Transfer of High Domain Knowledge to a Similar Domain

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October 22, 2007

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Abstract

Researchers have widely examined domain knowledge yet rarely investigate the transfer of knowledge from one domain to another. This study sought to fill in the literature gap concerning the impact of domain knowledge on memory in a similar situation. Specifically, this study examined whether high knowledge of baseball could enhance memory for the similar, yet unknown domain of cricket, using a 2 (knowledge) x 2 (prime) design. An interaction occurred, indicating that when primed, baseball knowledge improves memory for cricket events in high baseball knowledge individuals, but reduces memory in their low knowledge counterparts. These results suggest that extensive knowledge in one domain allows it to serve as an organizational framework for incoming information in a similar domain; conversely, priming poorly understood domain knowledge results in negative transfer.

Transfer of high domain knowledge to a similar domain

Remembering past events and behaviors is an essential element of learning. Moreover, the ability to generalize accumulated memory to new domains is extremely advantageous, reducing learning time as well as improving performance. This study explores the uncharted territory of convergence between the memorial enhancements of domain knowledge and transfer.

Domain Knowledge and Memory

Domain specific knowledge, the contents of the information processing software utilized by cognitive processes, has recently demonstrated a greater influence on cognitive processes than some of the hardware which utilizes it, working memory, singularly accounting for 54.9% of the variance in a memory task (Hambrick & Engle, 2002). Defined as knowledge pertaining to a specific subject or area and gained through previous study, domain knowledge can take the form of either procedural or declarative knowledge.

In a seminal study, Chase and Simon (1973) found that chess masters recalled chess pieces on a board ‘in-play’ more effectively than non-experts; however, they recalled random patterns of pieces no better than non-experts (see Engle & Bukstel, 1978, for a similar finding using bridge players). Related findings on the significant power of prior knowledge on memory include research within the domains of maps (Gilhooly, Wood, Kinnear, & Green, 1988), music (Meinz & Salthouse, 1998), dance steps (Allard & Starkes, 1991), economic problem-solving (Voss & Post, 1988), as well as sports such as soccer (Schneider, Korkel & Weinert, 1989), and baseball (Hambrick & Engle, 2002; Recht & Leslie, 1988). Even mnemonists appear to enhance their memory by converting numbers into domains with which they have great familiarity; receiving numbers not translatable to the familiar domain severely limits their memory (Hunt & Love, 1972; Ericsson, Chase & Faloon, 1980).

Subsequent theories were devised to account for the evidence that domain experts working within their expertise show minimal susceptibility to tasks which require maintenance of information within working memory (see Ericsson & Kintsch, 1995, for a review). Hambrick and Engle (2002) theorized that high domain knowledge individuals demonstrated superior recall because they use a pre-existing internal schema to organize incoming information. According to Glaser and Chi (1988), excessive exposure to a certain domain enables an expert to modify the conceptual organization of a pre-existing mental schema to more appropriately represent aspects of the domain, benefitting a person by: elucidating a mental image of the domain, aiding problem-solving by accelerating the process, and allowing a person to incorporate additional information within the domain in an appropriate mental location.

Chase and Simon (1973) suggested that the extensive prior knowledge of chess masters allows them to recognize familiar patterns of pieces in 'chunks', i.e., large groups of multiple pieces, minimizing the strain on working memory by placing a pointer in working memory to the appropriate pattern in LTM; non-experts, however, must represent pieces either individually in working memory or by using smaller chunks. The multiple template hypothesis (Gobet & Simon, 1996) proposes that templates of memory traces for chess piece arrangements are stored in LTM with variable slots stored in short term memory (STM). This differs from the chunking hypothesis in that LTM is accessed at retrieval times, instead of working memory.

A similar yet more general theory comes from Ericsson and Kintsch (1995) who suggest that an extensive knowledge base within a domain coupled with retrieval cues associated with incoming information enable an expert to quickly retrieve and manipulate information. This long term working memory (LT-WM) theory proposes that while information is stored and retrieved directly from LTM, the use of organized retrieval cues called retrieval structures enable

LTM to function much like working memory, but only in the domain of expertise. In summary, current theories predict that prior knowledge of a domain can enable individuals to remember information domain-relevant at levels that appear extraordinary, due, in part, to existing elaborate organizational schemas and established retrieval structures, created for that domain through excessive domain exposure: an exceptional working memory is not necessary.

Transferability of Domain Knowledge

Knowledge transfer, another widely studied area of psychological research, intrigues educators and researchers alike. Transfer is the process of carrying over knowledge from one domain to another (Detterman, 1993), comprising a broad area almost synonymous with learning (Kimball & Holyoak, 2000). Most psychological studies referring to transfer concern general transfer, defined as transfer from a broad area (such as problem-solving skill learning or how to use strategies) to a specific area (applying the problem-solving skill or strategies to appropriate problems or situations). Near transfer consists of applying similar skills or behaviors in virtually identical settings, whereas far transfer consists of applying them in disparate settings which appear very unlike the setting in which they were acquired (Detterman, 1993).

Near transfer of problem-solving techniques has been well documented (e.g., Gick & Holyoak, 1980; Novick, 1990; Keane, 1988) whereas evidence for far transfer has proven difficult to obtain, except under rather coerced circumstances (Detterman, 1993; Glaser & Chi, 1988). In one such attempt, Voss and Post (1988) gave Russian political science experts and expert chemists political science problems and observed that the chemists performed no better than novices at finding solutions.

Transfer of declarative domain knowledge from one domain to another, in a non-problem-solving context is rather rare[1]. Thorndyke (1977) conducted one such study, observing that participants who read two stories with similar structures exhibited significantly better recall of the second story; participants receiving stories with unrelated structures but similar characters or unrelated structures and characters, recalled either less or the same amount (respectively) of information as they did on the first story. However, the information was experimenter-taught, not pre-existing. In other words, the study did not concern true “prior knowledge”; their prior knowledge consisted of knowledge given to the participant by the experimenter and thus, certainly would neither be incorporated into (Dochy, Segers, & Buehl, 1999) nor representative of an elaborate pre-existing organizational schema (Glaser & Chi, 1988; see Ericsson & Polson, 1988, for an exception).

Thus far this review has focused on positive transfer. A more sparse literature exists on negative transfer, that is, the observation of a performance decrement in the target task. In his study, Thorndyke (1977) observed that stories with similar characters but not similar structures interfered with recall of the second story, as compared to two unrelated stories. The similarity of the characters between the two different stories apparently “over-primed” the participants, such that they expected to find similarities when they shouldn’t have. The above result corresponds well with the work of Landrum (2005) who found that surface similarities but tactical differences in problem-solving tasks induce negative transfer, as predicted by Osgood’s (1949) classic theory on transfer.

In a particularly relevant study, Marchant, Robinson, Anderson, & Schadewald (1991) observed that tax experts demonstrated negative transfer, unlike novices, when given a period of “puzzlement” in which they predicted the outcome before learning about the solution to the analogous problem that preceded the target hypothetical tax problems. With no puzzlement period, the experts outperformed the novices, with or without the analogical problem. To summarize, much research exists supporting transfer (cf. Detterman, 1993), predominantly involving near transfer of problem-solving tasks. Evidence for transfer of pre-existing domain knowledge, whether positive or negative, is extremely rare.

Rationale for Study and Predictions

Overall, research to date has established that those with greater domain knowledge outperform those with lesser domain knowledge on virtually all measures of memory or problem-solving performance within that domain; conversely, the literature regarding transfer of pre-existing domain knowledge to an alternate domain is sparse. The goal of this study was to fill these gaps by studying the ability of individuals to transfer their existing knowledge of one domain to another, unfamiliar domain. Specifically, the following question was posed: can prior knowledge in baseball serve as a framework on which to build the lesser known yet somewhat similar sport of cricket?

When contemplating whether transfer will occur, several distinct possibilities exist. According to the LT-WM theory, individuals with no prior knowledge of cricket who attempt to map incoming information about the sport onto their pre-existing framework for baseball should be better served by an extensive domain knowledge of the latter, much in the same way that the mnemonist SF was served by his extensive memory of running times when memorizing random sequences of digits (Ericsson et al., 1980). However, it must be reiterated that this is an extension of the theory to the transfer paradigm, as this model was designed to account for improved memory within a specific domain.

Regarding the likelihood of transfer, the amount of similarity between the two domains is important (Medin, Goldstone, & Gentner, 1993). According to Osgood (1949), negative transfer increases with similarity when the stimuli and responses in tasks are varied, whereas positive transfer increases with similarity when only the stimuli is varied but the responses are identical. The extent to which the individuals would perceive the two domains as similar was largely unknown, and thus this study should be considered exploratory. Spontaneous positive or negative transfer might have occurred if the participant perceived similarities between the two domains and attempted to map the new information into the framework of the old domain, a result observed by Thorndyke (1977).

Because it was also possible that the domains of baseball and cricket diverge enough to preclude spontaneous transfer, a priming mechanism was used to encourage transfer. Thus, in addition to high and low knowledge of baseball groups (knowledge factor), participants were either primed to think of cricket in terms of baseball or not primed (prime factor). An intensive prime was used in this study by teaching some participants, prior to the memory task, how to produce an external visualization of their prior knowledge of baseball, called a knowledge map. Participants were expected to use this visualization to draw lucid connections between the two domains.

Knowledge maps (k-maps) have demonstrated an ability to aid the recall of macro level ideas of scientific content (Chmielewski & Dansereau, 1998). O'Donnell and Dansereau (2000) define k-maps as two-dimensional node-link networks connecting important concepts, with idea units enclosed in nodes, and a system of differentiated links representing relationships. Individuals should utilize their own internal organizational schema of their prior domain knowledge to generate a k-map for use as a template for incoming information in related domains (Hall, Dansereau & Skaggs, 1992).

It was postulated that if transfer occurs, it seems quite likely that the prime groups would exhibit the most. The k-map should awaken associations between the two sports which might otherwise remain dormant, if not so overtly addressed. Additionally, the fact that the participants generated their own k-maps should have enabled them to exploit any prior domain knowledge of baseball, and those with greater baseball knowledge should benefit more from the k-maps than those with lesser knowledge because of their more highly elaborated schema for organizing incoming information about the new domain (Glaser & Chi, 1988; Hambrick & Engle, 2002) and established retrieval structures (Ericsson & Kintsch, 1995). No negative transfer was predicted.

Method

Participants

Participants were recruited from psychology undergraduate and graduate classes at a small university in west Texas, and were offered extra credit for their participation. The mean age of the participants was 22.35 (SD = 4.81) and 37.2% were male. Concerning ethnicity, 83.6% of the sample were European-American, Non-Hispanic, 7% were European-American, Hispanic, 4.7% were African-American, and 4.7% were Asian-American. Of the 42 participants who completed the pre-test, 41 completed the experiment; the other participant was unable to be contacted for the second session. There were 11 participants in the high knowledge of baseball, no prime group, and 10 participants in the remaining three groups (high baseball knowledge prime, low baseball knowledge prime, and low baseball knowledge no prime).

Procedure

Pre-Test. During the first session, participants took baseball knowledge assessments to determine whether they have high or low baseball knowledge. A median split of the participants' mean scores was used to divide the participants into high and low knowledge groups. Also, participants received general sports knowledge tests and working memory tasks to assess potential covariates.

Experimental Procedure. The low and high baseball knowledge participants were divided between the prime and no prime groups and after about two weeks they returned for the second session. Experimenters informed the participants in the no prime group that this study intended to test their memory of facts about cricket matches. These participants then received the first cricket passage, read and returned the contents, and then received two cricket memory tests. After completing these measures, they received the second cricket passage, read and returned it, and then received the corresponding cricket memory tests. The no prime groups were not told about any similarity between baseball and cricket in order to allow spontaneous transfer to occur.

Participants in the prime group learned how to design their own k-map, based on the recommendations given by Dansereau and Newbern (1997), who demonstrated that participants can learn how to design their own maps with minimal training. The learning took place at one training session. The participants were shown several sample k-maps, the last of which was designed for baseball and drawn by hand. A computer-produced k-map similar to the one shown to the participants is presented in the Appendix. Participants then heard that they should draw their own k-map concerning baseball, using the hand drawn k-map as a model, but that they should adjust it to their own conceptual understanding of baseball. The entire procedure took approximately 26 minutes, with 12 minutes devoted to actively creating the k-map. It should be noted that the main purpose of the k-map was to engage the participants in active thought on game play and process of baseball so as to elicit a strong prime for baseball in preparation for their memory tasks on cricket. After the learning session, participants were informed that this study intended to test their memory of facts about a cricket match and that they should use the k-map they designed for baseball to help them organize their understanding while reading the cricket passage, due to the similarity of the two sports.

Assessment Instruments

General Sports Interest Rating. Participants rated their interest in five major team sports in the United States (football, baseball, basketball, hockey, and soccer) and four team sports lesser known to those in the United States (rugby, cricket, lacrosse, and polo). The rating was on a one to five Likert scale.

General Sports Knowledge Rating. Participants rated their knowledge of the same five major team sports in the United States (football, baseball, basketball, hockey, and soccer) and the same four team sports lesser known to those in the United States (rugby, cricket, lacrosse, and polo). The rating was on a one to five Likert scale.

Baseball Knowledge. Participants completed two measures of baseball knowledge, with questions regarding baseball rules and terminology. Baseball knowledge test 1 consisted of 40 fill-in-the-blank questions and participants had 13 minutes to complete the measure. A sample question from this measure is: "A(n) ________ occurs whenever the pitcher gives the runner a base on balls on purpose" (Answer: intentional walk). Baseball knowledge test 2 consisted of 30 multiple choice questions, and participants had 10 minutes to complete the measure. A sample question is: "How many outs end a half-inning of a baseball game" (Answer: 3). These measures were developed by Spilich, Vesonder, Chiesi, and Voss (1979) and modified by Hambrick and Engle (2002). In the Hambrick and Engle study (2002), these two measures demonstrated greater predictive power of recall than did more advanced measures of baseball knowledge. The total number of correct responses constituted a participant's score on each of the two measures. A median split of the sum of these two scores divided participants into the high and low knowledge of baseball groups.

General Sports Knowledge. Participants completed a general sports knowledge measure with items concerning rules, game play, and terminology. The General Sports Knowledge test consisted of 40 multiple choice items concerning four major team sports in the United States (six questions each for football, basketball, hockey, and soccer) and four team sports lesser known to those in the United States (four questions for rugby, five for cricket, four for lacrosse, and three for polo). Participants had 13 minutes to complete the measure. The items concerning the four major team sports in the United States were very difficult, whereas the measures concerning the four lesser known sports were very basic questions concerning terminology and basic gameplay. One sample item from this measure is: "[Football] If a quarterback throws an underhand pass to a player beyond the line of scrimmage, this is called a ________" (Answer: shuttle pass). Another sample item from this measure is: "[Cricket] If a player bats the ball over the boundary line he scores ___ run(s)" (Answer: 6).

These measures were modeled after the baseball knowledge tests and used to determine the degree to which general sports knowledge accounted for variations in the dependent variable. The total number of correct responses to the 24 items concerning the four major United States sports constituted a participant's score on the General Sports Knowledge test. For questions concerning the remaining four sports, only the cricket items were used; the items concerning the other three sports were utilized so as not to suggest the purpose of the study. The total number of correct responses to the cricket subtest constituted a participant's score on the cricket subtest. The cricket subtest insured that participants have no prior knowledge of cricket. High (50% or greater) response accuracy of the five cricket items served as exclusion criteria. No participant correctly answered more than one question on the cricket subtest.

Working Memory Capacity. Participants completed the Letter-Number Sequencing (LNS) and Spatial Span (SS) subscales of the Wechsler Memory Scale-Third Edition (WMS-III), which together form the working memory capacity subtest. The working memory capacity subtest has achieved good reliability (.86) (*Weschler Adult*, 1997), and has been validated with the working memory subtest of the Weschler Adult Intelligence Scales-Third Edition (WAIS-III), demonstrating a correlation of .82 (*Weschler Adult*, 1997). For the LNS, the experimenter read the letters and numbers and the participant then repeated them back, giving numbers first, from lowest to greatest, and then letters in alphabetical order. The SS consisted of two subtests, Forward (SSF) and Backward (SSB). In these subtests, the experimenter touched the blocks in a pre-established order and the participant then touched the same blocks either in the same order that the experimenter touched them (SSF) or in the reverse order (SSB). This measure served as a check against covariates.

Cricket Memory. Participants completed two memory tests immediately after reading each cricket passage. Cricket memory test A consisted of 10 multiple choice questions designed to test participants' recognition memory of the game progress. A sample item from this measure is "How many runs were scored in the segment of the game that you read" (Answer: 11-15). The participants had 4 minutes to complete this measure. Cricket memory test B utilized a fill-in-the-blank format and the participant had 6 minutes to complete the measure. A sample item from this measure is "The batsman who is currently not batting is called the" (Answer: non-striker). These measures were modeled after the measures developed by Hambrick and Engle (2002). The total number of correct responses constituted a participant's score on each of the measures.

The four measures (two for Cricket Match 1 and two for Cricket Match 2) were then summed to form the overall Cricket Memory Score (CMS).

Cricket Passages. Participants read two cricket passages consisting of edited transcripts from BBC broadcasts. Cricket Match 1 was modified from a radio broadcast of an in progress cricket match in 1983 between England and Australia and included 765 words (Action Packed Cricket, 1983). Cricket Match 2 was modified from a BBC website article referring to a completed match which occurred in 2003 between Sri Lanka and New Zealand and consisted of 722 words (British Broadcasting Company, 2003). Both passages were modified to insure that all the questions on the cricket memory tests were answered. Also, a box score was included at the very end of the passage. For ease of understanding, the names of players and, for the first measure, the countries, were changed. Participants had five minutes to read each passage. These gameplay passages were selected instead of more passive texts concerning the rules of cricket because the former consist of procedural representations that better correspond with the encoding contexts of persons with high domain knowledge, much in the same vein as the experts in the Chase and Simon (1973) study were able to benefit from the "in-play" chess piece arrangements.

Results

Table 1 presents the overall means and standard deviations for the sample. Prior to hypothesis testing, a series of t-tests were utilized to determine whether significant group differences existed on the pretest measures. Participants in the high baseball knowledge group had significantly higher working memory scores (M = 109.81, SD = 12.59; $F_{1,40}$ = 2.16, p = .037) and general sports knowledge scores (M = 10.14, SD = 3.28; $F_{1,40}$ = 5.47, p = .000) than did those in the low baseball knowledge group (M = 102.05, SD = 10.62; M = 5.52, SD = 2.06).

These two measures were included as covariates in the analysis. No differences between prime and no prime groups were observed on the pretest measures.

To test the hypotheses, results were analyzed using a 2 (high baseball knowledge vs. low baseball knowledge) x 2 (no prime vs. prime) Factorial ANCOVA, with the overall cricket memory score (CMS) serving as the dependent variable. Three participants were removed from the analysis because they were extreme outliers (> 2 *SD* beyond the mean). All three were in the no prime condition, one in the low domain knowledge of baseball, two in the high knowledge group.

Insert Table 1 about here

Working memory had a statistically significant effect on CMS ($F_{1,33}$ = 9.29, p = .005). Participants with higher working memory scores displayed memory superior to those with lower working memory, regardless of condition. The effect of general sports knowledge as a covariate was not significant ($F_{1,33}$ = 1.82, p = .187), and thus the final model analysis was conducted without its effects removed. There was a main effect for baseball knowledge, with the high knowledge group having a significantly higher CMS than the low knowledge group ($F_{1,34}$ = 7.27, p = .011; High knowledge group: M = 22.75, SE = 1.22; Low knowledge group: M = 17.99, SE = 1.22) while the priming factor had a nonsignificant main effect ($F_{1,34}$ = 0.003, p = .957). The interaction between the baseball knowledge and prime factors was significant ($F_{1,34}$ = 11.27, p = .002). A bar chart of the cell means appears in Figure 1.

Insert Figure 1 about here

An examination of the bar chart indicates that group means for the two no prime groups are virtually equal; however, the priming mechanism of a k-map appears to affect the baseball knowledge groups differently -- improving the memory of high knowledge participants but diminishing the memory of low knowledge participants, such that the mean difference between these two groups is significant. Further analyses using hierarchical regression revealed no significant interactions involving working memory and the grouping variables.

To determine whether participants in the high knowledge group better learned how to design k-maps thus accounting for their superior memory performance, two independent raters measured how well the participants followed the rules of creating a k-map on a one to five Likert scale, ignoring accuracy or quality of baseball content[2]. The raters appeared to agree (*gamma coefficient* = .527, p =.001), and a ANOVA ($F_{1,18}$ = .008, p = .930) on the mean of each pair of ratings indicated that there was no difference in the quality of the k-maps produced by the groups. The mean rating score was then used to predict the CMS but did not account for a significant amount of variance in the data (R^2 = .051, p = .338).

In summary, with the effects of working memory statistically removed, a main effect for baseball knowledge but not the priming condition was observed, and an interaction emerged between the knowledge and priming factors. No higher order relationships were observed between working memory and the grouping variables; further, comprehension of the priming procedure, as evidenced by the quality of the k-map produced, could not account for the difference in memory performance between the high and low knowledge groups.

Discussion

The main question of interest concerned whether or not participants with high baseball knowledge would recall cricket information more easily than those with low knowledge. Additionally, a priming mechanism was used so as to determine whether or not participants would display improved memory of cricket excerpts through the elicitation of their knowledge of baseball gameplay. It was predicted 1) that participants in the no prime groups would not differ in group means, 2) participants in the prime groups would benefit, and 3) participants in the high domain knowledge of baseball group would benefit more from this prime. The results supported the first and third of these hypotheses but not the second. The means for the no prime groups appeared relatively the same, whereas the high baseball knowledge participants in the prime group exhibited significantly superior memory performance than the primed low baseball knowledge participants. Contrary to the predictions, low knowledge participants in the prime group appeared to be harmed by the priming mechanism.

Apparently, the prime enabled positive transfer for the high knowledge group but generated negative transfer for the low knowledge group. On one hand, high baseball knowledge participants in the prime group organized the incoming cricket information effectively, presumably because of the elicited framework of baseball. This result suggests that, indeed, people with greater knowledge of baseball can utilize their pre-existing baseball knowledge to help them organize and effectively retrieve information in cricket, a similar yet unrelated domain. Just as individuals use their established mental framework of a domain to incorporate incoming information within that domain, and those with greater domain knowledge are better able to organize and retrieve the incoming information when it is needed (Ericsson & Kintsch, 1995), so can individuals use that same pre-existing mental framework to organize information in a similar domain.

This result corresponds with the notion of representational transfer, which suggests that individuals can use a generic organizational framework to transfer problem-solving skills from one problem situation to another (Novick, 1990). Here, the mental framework of baseball appears to have served as an organizational framework for cricket. Consequently, this finding extends representational transfer beyond the problem-solving domain to memory.

On the other hand, low baseball knowledge participants in the prime group had a much weaker pre-existing organizational framework on which to build an understanding of the incoming cricket information. Thus, they attempted to use poorly structured pre-existing information to organize new information, resulting in negative transfer which decreased their memory performance. These results are difficult to interpret in light of the Marchant et al. (1991) finding that domain experts experienced both negative or positive transfer, when given or not given a period of "puzzlement" during which they were expected to reason through to a possible solution. Perhaps the present results would have been more similar had participants also been given a puzzlement period.

As opposed to labeling the result transfer, a possibility exists that those in the high baseball knowledge prime group outperformed the other participants for a two-fold reason: stimulated mind and interest. Whereas the no prime participants came in, and after a brief wait, read the excerpts and completed the memory tests, those in the prime group had engaged in organizational cognition for approximately 12 minutes before reading the transcripts. Moreover, because of their increased interest or ability to stay on the topic (because they have more baseball knowledge to contemplate) of baseball, those in the high knowledge prime group would outperform their bored counterparts in the low knowledge prime group. Perhaps if all the participants contemplated something of interest to them for 12 minutes, the scores might not have varied across groups

Another interesting result is the fact that participants in the no prime condition all fared the same on the dependent measures, suggesting that spontaneous transfer did not occur. One might alternatively explain the result by concluding that spontaneous transfer does occur, but spontaneous transfer is not strong enough to elicit the full advantage of prior domain konwledge.

In support of this explanation, an examination of the fill-in-the-blank responses revealed that participants in all four conditions used baseball to help them organize their memory of cricket. For example, one question in the cricket memory tests queries "A(n) ____________ squats behind the wicket at which the batsman is batting." While the correct answer to this question is "wicket-keeper," many participants, regardless of condition, answered "umpire" or "catcher." Additionally, informal interviews conducted with participants revealed that participants even in the low baseball knowledge no prime group noticed similarities between cricket and baseball and responded as such. It might be useful to mention that the low baseball knowledge participant in the no prime group who was removed from the study for being an extreme outlier (below the mean on the dependent measure) had the lowest baseball knowledge score.

Limitations and Future Directions

Throughout the course of this study, several limitations were realized. One limitation is the small sample size used. Ideally, a much larger sample size should be used so as to obtain a better estimate of the group mean scores on the dependent variable. Further a larger sample might reduce the need for dichotomizing variables, as was done in this study. Another limitation is that transfer was only assessed uni-directionally, that is, from baseball to cricket. Follow up studies should address this issue by considering bidirectional transfer.

As discussed in the previous section, at this point, an uncertainty exists whether the improved memory performance on the part of the high domain knowledge, prime group occurred because of the contemplation of baseball for 12 minutes, or simply the contemplation of a topic, specifically, a sport of interest for 12 minutes, thus stimulating the brain for further mental activity. To address this limitation, a future study might utilize a control group which designs a k-map for any topic of interest to the participant.

As for future domains, studying the ability of individuals to transfer high knowledge of American football to rugby or from the European game of chess (or checkers) to the Asian game of go might determine the generalizability of these findings. Further, similarity ratings collected from individuals who are familiar with all of these games coupled with transfer studies could aid in predicting which game pairs would be most likely to transfer. This would also address another of the shortcomings of this study, which was that the similarity between baseball and cricket was never empirically assessed.

Furthermore, instead of using the elaborate priming mechanism of a k-map, it might be useful to have a group which is informed that cricket is similar to baseball. This would be beneficial because the use of a k-map as a prime has additional tasks, including retrieving baseball knowledge and organizing it into the k-map framework. Lastly, the dearth of theoretical work uniting these domains precluded a comprehensive prediction for the outcome of this experiment. Although the work here should therefore be regarded as exploratory, future endeavors to blend these two areas of research should prove fruitful and will hopefully result in improved theoretical direction.

To conclude, this study unites research involving prior domain knowledge and transfer. Overall, the results indicate that high knowledge in one domain, if sufficiently primed, can improve memory performance in a similar, yet unrelated domain. Conversely, low knowledge of a domain, if primed, can actually interfere with memory performance in a similar and unrelated domain. Although the exact reason for the improved memory is uncertain, at present the results suggest that the use of pre-existing organizational schemas and retrieval structures enable transfer.

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A substantial portion of this paper was included in the author's master's thesis while at Abilene Christian University.

The author would like to thank Richard Beck for serving as thesis committee chair , Kyle Massey and Tim Pleskac for their help rating k-maps, and Anthony Bishara for advice on statistical analyses.

Footnotes

1. Although the term adaptive expertise is applied to transferable domain knowledge, studies concerning this topic generally concern problem-solving (see Kimball & Holyoak, 2000, for a joint review of these two topics).

2. Baseball knowledge or quality of the content was difficult to estimate from the k-maps due to the fact that not all participants appeared to learn how create k-maps. Furthermore, it was possible for participants to simply copy the content of the example k-map they were given, in which case the quality of the baseball content in the k-map they produced would not necessarily be representative of their baseball knowledge. Additionally, it should be remembered that the main goal of the k-map procedure was merely to prime knowledge of baseball gameplay; thus, attaining this goal was not conditional on correctly learning how to design a k-map.

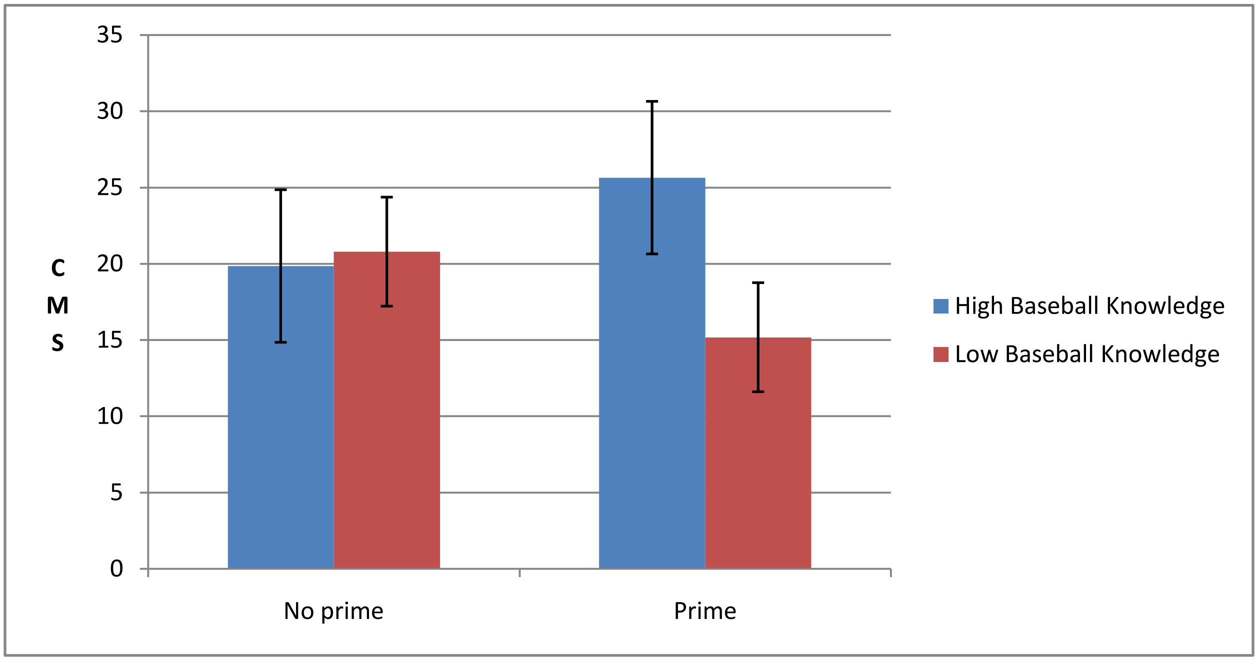
Table 1

Descriptive statistics for independent measures

	Mean	SD
Baseball Knowledge 1	18.12	11.45
Baseball Knowledge 2	15.40	5.63
Baseball Knowledge Sum	33.52	16.61
Cricket Knowledge	0.60	0.66
Working Memory Score	106.14	12.09
Baseball Interest Rating	2.91	1.23
Baseball Knowledge Rating	3.40	1.14
Cricket Interest Rating	1.05	0.21
Cricket Knowledge Rating	1.00	0.00

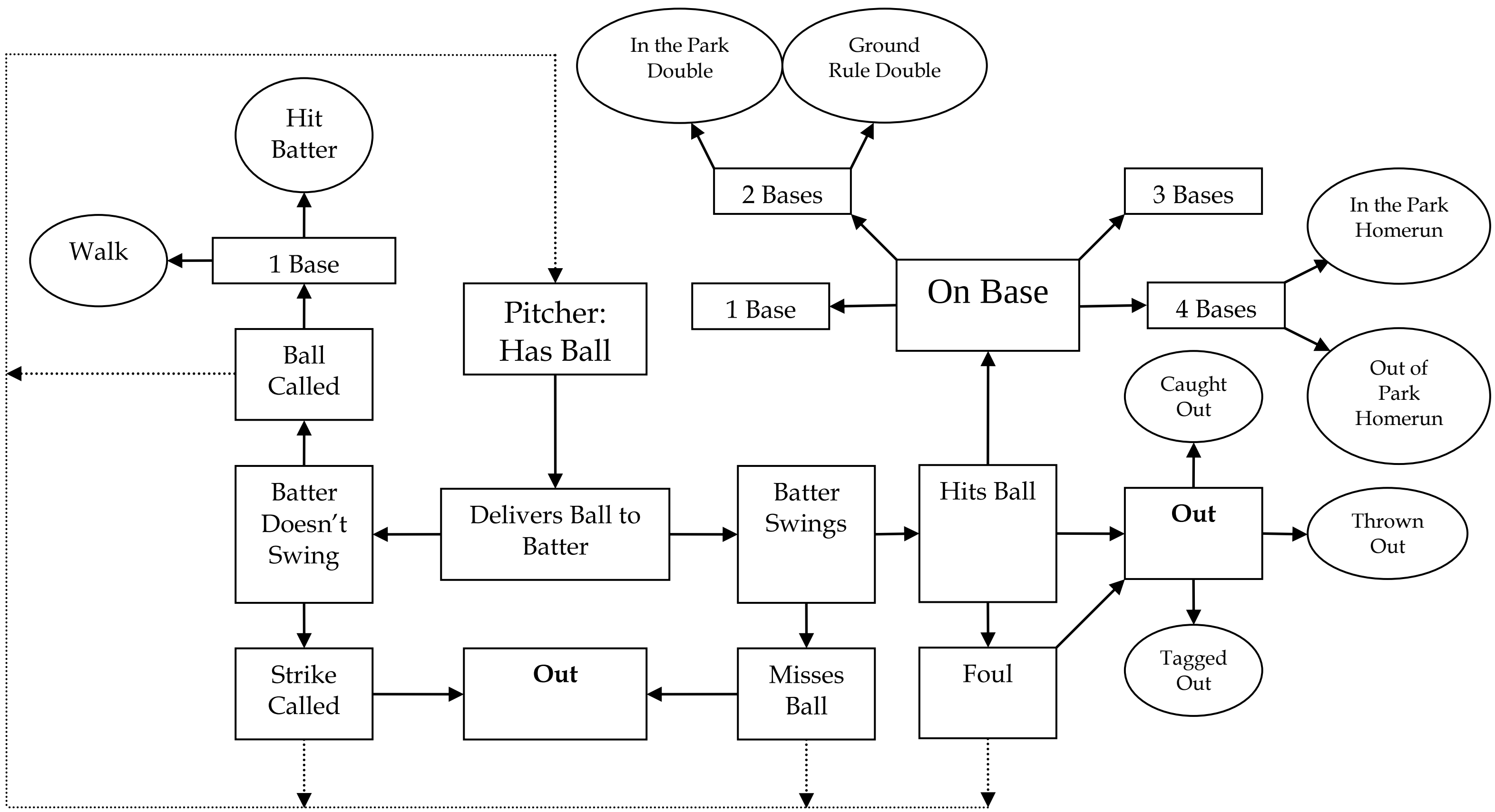
Figure 1

Bar chart of the group means on the CMS



Group means on CMS, controlling for the effects of working memory. Error bars show 95% confidence intervals.

Appendix



Sample Baseball Knowledge K-map