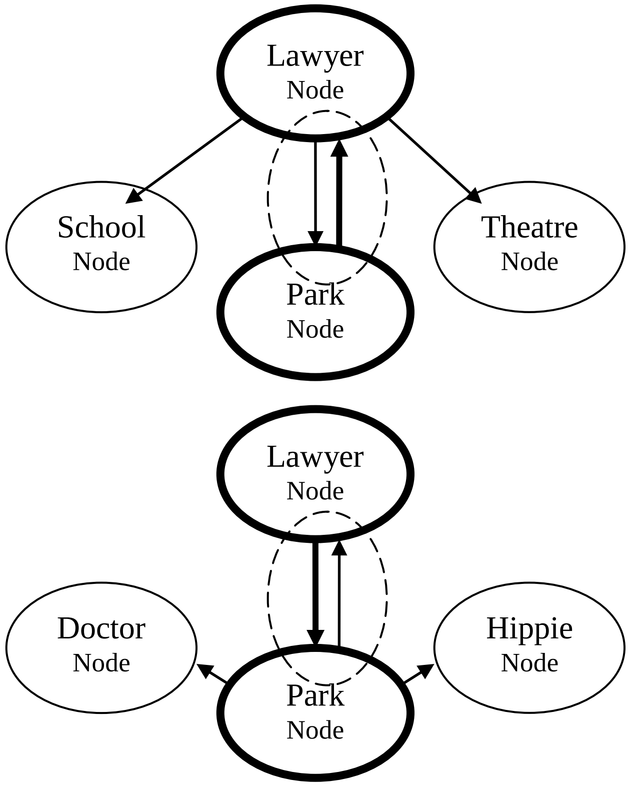
The lawyer is at the school.
The lawyer is at the park.
The lawyer is at the theater.
The doctor is at the museum.

In this example, the lawyer has a fan size of three and the doctor has a fan size of one. Participants are required to memorize these sentences to some criterion during the study phase. Then, after reaching criterion, participants move to a recognition test phase where they are asked to decide as quickly as possible whether or not sentences appeared in the study list. Typically, participants take longer to verify that the statement "The lawyer is at the school" appeared in the study list than "The doctor is at the museum," due to the larger fan of lawyer in this set.

There are two main accounts that have been offered for the *fan effect*: the propositional network theory (Anderson, 1974; Reder et al., 2007) and the situation model theory (Radvansky, Spieler & Zacks, 1993; Radvansky, 1999).

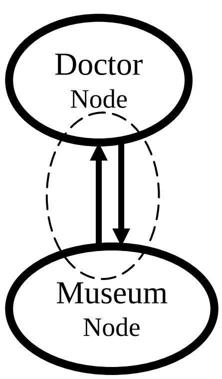
The propositional theory suggests that the fan effect is a function of the number of pathways that branch from a target concept in a memory network and a corresponding reduction in the spread of activation. To illustrate this, imagine that nodes exist in memory that correspond to the presented concepts (e.g. lawyer, park, doctor, school, park, theater, museum). When participants are required to verify if they have seen a sentence such as "The lawyer is in the park," the nodes "lawyer" and "park" are activated. As shown in the top of Figure 1, activation spreads along all connecting pathways that exist, represented by the arrows. For the "lawyer," with the fan of three, activation is diffused among the pathways connected to "school," "park," and "theater." Similarly, if three statements are presented involving "park", as shown in the bottom of Figure 1, then activation would also be diffused in that case.

Figure 1:
Two models with fan sizes of three



In contrast, the sentence, "The doctor is at the museum," has a fan size of one. As shown in Figure 2, there will be no diffusion of activation in this representation because there is only one pathway branching from each of the nodes "doctor" and "museum."

Figure 2:
A model with fan size of one



In the fan of three examples, the partitioning of activation among associations decreases the amount of activation that spreads to each connecting pathway, which increases the amount of time it takes participants to become aware of the target pathway (Jones & Anderson, 1987). In this model, the distribution of activation to irrelevant pathways is called interference (Anderson, 1974), and indeed the empirical results have generally supported that the number of associations predicts verification time (Reder et al., 2007).

However, one exception in previous empirical results, has been the observation that not all fans of three are equal. The situation model account suggests that the type of fan represented by the bottom network in Figure 1 will experience less interference than the type of fan represented in the top panel. The situation model account posits that when people can integrate incoming information into a single representation then they will not be susceptible to the interference due to multiple associations (Radvansky, 1999). In this explanation, slower verification times are not the result of the number of associations that are present, but rather the number of models that need to be searched. From this perspective, one can imagine all three sentences in the second example could refer to a single situation in the park, perhaps with the lawyer meeting the hippie and the doctor. If these three sentences are integrated into one representation in memory, then even though there are three items associated with park, there is only one model to search. Consistent with this approach, several studies have demonstrated that the ability to integrate sentences into a single representation or model can eliminate the fan effect (Gomez-Ariza & Bajo, 2003;Moeser 1979; Myers, O'Brien, Balota & Toyofuku, 1984; Radvansky, Spieler & Zacks, 1993; Smith, Adams & Schorr, 1978).

Although it has not yet been tested, one implication of this model is that participants may be able to overcome the fan effect for domain-related information, as prior knowledge may allow readers to represent and integrate sets of sentences into a single model. Thus, the goal of this research was to investigate if the possession of prior knowledge related to the topic of the sentences would eliminate the fan effect in recognition memory.

Experiment 1

Method

Participants. Participants were 110 students in introductory psychology classes at University of Illinois at Chicago who received course credit for their participation.

Procedure. Participants were administered a baseball-related fan task in groups ranging in size between 1 to 12. The sessions last approximately 1 hr. The stimuli were created by randomly pairing a type of baseball player (e.g., catcher) with a location on a baseball field (e.g., second base) to create sentences (e.g., The catcher is at second base). The task was analogous to the fan task used by Radvansky and Zacks (1991) with participants being presented 18 sentences and being asked to memorize them. The 18 sentences contained 4 at fan size 1, 4 at fan size 2 and 10 at fan size 3.

Each participant was seated at their own computer. During the study phase, the sentences were presented on a computer screen one at a time for 7-seconds each. After the study phase, participants we retested for their memory of the sentences. If participants were unable to remember 90 percent of the sentences correctly they repeated the study and test phase. Feedback was provided for incorrect answers during the test phase. This cycle was continued until participants reached the 90 percent criterion.

After the participants reached the 90 percent criterion, the completed a speeded recognition task. Twelve target sentences were presented from the studied materials (four sentences at each of the fan sizes of one, two, and three; Similar to Radvansky and Zacks (1993), studied sentences that had both a player and a location with more than one association were not used.).

Twelve foils were created by repairing the studied players and locations. The re-pairing was done within the fan size so fan 1 player/locations were re-paired with fan 1 player/locations. Participants pressed the “Z” key if the sentence was not studied and “M” if it was studied.

At the end of the study, participants completed a 45-item baseball knowledge questionnaire (Spilich, Vesonder, Chiesi & Voss, 1979). Average performance on the baseball questionnaire was 16.47 (SD 12.66) Range was 0 to 41. Two levels of domain knowledge were defined by a median split at 15. All participants’ accuracy was above 90% on the speeded recognition task and there was no significant difference for accuracy between high and low knowledge participants.

Results

A 2 X 3 mixed ANOVA was used to assess the effects of Fan Size (one, two or three), and Expertise (high, low baseball knowledge) on correct verification RT. Similar to Radvansky, Spieler, and Zacks (1993) responses that were faster than 500 ms and slower than 10,000 ms were considered errors. The pattern of results is shown in Figure 1. The ANOVA revealed a main effect for Fan Size, $F(2, 216) = 7.36$, $p < .001$, $\eta^2 = .06$, and Expertise, $F(1, 108) = 8.24$, $p < .01$, $\eta^2 = .06$, but not a Fan Size X Expertise interaction, $F(2,216) < 1$, $\eta^2 = .01$. As expected, participants experienced a slowdown in the recognition test as the number of associations increased from 1 to 3. There was also a main effect such that high knowledge participants made faster decisions than low knowledge participants. However, neither high knowledge nor low knowledge participants overcame the fan effect. Both high and low knowledge participants experienced increasing verification times as fan size increased. The same pattern of results was observed for the studied and foil sentences in this study.

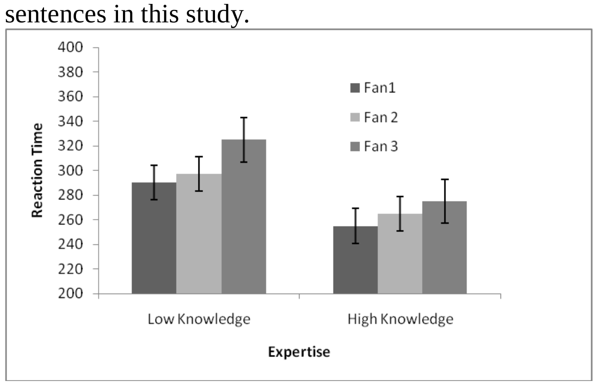


Figure 1: Verification time per syllable (ms) with random pairings in Experiment 1. Error bars represent standard errors.

These results provide a replication of the basic fan effect finding. As fan size increased, so did verification times. Simply having prior knowledge for the topics of the sentences did not change this pattern. However, because the pairings were random, it is possible that this task did not test the situation model account. In order to support the construction of a single model, one may need sentences that “make sense” within the domain. According to the situation model theory, the fan effect should not be eliminated unless participants are able to integrate the multiple players and locations into a single model. Randomly pairing the players and locations together made pairs that were not consistent with baseball experience and which may not have made it any easier for high knowledge participants to integrate sentences into single situations. Thus, in Experiment 2, we presented sentences that were more consistent with baseball situations.

Experiment 2

The goal of this second study was to use sentences that were more consistent with real baseball situations, and to test whether prior knowledge might affect performance under those circumstances. For this study, players and positions were paired to reflect plausible situations, such as:

The reliever is at the mound.
The manager is at the mound.
The catcher is at the mound.

These sentences could represent a pitcher conference, an event that happens in the majority of baseball games.

Method

Participants. Participants were 110 students in introductory psychology classes at University of Illinois at Chicago who received course credit for their participation. These were new participants that had not participated in Experiment 1.

Procedure. Participants were administered a baseball-related fan task almost identical to the one administered in Experiment 1. The only difference was that that the players and positions were not randomly paired together, but were paired to create plausible sentences by the researcher.
The 12 foils were also consistent with baseball expectations. Some example foil sentences were:

The pinch runner is at second base.
The reliever is at first base.
The pitcher is at the bullpen.

Participants again completed a 45-item baseball knowledge questionnaire at the end of the study. Average performance was 14.53 (SD = 13.35). Range was 0 to 41. A median split of 15 was used similar to Experiment 1. All participants' accuracy was above 90% on the recognition task and there was no significant difference between high and low knowledge participants.

Results:

A 2 X 3 mixed ANOVA was used to assess the effects for Fan Size and Expertise on correct verification RT. Again responses that were faster than 500 ms and slower than 10,000 ms were considered errors. The pattern of means can be seen in Figure 2. The ANOVA revealed a main effect for Fan Size, $F(2, 216) = 7.82$, $p<.01$, $\eta^2=.07$, but no main effect for Expertise $F(1, 108) < 1$, $\eta^2=.01$. However, there was a Fan Size X Expertise interaction, $F(2, 216) = 7.16$, $p < 01$, $\eta^2=.07$.

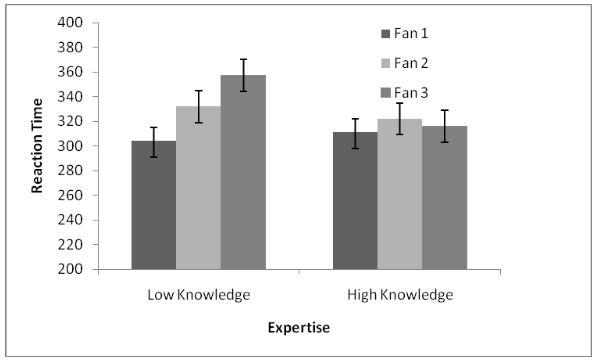


Figure 2: Verification time per syllable (ms) with plausible pairings in Experiment 2. Error bars represent standard errors.

As in Experiment 1, participants experienced an overall slowdown in verification time as the number of associations increased from 1 to 3.

However, this effect was qualified by a significant Fan Size by Expertise interaction, with low knowledge participants showing the typical fan effect, and high knowledge participants showing a diminished fan effect. On the face of it, these results can be seen as consistent with the situation model account. They suggest that, now that the sentences are plausible, participants with prior knowledge may be able to create a single model for each set of sentences, which allows for efficient search of memory, regardless of the number of overlapping associations.

What is responsible for the elimination of the fan effect among high knowledge participants? To further examine this question, we performed some additional analyses and in particular we examined whether performance improved on both target and foil trials. If the better performance among high knowledge participants is due to the efficiency of needing to search only a single model, then this account would predict facilitation for both correct acceptance of targets and rejections of foils. However, as can be seen in Figure 3, different patterns were found across target (top panel) and foil (bottom panel) decisions.

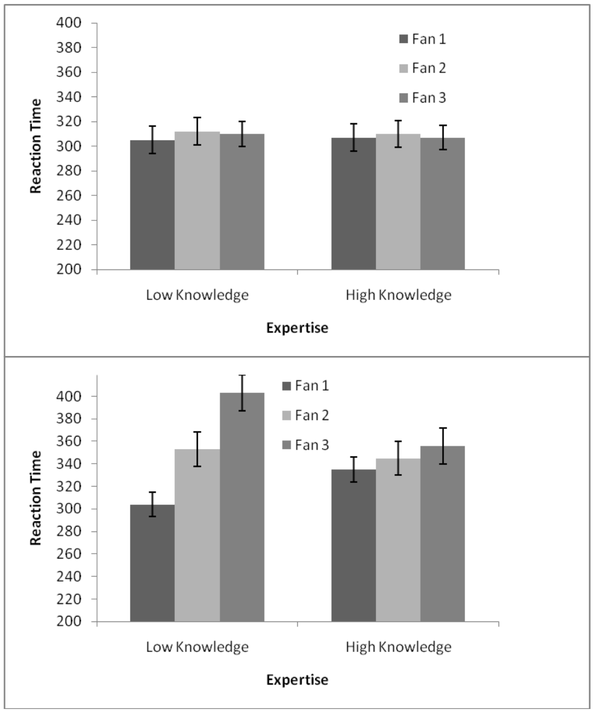


Figure 3: Reaction times per syllable (MSec) for studied sentences (top panel) and foils (bottom panel) . Error bars represent standard errors.

First, looking at performance on the studied sentences, here we can see that in fact, no fan size effect was found for either knowledge group. A 2 X 3 mixed ANOVA showed that there were no significant effects for Fan Size, F (2, 216) = 1.91, p <.15, η^2=.05, or Expertise, F (1, 108) = 1.31, p < .27, η^2=.01. Nor was there a Fan Size X Expertise interaction, F (2,216) = 1.60, p < .21, η^2=.03. Thus, neither high nor low knowledge participants experience a fan effect on correct verifications for plausible sentences.

Quite a different picture is seen when one examines the response times for the foils. Here another 2 X 3 mixed ANOVA revealed a main effect for Fan Size, F (2, 216) = 20.16, $p<.01$, η^2=.23. Although there was no main effect for Expertise, F (1, 108) < 1, η^2=.02, there was a Fan Size X Expertise interaction, F (2,216) = 8.17, p < 01, η^2=.07. Low knowledge participants were especially vulnerable to the slowdown on foils as fan size increased.

The results show that the fan effect was diminished for experts on both correct verifications and rejections, while novices experienced a fan effect, and this was driven by decision times on the foils.

DISCUSSION

According to the situation model account, the fan effect should be eliminated when participants are able to integrate multiple associations from a set of sentences within a single situation model. Consistent with this approach, it appears that presenting participants with sentence sets representing plausible combinations of baseball players and positions enabled both high and low knowledge participants to respond quickly to studied sentences, regardless of the number of associations among them. This finding is consistent with the situation model account. It is also reminiscent of findings that have demonstrated that the fan effect is diminished when participants are able to integrate the sentence sets into stories (Ariza & Bajo, 2003; Myers, O'Brien, Balota & Toyofuku, 1984; Smith, Adams & Schorr, 1978).

In addition, the further analysis of the studied and foil sentences separately revealed the interesting result that the non-studied foils showed a different pattern of verification times than the studied sentences. When participants were presented with foil sentences that were also consistent with realistic baseball situations, the performance of high and low knowledge participants diverged. High knowledge participants experienced a diminished fan effect. However, low knowledge participants foil response times were more affected by fan size. Thus, it does not appear that the low knowledge participants were able to efficiently reject the foils. If both low and high knowledge participants were able to form single models from the sentence sets, decisions on foils should have been as easy as on targets. Only the high knowledge participants showed this advantage.

Thus, this result highlights another recent perspective from the fan effect literature which emphasizes that recognition memory results need to be thought of as both being a function of differential representation in memory, as well as being a function of decision making processes (Anderson, 1999). In essence, making a recognition judgment requires not just memory retrieval or search, but also an evaluative assessment or decision. This current dissociation between performance on targets and foils suggests that high and low knowledge participants may be achieving fast verification times to studied sentences via different means. While high-knowledge participants may have the advantage of a single model which allows for fast, direct retrieval for each set of sentences, the low-knowledge participants may have used some sort of plausibility heuristic during the verification task. This improved their performance for the studied items, but made it difficult for them to reject the foils.

An alternative explanation is that the quality of the memory representations for the sentence sets differed among the low and high knowledge participants. It is possible that the high knowledge participants were able to create more detailed or distinctive traces for the sentence sets, which improved their ability to decide both what was studied and what was not (Hunt & Einstein, 1981). Low knowledge participants on the other hand, may have had "good enough" representations to aid performance on the studied items, but perhaps these traces were not detailed enough to aid them on the foils. Such a result would be consistent with a few recent findings that expertise can confer advantages in episodic memory (i.e. memory for words and order in domain-related word lists) (Rawson & Van Overshelde, 2006; Ricks & Wiley, 2009).

While most previous studies have suggested that reductions in the fan effect are due to unitized representations, thepresent results suggest that effects on decision processes are critical to consider. However, decision processes can only be explored when one uses plausible foils that require detailed memory for the studied sentences. In present study, thematic materials allowed all participants to avoid fan effects for the studied sentences, but only high knowledge participants were better able to detect foils. Thus the present design allowed for a clearer understanding of how prior knowledge may support both better integration and discrimination in recognition memory.

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