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The World of Competitive Scrabble: Novice and Expert Differences in Visuospatial and Verbal Abilities

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Competitive Scrabble players spend a mean of 4.5 hr a week memorizing words from the official Scrabble dictionary. When asked if they learn word meanings when studying word lists, only 6.4% replied "always," with the rest split between "sometimes" and "rarely or never." Number of years of play correlated positively with expertise ratings, suggesting that expertise develops with practice. To determine the effect of hours of practice (M = 1,904), the authors compared experts with high-achieving college students on a battery of cognitive tests. Despite reporting that they usually memorize word lists without learning meanings, experts defined more words correctly. Reaction times on a lexical decision task (controlling for age) correlated with expertise ratings, suggesting that experts develop faster access to word identification. Experts' superiority on visuospatial processing was found for reaction time on 1 of 3 visuospatial tests. In a study of memory for altered Scrabble boards, experts outperformed novices, with differences between high and low expertise on memory for boards with structure-deforming transformations. Expert Scrabble players showed superior performance on selected verbal and visuospatial tasks that correspond to abilities that are implicated in competitive play.

Keywords: expertise, Scrabble, visuospatial abilities, verbal abilities, de Groot paradigm

Quackle, which is an obscure word that means "to choke," is the name of a remarkable computer program. In November 2006, it shook the world of competitive Scrabble by becoming the first computer program to beat a world champion player in a "best of 5" match (Read, 2007). For competitive Scrabble players, the defeat of human intelligence by artificial intelligence is a watershed event comparable to the May 1997 win by IBM's computer program Deep Blue in a chess match against the reigning champion Gary Kasparov (Man versus Machine, 2007). Deep Blue's advantage is not in its strategic abilities, but in its tremendous ability to search five moves ahead (approximately 10^{30} positions), although it does not attend to all possible moves equally and it has the ability to reject bad moves while considering good ones. Quackle, Deep Blue's newest kin in the world of artificial intelligence, is described as a crossword game artificial intelligence and analysis tool that can be configured to play and analyze crossword games with any board layout. As computer programs gain expertise that can surpass even the best human experts, there is renewed attention to research that examines the origins and maintenance of expertise in a variety of areas.

Studies of expertise in fields as diverse as chess (Charness, 1991), physics (Chi, Feltovich, & Glaser, 1981), and medical diagnosing (Norman, 2005) have shown not only that human experts have more knowledge about their field of expertise, but that relevant knowledge is organized in long-term memory in ways that make it more accessible when it is needed. The expert's ability to recognize "the multiple perceptual ways that a particular feature may arise" (Norman, 2005, p. 38) when making a medical diagnosis has direct parallels to the rapid perceptual analysis that distinguishes experts from novices in other domains. Efficient pattern recognition directs a more productive search through memory. Thus, one way of conceptualizing expertise is the development of a two-step process that combines the rapid perception of relevant information with a focused search through memory; taken together, these mechanisms increase the probability that an expert will make a rapid and correct diagnosis or select a more promising move relative to a novice. The efficient cognitive processes that underlie expertise are acquired through a costly investment of time and effortful practice. In Ericsson and Smith's (1991) review of expertise, they describe the making of an expert as taking "a decade of intensive preparation" (p. 7) in sports, the arts, or the sciences.

Although expertise has been studied in many domains of knowledge, psychologists have had a long-standing interest in chess, using it to understand the development of expertise and skill (Chase & Simon, 1973; de Groot, 1946, 1965). The game of chess has been called the "drosophila of psychology" because of its frequent use as a paradigm to understand how people think and remember (Didierjean, Ferrari, & Marmeche, 2004, p. 771). Researchers have looked to chess for insights into the workings of memory and its relation to expertise, asking questions such as whether the ability to remember the position of pieces on chess boards is related to a player's level of skill (Chabris & Hearst, 2003; Charness, 1991; Van Der Maas & Wagenmakers, 2005). Chess has also been used to investigate more sophisticated ques-

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tions about cognition and performance, such as “What abilities are necessary to perform at the very highest levels?” and “What is it that makes a grandmaster so different from a master or a novice?” The ability to play at a master’s level in chess, for example, takes thousands of hours of deliberate practice, which alters the underlying representation of the problem space. It is during the many hours of practice that perceptual structures are transformed from discrete, small packets of knowledge to larger chunks of meaningful information in long-term memory, which allows the expert chess player to rapidly recognize and retrieve larger quantities of information as they are needed (Chase & Simon, 1973). Chess has been described as “the kings’ game of choice because ‘in this game skill always succeeds against ignorance’” (Fatsis, 2001, p. 22).

Although there have been many studies utilizing the ancient and venerable game of chess as a framework for understanding the human mind, there have been relatively few studies that have examined other cognitively demanding games. There have been studies of the game of Go (Masunaga & Horn, 2001), video games (Sims & Mayer, 2002; Vandeventer & White, 2002), and card games such as blackjack (Gaboury, Ladouceue, Beauvais, & Genevieve, 1988), but psychologists have not yet branched out to study the wider variety of games that people play. In parallel to questions about chess and these other games that have been studied to a lesser extent, we were interested in understanding the abilities that are necessary for games that require the use of language and the alphabet. In an attempt to bridge this gap in the literature, we chose to closely examine the game of Scrabble. There have been no other cognitive analyses of expert and novice Scrabble players.

The Game of Scrabble

Scrabble has unique game characteristics that should be of interest to psychologists because they involve three major cognitive abilities that are integral for successful play: (a) verbal ability in the form of word fluency, because the game requires the rapid retrieval of appropriate words from memory; (b) visuospatial ability, because the spatial layout of words and letters on particular squares on the board determines the point value of a play; and (c) numerical ability, because players need to calculate probabilities and rapidly use the numerical properties associated with different combinations of words located in different places on the board. We use the term *ability* as it was defined by Fleishman (1972), as a general trait of an individual that is the product of learning and development. As an example, he stated that visuospatial abilities are important to performance on many tests in applied areas such as dental skill. We were interested in understanding the development of cognitive abilities that are important to expert-level performance in the game of Scrabble.

In Scrabble, players place letter tiles in a horizontal (left to right) or vertical (top to bottom) sequence in a way that makes up a legitimate word, using what they believe to be the optimal location on the Scrabble board to yield the highest numerical score, which is determined by the point value of each letter that is played and the value of the squares on which the tiles are placed. Like chess and other games, Scrabble is played in international, national, and regional competitions for money and fame. Top players in the United States win approximately $25,000 in national competitions, with the total amount won by all players at a national competition being approximately $85,000. The winner of Division 1 (top-level play) takes home $25,000; the top prize for Division 2 is $4,000; for Division 3 the top prize is $2,500; and for Divisions 4, 5, and 6 it is $1,500 (Arneson, 2006).

Competitive Scrabble differs from casual or living-room Scrabble (i.e., the rules used in casual play are different from those used in competitive tournament play) in several critical ways. In competitive Scrabble, each player has a total of 25 min of play. If players go over time, 10 points are deducted from their total score for each minute (or part of a minute) by which they have exceeded their allotted 25 min (Alexander, 2006). With severe point penalties for any player going over the total time allowed, each play must proceed as quickly as possible, allowing only seconds for many rounds. The number of rounds varies from game to game because the game ends when all of the letters are exhausted. An average game will take 12 to 15 plays per player, which is less than 2 min per play. Thus, speed is critical to successful competitive play. For expert players, the game requires the simultaneous interplay of verbal, visuospatial, and mathematical abilities under speeded conditions. There are no other games that require the simultaneous, rapid use of all of these abilities.

The Background of Scrabble

Alfred Mosher Butts, an unemployed architect who enjoyed anagrams and crosswords, is the generally acknowledged father of Scrabble (Edley & Williams, 2001). Unlike older games, such as chess, Go, or backgammon, Scrabble is owned by a game company (Hasbro, Inc.) and therefore cannot be copied or mentioned without its trademark. The chessboard has 64 squares and includes 32 pieces, of which 6 have different functions. In comparison, Scrabble has 225 squares and 100 tiles, of which each of the 26 letters of the alphabet is represented in direct proportion to its frequency in words in the English language. Letters are assigned point values according to this framework. For example, the letter *z* is worth 10 points and shows up only once, whereas the letters *a* and *i* are each valued at 1 point and show up nine times apiece. A Scrabble board is shown in Figure 1.

Scrabble is a game that proceeds from the center of the board outwards, whereas chess is played from opposite sides toward the center. Just as each game of chess is uniquely determined by the choice of moves by each player, each game of Scrabble exhibits different board patterns that are determined by the players’ individual moves at each round of play. And just as the number of moves to select from is limited by the spaces already taken on the chessboard, each play in Scrabble is determined by seven tiles on a rack and the current word patterns that exist on the board.

In both chess and Scrabble, cognitively complex decisions must be made, but in Scrabble knowing “legal” key words in the *Official Scrabble Player’s Dictionary* (2005) greatly adds to the chances of victory, especially among expert players who study lists of unusual words from this “bible” for Scrabble players (Fatsis, 2001). The official dictionary presents the word lists arranged by the number of letters in the word and by letter combinations, such as all words that contain *q* but not *u*, instead of using an alphabetical listing. Although a brief definition for each word is presented, knowledge of word meanings is not needed for competitive play. Numerous books about Scrabble have claimed that players do not pay atten-

Figure 1. A sample Scrabble board at the end of play.

tion to word meanings (e.g., Edley & Williams, 2001; Fatsis, 2001). New words can be formed by adding letters to a word that is on the board, placing a word at right angles to an existing word, and placing complete words parallel to an existing word so that all adjoining letters form complete words.

Scrabble is not only a game of word knowledge, but also a game of mathematics and probabilities. Expert players need to estimate the probability of selecting specific letters from those remaining to be played, and they need to rapidly add the point values for different possible words placed on different squares on the board in order to determine which of several possible words will yield the highest point value. The mathematical processing demands are so high that one expert player explained that "by tracking tiles as they are played, I can also deduce exactly which tiles my opponent has in the endgame. In other words, competitive Scrabble is a math game" (Brown, 2006, p. M4).

Vocabulary: Word Recognition Versus Word Understanding

Unlike casual Scrabble players (i.e., those who do not compete in tournaments), competitive players prepare for competition by memorizing long lists of words and practicing *anagramming*, defined as rearranging letters to make different words, in order to find the best possible play on each move (Fatsis, 2001). If findings from studies of chess and other domains of knowledge can be generalized to Scrabble, then we would expect that the time spent in effortful learning would be predictive of a competitive player's level of expertise (Charness, Tuffiash, Krampe, Reingold, & Vasyukova, 2005). Brown (2006, p. M4), for example, was a nationally rated Scrabble expert who finished 12th in the open Scrabble tournament in 2006. He reflected on his near-victory this way: "When playing top notch opponents I assume that they, like me, have memorized all 83,667 valid words of up to eight letters." Expert Scrabble players sometimes argue about whether knowing the meaning of the words interferes with their ability to find the right word just when they need it (Fatsis, 2001). Many players believe that they may get "distracted" by word meanings, when what they need for play is very rapid access to letter combinations that make up "real words," with no regard for what the words might mean (Fatsis, 2001). Thus, the world of competitive Scrabble offers a window onto the cognitive processes of expert players and how experts differ from novices in the way they represent and use their knowledge of words because experts spend many hours of deliberate practice learning to recognize legal words with little or no regard to their meaning.

Does the way in which experts prepare and play affect their underlying cognitive abilities? If, in fact, experts spend thousands of hours spaced over many years memorizing words without attending to their meaning, we would expect them to have less knowledge of word meanings than a comparison group that spent less time studying words, but concentrated on learning the word meanings of new words. At the same time, the experts would be expected to excel at the rapid perception of adjacent letters to determine if they form a legal Scrabble word. As an example of a strategy that would assist with learning legitimate letter combinations that make up words without paying attention to word meaning, each letter could be mentally translated to a specific color, and each word could therefore be seen as a color pattern. With this strategy, a mentally generated visuospatial array of color combinations would become the retrieval mechanism for legal words. It would be these colored patterns that competitive players might search for as they bring information about words from long-term memory into working memory in the hope of finding the best possible letter combinations to play.

The distinction between *word knowledge*, defined here as knowing whether a word is in the Scrabble dictionary, and *word understanding*, which is understanding the meaning of a word, is important for a number of reasons. Novice players will not have invested the time and extensive effort required into memorizing the lists of words that appear in the Scrabble dictionary. Novices and casual players rely on their stored lexicon of word meanings because that is how most people learn and retrieve words. Classical studies using a lexical decision task, in which participants rapidly identify words or nonwords, have shown that reaction times (RTs) are decreased when a word is preceded by one that is associated with it in a meaningful way (den Heyer, Briand, & Dannenbring, 1983). Evidence that words are normally organized in memory according to their meaning is provided with the robust finding, for example, that the word *nurse* is identified as a word more quickly when it follows *doctor* than when it follows *butter*, with opposite results for the word *bread*. Cooke, Durso, and Schvaneveldt (1986) explained:

> The nature of memory organization is of importance to researchers interested in the learning and comprehension of recently experienced events as well as those interested in the representation and use of knowledge. The ability to recall information is related to the organization of that information. (p. 538)

In the normal course of learning vocabulary, most people would have relatively few words in their lexicon whose meaning they do not know because without a meaningful organization, each word would be stored as a discrete chunk of information. By contrast, an organization of word knowledge by meaning for Scrabble experts might be groupings by the number of letters in words whose only meaning is that they belong to the category of legitimate Scrabble words.

Spatial Ability and Anagramming

In many ways, competitive Scrabble calls upon spatial visualization (visuospatial abilities) because the mental processes used during play require anagramming and mentally rotating words at increments of 90° angles (for four-player games, which are allowed in casual play) or 180° (for championship two-player games) as the board rotates to face each other player during the game. Novice players usually play without time rules, so they have the leisure to physically manipulate letter tiles to determine what words can be constructed from a given rack of seven letters plus the tiles on the current board. Competitive players cannot as easily afford the time to physically manipulate letter tiles and thus will do most of the rearranging of the tiles mentally, relying on what is commonly known as the visuospatial sketch pad in working memory (Baddeley, 2003). The visualization of different combinations of letters needs to be maintained long enough to mentally scan them and determine if they make up a good word—one that is listed in the *Official Scrabble Player's Dictionary*, yields high point values, and can be placed on the board during the current round of play. While the letters are being maintained and manipulated in visuospatial working memory, expert players are simultaneously computing point values for different letter combinations (Fatsis, 2001). Thus, mental arithmetic is also taxing the resources of working memory, which means that the ability to perform rapid mental calculations is also important for expert-level players.

Identifying the Scrabble Expert

It is a straightforward task to identify the level of expertise among Scrabble players because everyone who plays competitively has an official rating that takes into account their past wins, losses, and point spreads relative to other competitive players. Official ratings range from approximately 663 (theoretically ratings could be as low as 0) to 2050, divided into six divisions. The highest scorers are in Division 1; the lowest are in Division 6. With official ratings, players in a comparable band of ability can compete against one another by playing within their division or an adjacent division (Alexander, 2006).

Study 1

Because we were interested in the way in which training to become a Scrabble expert alters the underlying representation of information in memory, Study 1 was a survey of experts and novice players to ask them about the way they train for Scrabble and to look for relationships, such as amount of time spent training and how the way in which an expert trained correlated with their official Scrabble rating. Competitive Scrabble players have a wide range of ratings. Although individuals with ratings in the lowest two divisions may be expert relative to noncompetitive players, they are novices when compared to players with ratings in the top two divisions. Thus, all analyses proceed by comparing competitive players with a noncompetitive comparison group and, when appropriate, analyzing differences among the competitive players as a function of their official ratings.

Method

Participants and Procedures

Expert players. An e-mail was sent to the official listserv for competitive Scrabble players in North America. Recipients were told that we were studying Scrabble expertise. They were invited to take an online survey that was accessible by clicking a link that was embedded in the e-mail message. Membership in the listserv was restricted to players with official National Scrabble Association ratings. In the message, we asked for participants who were native English-language speakers living in the United States and Canada, because we thought that someone for whom English was not their native language might prepare for English-language Scrabble in a different way than native English speakers. We had no way of ascertaining that all of the Scrabble experts met these criteria, but we have no reason to believe that nonnative speakers would have been eager to take the survey. In exchange for their participation, which took approximately 20 to 25 min, they could choose to be entered into a drawing for one of five $50 gift certificates to Amazon.com, a popular online book and gift store. These certificates were awarded to 5 participants at random when data collection was completed.

Comparison group. The comparison group consisted of college students at an academically rigorous liberal arts college in California. The median SAT scores for the mathematics and verbal tests for the entering freshman class at this college had been 700 for the past 4 years. Thus, on average, the students in the comparison group were academically high achievers. Their research participation was in partial completion of a requirement for all students enrolled in lower division psychology courses. The students took their survey on line using the same software system as the expert group. Most of the questions were the same for both groups, with a few differences. The students were asked their year in school and major, for example, and the competitive Scrabble players were asked about their official Scrabble rating, highest level of education, and current job title.

Results

There were 114 people in the competitive Scrabble group, 66% men. The comparison group had 147 students, 55% men. For the competitive group the mean reported rating for men was 1465.71 (SD = 302.31); the mean reported rating for women was 1354.53 (SD = 273.77). The difference in official ratings between the men and women did not reach statistical significance, $t(106) = 1.86$, *ns*, $d = .26$. (Six of the experts had missing data.) As expected, on all continuous measures, the group of competitive Scrabble players was more variable than the comparison group of college students. The mean age for the competitive group was 41.89 years (SD = 14.78); the mean age for the comparison group was 19.48 years (SD = 1.14). The competitive group reported their mean years of education as 16.5, or approximately a half year beyond college. The mean SAT mathematics score for the students was 695 (SD = 62.83) and mean SAT verbal score was 680.2 (SD = 59.41), thus they were representative of the students at this college in terms of their intellectual ability as assessed on the SATs. The students had completed a mean of 2.27 years of college. All of the students in the comparison group had played Scrabble at some time, and none had competed in a tournament or had an official rating.

When asked if they ever studied words from the *Official Scrabble Player's Dictionary* (or a similar source) all but 1 of the 114 competitive players (99%) answered "yes," compared to 8 of the 147 students (5%) in the comparison group. The mean number of years the expert group had played Scrabble was 26.92 (SD = 16.37). We computed an estimate of the total number of hours the experts practiced or played Scrabble by combining the number of years they had played (current age minus age first started to play Scrabble) with the number of days per year they played and the number of hours per day they studied words or played Scrabble (converting all estimates to hours). The estimated total number of hours the experts spent playing or practicing Scrabble was a mean of 1,904 (SD = 2,532). As seen from the large standard deviation, there was a great deal of variability in these data, ranging from 52 (1 hr a week for 1 year) to 14,872 hr per year.

The most interesting data for the hypotheses under investigation were the answers to the questions about how the players practice and their knowledge of word meanings. When asked "When you study Scrabble words, do you try to learn what the words mean?", only 7 of 109 (6.4%) competitive players (total sample size varies slightly from question to question because of missing data) responded "always." Of the rest, responses were evenly split between "rarely and never" and "sometimes." Comparable data were not computed for the comparison group because only a small percentage responded that they studied Scrabble words. Both groups were asked "Are there words that you know are legal in Scrabble, but you do not know what the word means?" Of the competitive players, 89% responded "yes" compared to 26% of the comparison group.

Data in response to questions about the strategies that the participants used when playing Scrabble and various measures of how long and how much they played are presented in Table 1. Correlations with official Scrabble ratings are presented in Table 2. Data in Table 2 are only for the expert group because the comparison group did not have official Scrabble ratings.

Discussion

The expert Scrabble players differed from the comparison group on every question asked. They reported that they were more likely to know words that are legal in Scrabble but not know what the words mean, and they spent considerable amounts of time studying words that are legal. Experts reported that they were more likely than the students to keep track of letters that were played (so they could estimate the probability of getting a desired letter), to use mental imagery when trying out possible words, and to know the point values of the squares on the board. Surprisingly, it was the comparison group of students who responded that they were more likely to mentally rotate the board while it was facing an opponent. Experts who started playing competitively at younger ages and who practiced/played more years and more total hours (which necessarily included the number of years) had higher official Scrabble ratings, so like every other area of expertise that has been

Table 1
Comparison of Expert and Student Responses to Questions About How They Practice for and Play Scrabble

Questions and possible responses	Experts	Students	Statistical test
During an average year, how many days do you play Scrabble?	211.37 (109.72)	8.10 (34.43)	$t(130) = 19, p < .01, d = 1.54$
How many hours a week do you study Scrabble words?	4.56 (5.90)		
When you play Scrabble do you keep track of the letters that have been played, so you know if you are likely to get a rare letter that you might need?			
All of the time	80% (90)	4.8% (7)	$\chi^2(3) = 61.64, p < .05$
Some of the time	15% (17)	28% (41)	
Rarely	2.5% (3)	31% (46)	
Never	2.5% (3)	36% (53)	
When you are thinking about words you can form with the letters on your rack, do you physically move the tiles to try out words or do you imagine the tiles in different word combinations?			
Most of the time, I physically move the tiles.	38% (43)	51% (74)	$\chi^2(2) = 6.13, p < .05$
Most of the time, I imagine tiles moved.	22% (25)	24% (35)	
About half of the time I physically move tiles; half of the time I imagine tiles moved.	40% (45)	24% (35)	
When your opponent has the Scrabble board facing him or her, do you mentally rotate the board to imagine what it would look like if it were facing you?			
All or most of the time	16% (18)	29% (42)	$\chi^2(2) = 29.11, p < .01$
Some of the time	17% (19)	38% (56)	
I never mentally rotate the board when it is facing my opponent.	67% (75)	33% (49)	
When you think about the layout of Scrabble boards, how do you think about the point values for different squares (e.g. double or triple word/letter score tiles)?			
I know the point values for every square on the board.	70% (78)	3% (5)	$\chi^2(3) = 133.77, p < .01$
I know approximately where the high point squares are.	8% (9)	32% (39)	
I look for high point squares as I play.	20% (23)	64% (78)	
I do not pay much attention to the location of high point squares.	1% (1)	0% (0)	

studied, the investment of significant amounts of time into practice and play pays off in the development of expertise.

Although we found these self-report data useful in understanding the way Scrabble experts think about and prepare for the game compared with novices, we wanted to know if the hours invested in developing their expertise in Scrabble would be manifest in cognitive tasks that share variance with the abilities developed by practice and play at Scrabble. Would we find a correlation with official Scrabble ratings and any of the abilities that might predict expertise? Are standard measures of verbal ability relevant to Scrabble expertise? One reason why standard tests of verbal ability may not be useful in predicting expertise at Scrabble is that the learning process and subsequent memory representation of a huge number of words that are memorized without regard to their meaning should be quite different from the underlying memory representation of the same number of words that are acquired with an understanding of their meaning (Bailey & Hahn, 2001). Meaningful words would be organized in a way that is efficient for searching the lexicon by meaning; this organization would not be optimal for Scrabble word lists, which are more likely to be retrieved by letter components (e.g., the need to retrieve words with mostly vowels or the letter *z*; Anshen & Aronoff, 1999).

In a study of the availability of information in memory, Kahneman and Tversky (1972) found that people are better at generating words that begin with a given letter (e.g., *k*—king, kite) than words that have that letter in the third position (e.g., make, bike)

Table 2
Correlations With Official Scrabble Ratings (Experts Only)

Variable	1	2	3	4	5	6	7	8	9
1. Official Scrabble rating	—	−.178	.116	−.173	$-.202^{*}$	.021	−.128	$.227^{*}$	$.224^{*}$
2. Gender		—	$.318^{*}$	.094	$.265^{*}$	.104	−.181	$.220^{*}$	$.242^{*}$
3. Current age			—	.167	$.727^{**}$	.088	−.094	$.769^{**}$	$.515^{**}$
4. Age started playing Scrabble				—	$.355^{*}$	$.233^{*}$	.094	$-.501^{**}$	.058
5. Age started competing					—	.096	.112	$.386^{*}$	.121
6. Days of year playing Scrabble						—	.050	−.093	−.196
7. Hours per day playing Scrabble							—	−.134	$.377^{*}$
8. Years of practice								—	$.492^{**}$
9. Total hours playing (Years × Hours)									—

$^{*} p < .05.$ $^{**} p < .01.$

because words are more often retrieved by their initial letter. It is possible that expert Scrabble players structure their word fluency in ways that would allow easy retrieval with letters in any position because during play a letter may be available with two blank squares situated so that it would be in the third position. As in this example, an organization in memory that is based on word meanings would not facilitate retrieval by letter position and thus may differentiate expert players from novices.

The expert Scrabble players who participated in Study 1 responded that they were more likely to use mental anagramming than the comparison group of nonexperts. With seven letter tiles on a rack, it is not possible to manually move or mentally imagine every possible combination of the letters with those already on the board, especially under the timed conditions of competitive play. Thus, the visualization of spatially aligned letters that create partial word combinations using implicit rules of how letters combine in English to create words (e.g., *thr* is a common alignment of letters; *rht* is not) is hypothesized as a necessary step in deciding which letters to play.

Earlier studies have shown that anagramming is related to spatial ability. Researchers found that performance on the Minnesota Form Board could be used to predict the ability to solve anagrams, $r(26) = .54$ (Gavurin, 1967). In a follow-up investigation of the relationship between anagramming and spatial ability, Wallace (1977) found that college students who scored high on spatial aptitude solved significantly more anagrams than students with low spatial aptitude. The ability to find as many possible good plays through mental anagramming is more important in competitive Scrabble than in casual or living-room games because players have a limited amount of time on the clock during competitive play. It can be argued that the ability to mentally manipulate letters in an anagramming task is, in fact, a visuospatial task because it involves rearranging letters and quickly determining if the possible combinations of adjacent letters yield good word possibilities.

Like poker and other card games, Scrabble involves a process called *tile tracking*, in which the letters on a player's rack are analogous to the cards in a poker player's hand. Players need to keep track of the letters that have already been played in a game, similar to the way players keep track of the cards that have been played in poker or other card games so the probability of drawing a particular letter on future rounds can be computed. (In competitive Scrabble, players are allowed to use preprinted tracking sheets, but very few players use these sheets because they do not want to spend their valuable time on this additional task; National Scrabble Association, 2006.) Thus, there is a simultaneous memory load that incrementally advances during competition as more letters have been played. Scrabble players also correctly need to recognize when seemingly real words are not legitimate Scrabble words so they can challenge other players who are using words that do not appear in the *Official Scrabble Player's Dictionary*. The penalty for issuing an inappropriate challenge (i.e., the contested word is in fact in the *Official Scrabble Player's Dictionary*) or for playing a made-up word is a lost turn, which can cost a player the entire game. Good words yield high point values, so expert players need to also add word values as they mentally position different possible words on the board.

There are several psychological theories that provide a framework for understanding the cognitive processes that underlie competitive Scrabble. Numerous researchers have made a strong case for the separability of attentional or cognitive resources for visuospatial and verbal tasks in working memory (Shah & Miyake, 1996). Working memory is critical in processing complex information because intermediate processes need to be maintained in memory while, simultaneously, new information is being processed. In a series of experiments, Shah and Miyake (1996) and others (e.g., Just & Carpenter, 1992) showed that working memory is not a unitary concept. Baddeley (1993) hypothesized that it is composed of a language (phonological loop) component and a visuospatial processing component, both of which are directed by an "executive" that directs and coordinates cognitive processes. Studying expert Scrabble players, those who have invested thousands of hours in practice and play at a task that requires rapid recognition of legal words and high spatial ability, allows us to examine how expertise training in Scrabble alters their verbal and visuospatial abilities.

Hypotheses for Study 2

Given the thousands of hours that experts spend learning which letter combinations make up legal words without deliberately learning their meanings, we proposed that the experts would actually know the meaning of fewer words than novices who routinely learn words with their meanings. However, we did not expect differences in knowledge of word meanings among the competitive players as a function of their level of expertise because all of the competitive players would have used study strategies that place little emphasis on word meanings when they prepare for competition. Thus, despite their much higher ratings, experts would not show a commensurate advantage in their knowledge of word meanings relative to competitive players who have less expertise.

Expert players were also expected to have an advantage relative to the novice group on measures of visuospatial ability because deliberate practice at Scrabble implies the motivation to improve at this game, which uses several different visuospatial abilities. These include (a) visualizing what a rotated board will look like when it faces the player, (b) mentally aligning letter tiles in ways that create words, (c) maintaining the image of newly created words while they are scanned and checked for their point value, (d) memorizing the layout of point values on the board, and (e) transforming imaged words into different orientations to make new words adjoining those already on the board. The purpose of Study 2 was to identify the cognitive abilities that distinguished players of novice or moderate standing from more expert players.

Study 2

Method

Participants

Expert participants. We recruited 26 (11 women, 15 men) competitive Scrabble players at random from volunteers at the 2002 Scrabble National Championships in San Diego, California. In exchange for their participation, they were offered a choice of small gifts, which included picture frames, travel alarm clocks, and a pen set. The experts ranged in age from 20 to 74 years old, with a mean age of 49. Their mean number of years of education was 16.6, or more meaningfully, they had attended a half year of graduate school after completing a college degree. (This was virtually the same level of education that had been reported by the expert participants in Study 1.)

The mean Scrabble rating for study participants at the time of the tournament was 1496.8, which was just at the border between Divisions 3 and 4, close to the midpoint of competitive players. All official ratings were obtained from published lists available at the tournament. The men's mean rating was 1689.9 ($SD = 228.9$); women's average rating was 1233.4 ($SD = 275.6$), which was significantly different, $t(24) = 3.75$, $p < .05$, $d = 1.25$, a large effect according to the criteria proposed by Cohen and Cohen (1983).

We asked about other games they played to see if we could determine whether they played other games that could have been affecting their cognitive abilities. The competitive Scrabble players indicated that they also played card games, chess, crossword puzzles, cribbage, poker, bridge, blackjack, and the video game Tetris. The mean number of hours per week they played Scrabble was 9.02 ($SD = 8.72$). This group of experts had higher average ratings and practiced more hours a week than those who had participated in Study 1. As in Study 1, the relationship between the number of hours played per week and participants' official Scrabble ratings failed to obtain statistical significance. It may be that correlations are only found when practice is measured in number of years they have been playing.

Comparison group. The comparison group consisted of 26 students (11 women and 15 men, the same as the expert group) at the same liberal arts college described in Study 1. None of the students had participated in Study 1. They volunteered for participation in exchange for partial credit toward a research participation requirement.

Procedure and Design

The expert participants volunteered for a study of the cognitive processes of competitive Scrabble players that was conducted on site at the 2002 National Scrabble Championship. We received permission to collect data at the championship event, but we were restricted to days and times when there were no main events. Given the amount of time available to us, we were only able to collect data from 26 experts for this study. The experts were told that it would take about 1 to 1.5 hr of their time.

Five cognitive assessments were administered individually. Half of the participants began with assessments that were presented on a laptop computer; the other half began with assessments that were administered via paper and pencil. Test order within these two administration modes was random. All computer-administered tasks were presented on a Dell notebook using MicroExperimental Laboratory software to control presentation times and collect RTs in milliseconds. Participants were instructed to work as quickly and as accurately as possible for all tasks in which RTs were collected. Both accuracy and speed were emphasized as important in these tasks at the start of the practice trials and again when the actual data collection began. The student comparison group took the same battery of tests in the same order. The comparison group took their assessment in a quiet classroom on campus.

Two tests of verbal ability were administered: the Extended Range Vocabulary Test from the Educational Testing Service kit of factor-referenced cognitive tests (Ekstrom, French, Harman, & Dermen, 1976), which consists of 48 words; and a lexical decision task, a standard cognitive paradigm in which participants are shown a series of five-letter words that appear on a computer screen (Ratcliff, Gomez, & McKoon, 2004). The task for the participant in the Lexical Decision Task was to press a computer key that corresponded to judgments of word or nonword for the letters on the screen. The lexical decision task provides a measure of speed of access to verbal information in long-term memory. RT measures from the lexical decision task provided a comparison for RT measures taken for the visuospatial tasks. Unlike the vocabulary test, it was assumed that all participants would recognize all of the words and nonwords if there were no time pressures, so the lexical decision task provided speed of access information that was different from the information about verbal ability that the vocabulary test provided. Carroll (1993) presented data on the information-processing correlates of reading whereby he showed that vocabulary tests load on different primary factors than the lexical decision task, which provides construct validity for the contention that they provide information about different underlying abilities.

Three qualitatively different measures of visuospatial ability were used. The Shape Memory Test is a paper-and-pencil test from the Educational Testing Service kit of factor-referenced cognitive tests (Ekstrom et al., 1976). Participants were presented with pictures of shapes (not easily labeled to ensure visuospatial processing) for 5 min (timed presentation of stimuli). They then were presented with a second picture in which they had to circle those shapes that had been moved or had not appeared in the first picture. The two other tests of visuospatial ability, paper folding and mental rotation, were computer administered so we could record RTs in addition to number correct. In Carroll's (1993) extensive review of the factor-analytic approach to cognitive abilities, he listed five visuospatial factors. The Paper Folding Test and mental rotation task both load on a general visualization factor, which he described as "the ability to comprehend imaginary movements in a 3-dimensional space or the ability to manipulate objects in imagination" (p. 308). He stated that similar tests are used to assess mechanical movement, principles, and reasoning. By contrast, the shape memory task is a visual memory task in which participants need to form and remember a mental representation of groups of objects that are not recognizable and thus do not generate a verbal label (Lohman, 1979). The use of a vocabulary test allowed us to answer the question of whether years of practice using words without attending to their meaning would show up in the expert players' knowledge of word meanings. The lexical decision task was a laboratory task that was similar to a task that is required of Scrabble players who must decide quickly if a combination of letters comprises a word. RTs were of primary interest in lexical decision tasks because accuracy was expected to be near 100% for all participants.

The Paper Folding Test was taken from the Educational Testing Service kit of factor-referenced cognitive tests (Ekstrom et al., 1976). It is designed for paper-and-pencil administration; however, we altered the way in which it is given by scanning the images into the computer, which allowed us to collect RTs. A drawing of a piece of paper folded up to three times is shown; a hole is punched into the folded paper, which is then unfolded. The participants' task was to select the correct unfolded paper from among four alternatives. The mental rotation test was adapted from Vandenberg and Kuse's (1978) paper-and-pencil test of mental rotation. The stimuli required rotation in both the depth and picture planes. We used three-dimensional rotation because we were concerned that the expertise advantage might only be found with more difficult tests (i.e., there would be a ceiling effect with two-dimensional rotation). Each item plus two practice items from the Vandenberg and Kuse 25-item mental rotation test was scanned into the computer to allow for collection of RTs in addition to number correct. The participants' task was to indicate which figure among the three on the right could be rotated to match the figure on the left. Stimuli similar to the ones used are shown in Figure 2.

These three measures of visuospatial ability were selected because of the similarity between the underlying cognitive processes they tap and those that we believe are needed for playing competitive Scrabble. The paper folding task requires visuospatial manipulation of information in memory, which is the same ability required for mentally manipulating letter tiles while imagining them placed on different combinations of squares on the board. The mental rotation task requires the ability to mentally transform the orientation of a complex stimulus while deciding if it is similar to another stimulus. For approximately half of the time spent in competitive Scrabble play, the board is oriented toward an opponent, so we hypothesized that the ability to generate and maintain a mental representation of the board (or parts of the board) in a different orientation would be important in competitive play. Finally, the shape memory task requires the ability to maintain accurate information about the relative location of different shapes, which parallels the ability to keep the layout of a current board in mind while working with the tiles on one's rack and selecting new tiles for the next round. Thus, all of the measures were selected because of the similarities between the underlying cognitive processes they require and the cognitive processes that we hypothesized would (and that are thought to) be used during Scrabble.

Results

Data were analyzed first with a multivariate test of statistical significance that compared the novice and expert groups on five assessments with the number correct on each as the dependent measures: vocabulary test, lexical decision task, mental rotation task, paper folding task, and shape memory task. The groups were found to be statistically different, Wilks's $\lambda = .475$, $F(5, 41) = 10.37$, $p < .01$. (RT dependent measures were not assessed in the multivariate analysis because of the sensitivity of multivariate analysis to outliers and nonnormality and other statistical requirements that are difficult to achieve with RT data; Tabachnick & Fidell, 2001.) Data analysis then proceeded for each test, including reaction measures.

Tests of Verbal Ability

Extended Range Vocabulary Test. Participants indicated the correct definition for 48 words. Each correctly defined word was scored as 1 point, making the maximum score on this test 48. Mean data for the experts and novices and tests of statistical significance are presented in Table 3. Cronbach's alpha, a measure of internal consistency reliability, was computed. The internal reliability for this scale was .77, which is acceptable according to the guidelines suggested by Pallant (2005). In addition to comparing the two groups, we also analyzed data as a function of participants' official Scrabble rating for the expert group. Contrary to expectations, the number of correctly defined words correlated significantly with participants' official Scrabble rating, $r(21) = .45$, $p < .05$, showing a moderate relationship (Cohen & Cohen, 1983), with higher rated players defining more words correctly.

Lexical decision task. Data pertaining to the number of correct responses for each group are presented in Table 3. Two reliability coefficients were computed for the lexical decision task—one for the number of correct responses ($\alpha = .71$) and one for the RT data ($\alpha = .72$). Because accuracy on this task was so high for both groups, we were able to examine the RT data to see if they differentiated novices from experts. For the lexical decision task, mean RTs in milliseconds were computed for each participant for correct responses and then tested for significant group differences using an independent samples t test, assuming nonhomogeneity of variance. Data from these analyses are presented in Table 3. RTs for the lexical decision task were not significantly correlated with official ratings for the expert group; however, because RT slows with age (Der & Deary, 2006) and the most expert players were older, a partial correlation was computed controlling for age and was found to

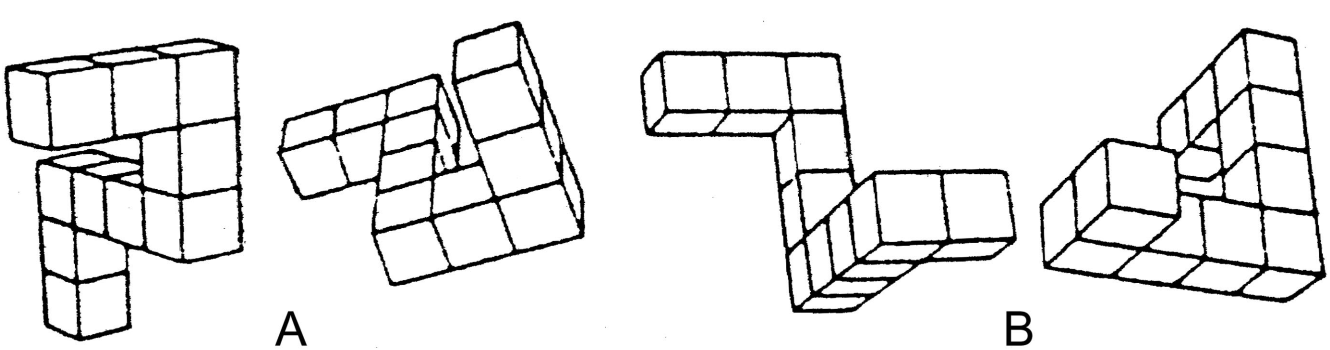

Figure 2. Panels A and B show figures similar to the ones used in the mental rotation task.

Table 3
Comparisons of Expert and Student Performance on Five Tests of Cognitive Abilities

Test (dependent measure)[a]	Experts	Novices	Statistical test
Extended Range Vocabulary (48)	33.46 (7.84)	26.31 (6.66)	$F(1, 50) = 12.57$, $p < .01$, $MSE = 52.92$, $d = .88$
Lexical decision (40)	37.03 (2.85)	38.88 (2.41)	$F(1, 50) = 2.05$, *ns*
Mental rotation (25)	15.30 (5.13)	16.04 (4.36)	$F(1, 50) = 0.21$, *ns*
Paper Folding (20)	15.12 (3.44)	13.00 (2.97)	$F(1, 50) = 1.72$, *ns*
Shape Memory (32)	26.46 (8.40)	20.20 (3.18)	$F(1, 50) = 16.25$, $p < .05$, $MSE = 37.09$, $d = .90$
Paper folding reaction time (ms)	27,556 (1,877.21)	31,534 (1,994.91)	$F(1, 50) = 12.25$, $p < .01$, $MSE = 15{,}256$, $d = -2.05$
Lexical decision reaction time (ms)	865.02 (381.58)	922.06 (646.79)	$t(41) = .318$, *ns*

[a] Number in parentheses indicates total possible correct for that measure.

be statistically significant, $r(23) = -.39$, $p < .05$,[1] with greater expertise associated with faster speeds. (Note that sample sizes vary slightly among analyses because of missing data.)

Tests of Visuospatial Ability

Shape Memory Test. A total of 32 changed and new items were presented on the Shape Memory Test, for a maximum score of 32. Data comparing the number correct for the expert and novice groups are presented in Table 3. Reliability for the Shape Memory Test was .75. The number of changes and new items correctly identified in the Shape Memory Test were not significantly correlated with participants' official ratings.

Mental Rotation Test. Mean number correct and RTs for correct and incorrect stimuli were computed for each participant. The data and analyses for number of correct items are presented in Table 3. As with the lexical decision task, two reliability coefficients were computed for the mental rotation test—one for number of items correctly answered ($\alpha = .88$) and one for the RT data ($\alpha = .90$). Perusal of Table 3 will show that both groups got a large number of items incorrect (38% for the experts and 36% for the novices), which makes an analysis of RT data questionable because RT measures are only valid indicators of processing time when they are accurate reflections of the time needed to complete a complex task. The large number of incorrect answers could mean that the participants were guessing on many of the items (i.e., not using the hypothesized underlying cognitive processes—in this case mentally rotating the item) or that items were so difficult the participants could not accurately solve many of them even after concerted effort.

Paper Folding Test. The Paper Folding Test had a maximum of 20 correct responses. Data and analyses comparing the novice and expert groups are shown in Table 3. The reliability coefficient for the number of correct items on the Paper Folding Test was .79 and for the RT data, .81. The total number of paper folding items answered correctly correlated with official ratings, $r(24) = .59$, $p < .05$, for the expert group.

Correlations among variables were computed separately for the comparison group of college students and the competitive players because differences in the variability of these two groups made their combination problematic. These values are presented in Table 4. Multiple regression analysis was used to predict official Scrabble ratings from the number correct on the five cognitive tests. The visuospatial tests were entered on the first step; however, review of the output showed that the number correct on the paper folding task was the sole statistically significant predictor of rating, $\beta = .590$, $F(1, 21) = 11.27$, $p < .05$, $R^2 = .35$.

Discussion

In an attempt to understand the cognitive abilities that differentiate expert Scrabble players from those at lower levels of performance, we gave five cognitive ability tests to players with a broad range of official Scrabble ratings who were recruited from a nationally representative Scrabble tournament. Their performance on these tasks was compared to that of a group of college students at a selective university as a test of the general idea that the encoding and retrieval processes of Scrabble experts who have spent thousands of hours practicing and playing Scrabble should reflect the way they prepare and play. Although we expected that the comparison group of high-achieving students would have a greater knowledge of vocabulary than the expert group because the experts reported that they often did not attend to word meaning, the expert group scored higher on the vocabulary test. Of course, the difference in vocabulary knowledge might also have been expected because the expert players were decades older than the college students and would be expected to have accrued vocabulary knowledge throughout their adult life. In a study of 210 separate articles on the topic of aging and vocabulary, Verhaeghen (2003) found the average effect size, favoring older adults, was 0.80 *SD*. Although the expert group was not "old," but closer to the mid-adult age range, aging effects could have been a contributing factor to their superior vocabulary. The relationship between the expert players' official Scrabble rating and the number of vocabulary words they correctly defined had not been expected, but in hindsight it seems that the lower end of the expert group may not be all that "expert" given their low ratings. It may be more useful to think of them as potentially future experts.

We hypothesized that the expert group would be particularly good at speeded cognitive tasks that are similar to those used during play. The lexical decision task seemed to be such a measure, because competitive Scrabble players need to make rapid decisions as to whether a string of letters forms a legal word. Speed of lexical access was correlated with expertise, but only when we controlled for age because the more expert players were older, and thus would respond more slowly than the younger players. It is

[1] We thank Dr. Phillip L. Ackerman at Georgia Institute of Technology for suggesting this analysis.

Table 4
Correlations Among Variables for Cognitive Tests and Demographic Variables for Expert (Above Diagonal) and Novice (Below Diagonal) Scrabble Players

Variable	1	2	3	4	5	6	7	8
1. Vocabulary	—	−.039	.234	−.131	.105	.072	.245	.030
2. Lexical decision	−.426**	—	.135	.124	.204	−.056	−.405*	.315
3. Paper folding	−.153	.118	—	.162	.731**	.183	−.115	.414*
4. Shape memory	.154	−.244	.083	—	.271	−.176	−.001	.162
5. Mental rotation	−.175	.065	.250	−.019	—	.272	−.098	.403
6. Gender	−.124	−.156	−.160	.023	.156	—	−.308	.633**
7. Age (experts only)							—	.104
8. Official Scrabble rating (experts only)								—

* $p < .05$. ** $p < .01$.

well known that RT, especially choice RT, slows with age. Although the mean age of the expert group was mid-adult, the comparison group had the advantage of youth, which can be considerable in speeded tasks (Der & Deary, 2006).

The large number of errors on the mental rotation task showed that both groups had difficulty with this task. The vast literature on mental rotation has found individual differences with this task. The failure to find a significant advantage for the expert group on this task was in accord with the reports given by expert players in Study 1. When asked about their use of mental rotation when they played Scrabble, they responded that they were less likely than a novice group to mentally rotate a board in play. The most interesting results were obtained with the paper folding task, which was not performed more accurately by the expert group but was performed more quickly with increasing differences in speed as a function of official rating.

Overall, we have some intriguing findings on working memory abilities in Scrabble players and a comparison group of college students and the possibility that they use different abilities in common information processing tasks. Shah and Miyake (1996) presented a strong case for the separability of working memory resources for visuospatial thinking and language processing. Logie (1995) declared that there is a "dissociation between verbal and visuospatial processing" (pp. 87–88). Because expert-level Scrabble play requires both verbal and visuospatial cognitive processing in working memory wherein the spatial layout of the letter tiles is integral to play along with the words made up by the tiles, we hypothesized that Scrabble would be an ideal paradigm for examining how these two cognitive components operate during the same cognitive task.

There are several reasons why we believe that visuospatial processing is important in determining high-level success at competitive Scrabble, although the data from Study 2 provided only partial support for this belief. We have been struck by group differences at the top levels of Scrabble champions. For the past quarter-century, women have outnumbered men at Scrabble clubs and tournaments, but a woman has won the championship only once (Tierney, 2005). Among the top-ranked 50 players at any one time, approximately 45 will be men. This finding is especially difficult to explain if we are to assume that competitive Scrabble is primarily a word game because women, on average, score higher on many tests of verbal ability, especially tests of writing, learning paired associations, and early vocabulary development. (See Halpern, 2000, 2006, for reviews.) In contrast, large differences favoring men are found on some visuospatial tests, especially tests of mental rotation (Halpern & Collaer, 2005). If Scrabble expertise depended more on visuospatial abilities than on verbal abilities, we would expect many fewer women among the very top players, which are what the data on tournament Scrabble show. Of course, there are many other possible explanations, such as differences in the motivation to achieve the very top of Scrabble success and differences in time spent studying lists of words, or other factors that could account for the large disparities in the representation of women and men at the top levels of Scrabble tournaments.

The question of whether visuospatial processing or memory can explain success in Scrabble is central to researchers' understanding of the cognitive processes that underlie tasks that require memory for spatial arrays and manipulations of images. The question about the role of visuospatial abilities has not been answered satisfactorily for chess, despite the large research literature on this topic. Spatial abilities have tended to be overlooked in many contexts (Shea, Lubinski, & Benbow, 2001), including academics, and thus were investigated further in Study 3.

Study 3

To further examine the relative role of verbal and visuospatial abilities in Scrabble experts, we borrowed and adapted an old paradigm that was originally devised for the study of chess. In the classic experiment conducted more than 60 years ago, de Groot (1946, 1965) set up chess boards that were either in the middle of legitimate chess play or with the pieces placed on the chess board in positions that were random and thus violated the rules of the game. Chess players with different levels of expertise viewed the boards for a few minutes, and the boards were then covered. The task for the participants was to reproduce the boards from memory. It was surprising at the time to find that the experts were highly accurate at reproducing legitimate boards but no better than novices at reproducing boards on which the pieces had been placed at random.

Studies in which novices and experts reproduce chess board games from memory have provided psychologists with information about the development of expertise in general and in chess, more specifically. Experts organize information about legitimate board games in an efficient manner so that entire boards create recognizable patterns that are quickly "chunked" into templates that facilitate strategic play and reduce the load on working memory. Illegal boards with chess pieces placed in ways that violate the rules cannot be chunked into easily recognizable patterns, so experts do not have the same memory advantage over those less experienced with these boards. The ability of expert chess players to recall very large amounts of information from chess boards that represent real games has led Ericsson and his colleagues (Ericsson & Kintsch, 1995) to hypothesize the existence of long-term working memory, a construct that explains how experts can access and utilize the large amounts of information that are needed during play.

By analogy to chess and the oft-repeated paradigm of presenting experts and novices with boards that have been manipulated in predetermined ways, we reasoned that players' memory for letter tiles on a board would differ depending on the type of violation to the rules of Scrabble that was shown on the board to be recalled. Thus, we utilized four boards, three of which were devised with different types of violations: (a) a real board that was taken from a tournament game and thus did not violate the rules of Scrabble, (b) a board on which there were misspelled words—a verbal error, (c) a board with detached words—a spatial error, and (d) a board with too many blank tiles—a general violation of official game rules that did not cause misspelled words or spatial disconnects for the words on the board.

The board with the spatial error was an example of a structure-deforming transformation. Unlike a misspelled word, a structure-deforming error should be most difficult for Scrabble players who have not achieved a high level of expertise. To novices, all errors should be approximately the same because these individuals do not have highly developed perceptual patterns for legitimate boards. Experts should be able to recognize the transformation as a legitimate board with a fundamental, easily perceivable error. It is the "experts in training" who are in the process of developing expertise whose performance should be most disrupted by structure-deforming transformations. Experts who are early in their development cannot ignore or rapidly encode a disruption that creates major changes to the game. Novices may not even notice something that is immediately obvious to an expert, such as a disconnected array of letters or the wrong combination of letter tiles.

We hypothesized that competitive players who had not yet obtained expert status—those with low official ratings, for example—would have more difficulty than novices or experts when a fundamental principle or rule had been broken because they would lack the perceptual ability to quickly assess what the error is and they would not be able to find a match between their perception of the board and an explanation in memory. We hypothesized that differences among players with different levels of ability would be found when spatial rules were violated, if spatial skills make the greatest contribution to expert success at Scrabble. Experts should be more likely to notice these violations during the study part of the experiment and correctly reproduce them than players with lower ratings.

Method

Participants

Expert Scrabble players. We recruited 48 (28 men, 20 women) competitive Scrabble players through local Scrabble clubs located all over the United States. They ranged in age from 17 to 76 years old, with a mean age of 44.25 (SD = 11.95). All participants were contacted via e-mail and participated voluntarily in exchange for a $10 gift certificate from the online marketplace Amazon.com or the opportunity to donate the gift certificate to a charity of their choice. (Several talked to the experimenters on the phone to verify the authenticity of the study and for reassurances about the programs they downloaded to their computers.)

Comparison group. As in the previous studies, the comparison group consisted of college students from a selective liberal arts college. We recruited 28 men and 20 women to match the numbers in the expert group. None had participated in Studies 1 or 2. The college students were all between 18 and 23 years of age. They participated in exchange for partial credit toward a research requirement of all students in lower division classes.

Design and Procedure

After agreeing to participate, expert players were sent an executable program as an attachment to their e-mail. They were told to download the program to the desktop of their computer and follow the detailed instructions that appeared on their screen and were duplicated in the e-mail.

When the program was executed, it presented a full-color picture of a Scrabble board with letter tiles on the square spaces as might be seen in any game that has completed play. Five different Scrabble boards were shown, one at a time. The board for the study portion of each trial remained on the screen for 3 min, then it disappeared and a blank board was shown on the screen with Scrabble tile letters shown along the side of the screen. Participants had up to 12 min to reproduce the board that they had just seen during the previous study portion of the experiment. Virtual letter tiles could be clicked and dropped onto the board to the square that participants recalled seeing them on the board they were reproducing. Participants reported that 12 min was more than enough time to complete the memory task. When they completed one trial (i.e., studied the board for 3 min, then reproduced the board within 12 min), they could start the next trial or take a break before going on to the next trial. The program automatically saved the position of the letter tiles at the end of each trial. Once a board was used, it could not be reused by participants because their responses were saved to the file. Participants returned the program files with their responses saved for each trial via e-mail.

The comparison group used the same software program for studying and reproducing the Scrabble boards. They participated at school during a time that was convenient for them, with instructions given by an assistant.

We created five Scrabble boards: one for practice, one that depicted an ordinary game at the end of play (the real board), and three that included different game violations (misspelled words, disconnected words, and too many tiles). Thus, we extended earlier work on memory for chess games by including three different types of violation conditions so that we could distinguish the effects of spelling violations, spatial violations, and arbitrary game violations on memory for the tiles on the board.

The executable program, which we named *Scrabble Tester*, was designed to accommodate online testing and to allow participants to complete the experiment at their own pace. This program was in color and replicated a normal online Scrabble® board to fine accuracy. It was designed specifically to test memory for each of our Scrabble board situations.

Each trial started with a participant-initiated response. For both the study and reconstruction phases of each trial, a small timer was visible in the bottom right-hand corner of the screen that indicated how much time was left until the study or reconstruction phase terminated. After the testing phase was completed, participants were asked to also provide the following information electronically: their official National Scrabble Association rating, gender, age, whether they were native a English speaker, the average number of days per week they played Scrabble, and the average number of hours per day they played.

Results

The mean official rating of participants in the expert group was 1391.85 (SD = 296.04), which is near the border between Divisions 3 and 4 and close to the midpoint of competitive players. The mean ratings for the men and women were 1461.86 (SD = 312.5) and 1293.85 (SD = 246.35), respectively, which was a statistically significance difference, $t(21) = 3.69$, $p < .01$, $d = .57$, a moderate effect size according to the criteria suggested by Cohen and Cohen (1983). The experts played a mean of 2.25 (SD = 1.07) hr a day and 4.92 days a week (SD = 1.78), which is equivalent to a mean of 11.07 hr a week or 575 hr a year of Scrabble play. Thus, this sample played a mean of an additional 2 hr per week as compared to the players in Study 2. The questions about time spent playing were worded differently in the studies, so we cannot know if the differences in reported time reflect differences in how the questions were asked or whether they reflect genuine differences. All participants reported that English was their native language.

The relationships between the participants' official rating and age or total time per week they reported playing Scrabble did not obtain statistical significance. Memory for the four types of Scrabble boards was analyzed two ways. One method of scoring was based on the number of words correctly recalled, with 1 point for each word recalled in its correct position and 0.5 points for every correct word in an incorrect position or for "near misses" in the correct spelling or placement of the word. Boards were also scored on a per letter tile basis, with 1 point awarded for each letter tile that was correctly recalled in its exact same position as in the study phase. With these two scoring methods, the maximum points for each of the four reconstructed boards varied in this way: (a) real board at the end of play (maximum 39 words, 97 letter tiles; mean word score: 24.12, mean letter tiles: 66.77); (b) board with misspelled words (maximum 42 words, 98 letter tiles; mean word score: 23.55, mean letter tiles: 62.77); (c) board with disconnected words—spatial violation board (maximum 43 words, 98 letter tiles; mean word score: 24.40, mean letter tiles: 63.58); and (d) board with three extra blank tiles (maximum 44 words, 99 letter tiles; mean word score: 22.74, mean letter tiles: 61.17). The two methods of scoring were highly correlated, with all rs $> .90$ for the two methods of scoring the same board.

Differences between the two groups were tested with two multivariate analyses of variance, one for the four boards scored by letters and one for the four boards scored by words. The results were essentially identical. The groups differed in the number of letters correctly reproduced, Wilks's $\lambda = .620$, $F(4, 86) = 13.17$, $p < .01$, and in the number of words correctly reproduced, Wilks's $\lambda = .562$, $F(4, 86) = 16.73$, $p < .01$. Because the results were so similar with both measures, we present the data and analysis only from the letter scoring method in Table 5.

Correlations were computed with participants' official ratings for the expert group and their scores on each of the board types. We found that official ratings were significantly correlated with both word and letter scores on the board with spatial violations, $r(46) = .30$ and .33, respectively, and with the board with too many blank tiles, letter tile scores only, $r(46) = .32$, all ps $< .05$.

Data were further examined with multiple regression analysis, using official rating as the dependent variable. The boards that deformed the structure of the game were entered into the regression equation with spatial transformation entered on the first step and data from the board with extra letter tiles entered on the second step. Scores on the board with spatial violations (letter tiles disconnected) showed a significant relationship to Scrabble rating, $F(1, 46) = 5.52$, $p < .01$, $R^2 = .11$; scores on the board with too many tiles made a significant increment to the percentage of variance explained, $F(2, 45) = 5.95$, $p < .05$, delta $R^2 = .10$. Scores from the other two boards failed to account for a significant increment in variance accounted for in official Scrabble ratings.

General Discussion

These studies show that the game of Scrabble can be added to research paradigms that offer a window into the minds of experts and novices. And like with other games and research paradigms, the view is not as clear as we would like. The generally acknowledged way of becoming an expert in Scrabble is to memorize long lists of unusual words that appear in the *Official Scrabble Player's Dictionary*, concentrating on the ones that are most likely to be needed to get high scores from the letters on one's rack (Fatsis, 2001). The survey data collected from the experts provide support

Table 5
Scores on Scrabble Boards Reproduced From Memory for Comparison and Expert Scrabble Player Groups (Letters)

Type of board	Group	M (SD)	Statistical test
Real (no errors)	College students	38.61 (14.16)	$F(1, 89) = 52.52$, $p < .01$, $MSE = 342.62$, $d = 1.11$
	Experts	66.71 (21.67)	
Spelling error	College students	33.28 (23.21)	$F(1, 89) = 42.08$, $p < .01$, $MSE = 468.84$, $d = 1.17$
	Experts	62.77 (18.08)	
Spatially disconnected	College students	32.56 (20.52)	$F(1, 89) = 40.07$, $p < .01$, $MSE = 544.90$, $d = 1.14$
	Experts	63.58 (25.61)	
Extra blank letter tiles	College students	31.26 (21.84)	$F(1, 89) = 52.17$, $p < .01$, $MSE = 388.99$, $d = 1.15$
	Experts	61.17 (24.70)	

for this generally acknowledged practice. Players want to be able to recognize words that contain the rare high-point letters in order to maximize their ability to make high scores with them. Such lists would include words with many vowels and words that include rare and high-point letters like *z* or *q* (no one wants to have these left on their rack at the end of the game because the point values are subtracted from the unfortunate player's score and added to the score of the other player). Thus, it is a universal strategy for competitive Scrabble players to memorize relevant word lists.

One of the attractions of studying Scrabble is that experts are expected to learn words and retrieve them in ways that differ from those of casual players who rely on the words they know by meaning. As expertise develops, players should become more reliant on the visuospatial nature of the game than its verbal components because the meaning of words is not relevant for successful play. However, as shown in Study 2, Scrabble experts have an advantage in word knowledge with meanings when compared with high-achieving college students. The greatest advantage for the expert group was found with the time needed to complete the paper folding task. RT measures on the lexical decision task, which measures speed of access to word knowledge in memory, correlated with expertise, but only when the slowing effects of older age were controlled. The importance of visuospatial abilities was seen again in Study 3, which showed that better players, as identified by their official Scrabble rating, performed better on memory for Scrabble boards than players with lower ratings both when the spatial rules of the game were violated and when the rules of Scrabble were violated with too many blank tiles, but not when the violation was a misspelled word or the board was legitimate. The experts consistently outperformed the comparison group on all types of boards.

The results of our adaptation of de Groot's (1946) original experiment to Scrabble are not parallel to those originally found with chess. Unlike in the older chess study, differences between the best of the expert players and competitive players with relatively low ratings were not found on the board that represented legitimate play; instead, they were found on two boards that violated specific rules of the game—a spatial violation and a playing violation (too many blank tiles). How might we explain these important differences? One explanation can be found in research by Chase and Simon (1973) that was designed to replicate the original de Groot study. They found that the differences between novice and expert chess players were not as great for reproducing end-game positions from memory as they were for middle-game positions. Chase and Simon hypothesized that end-game positions were easier to remember because they are more standard than middle-game positions. We note here that the legal board that we used (as well as the one we used for training) was an end-game board for a real game that had been played.

It is also possible that the difference lies in the fact that the violation boards used by de Groot for chess had pieces placed randomly so each piece would need to be recalled separately. For our own violation boards, tiles were placed in generally meaningful word patterns. Expert players could use a cognitive strategy of noting the templates plus the violation, a strategy that would reduce the load on working memory. This sort of strategy would not have worked if all of the letters had been placed on the board at random. Thus, these results are consistent with the classic studies of schema inconsistency in which participants show enhanced recall for information that violates their expectations (e.g., Brewer & Treyens, 1981). It is likely that Scrabble schemata are better developed for better players.

There are also differences between chess and Scrabble in the extent to which players rely on visuospatial memory. Waters, Gobet, and Leyden (2002) concluded that chess players do not rely on their visuospatial abilities, so one explanation for the differences in the results is that the underlying cognitive process may not be the same for these two games. Scrabble is also distinct from other games like chess such that we hypothesized that experts would use memory and coding strategies that differ in qualitative ways from those of novices.

More recent studies with the de Groot (1946) chess paradigm found that strong players had better recall than weak players for both legitimate and random placement of the chess pieces (Gobet & Simon, 2000). The advantage for stronger players increased as the study time was increased, which the authors attributed to the ability of stronger players to hold more chunks of information in long-term memory. Expertise involves the ability to recognize patterns as single memory units, the translation of these chunks of information into templates, and an increase in the number of chunks that can be held in memory. Even if we determined these processes are a good description of what develops with expertise, we still have much to learn about the role of deliberate practice and the effects of different types of disruptions on performance (e.g., Ericsson, 2005).

In chess, swift pattern recognition for the position of pieces as they are played is important for the *forward search*—deciding what move to make next (Chabris & Hearst, 2003). The same hypothesized process of recognition and search does not map neatly onto Scrabble because the pattern of tiles on the board shares the importance in determining how to find the next move with the letters actually printed on the tiles. Spatial layout alone does not provide enough information to guide the next move, which is an important difference between these two types of games. Support for this view comes from a de Groot-type memory study by McGregor and Howes (2002). They found that skilled chess players had better memory for chess board positions only for those pieces that were important for their role in attack and defense strategies. The proximity of chess pieces was not important in determining which pieces were correctly recalled by experts, so it is not just expert encoding of a legitimate board that differentiates expert and novice chess players, but it is memory for the pieces that are important in the strategy of playing that determines what experts will remember. As with other types of expertise, Scrabble players with higher ratings select the most relevant information and encode it as a representation that facilitates the planning and execution of moves (Ericsson & Lehmann, 1996). Thus, future research on whether expert memory is better than novice memory for those words on the board that offer the possibility of high points on subsequent plays would allow us to determine if there are parallel attentional mechanisms at play in Scrabble.

We hypothesized a shift in how players study and retrieve information during play that would move away from strategies that search memory representations organized by meaning to those that search memory representations that are organized by letter combinations. It seems that experts in fact have considerable knowledge of word meanings, which must have been attained incidentally over their many years of play. At the same time, experts learn to attend to and utilize visuospatial arrays on the board. Working memory is often conceptualized as relatively independent pools of resources (e.g., Logie, 1995; Shah & Miyake, 1996), one for verbal or phonological tasks and one for visuospatial tasks, which makes competitive Scrabble, with its reliance on both skills, an excellent paradigm for understanding how these two types of resources are developed and utilized.

In addition to informing the expertise literature, the results are relevant to a large number of applied fields because they provide information about the development of verbal and visuospatial abilities over decades of adulthood. The usual finding in the adult aging literature is that visuospatial skills decline with age (Shaw, Helmes, & Mitchell, 2006). Yet, the present data show that the experts who were decades older than a group of high-achieving college students had better memory for words and letters and their placement on legitimate and transformed Scrabble boards (Study 3) and for shapes (Study 2) and that they had faster RTs for a visualization test (paper folding). These results provide direction for studies of cognitive aging by suggesting that decades of intensive practice and training may have positive effects on some cognitive abilities. Although we cannot make causal claims without random assignment of participants to different conditions, the stringent requirements for causal claims cannot be obtained in real-life (applied) studies for which experts train for decades. Correlations between level of expertise and number of years that the experts have played Scrabble suggest that the abilities that underlie Scrabble expertise develop over time (i.e., a dose size effect). This conclusion does not rule out the hypothesis that individuals who are naturally better at these abilities are the ones who reach the highest level of expertise after years of practice, but practice appears to be necessary for the development of expertise.

The results from the expert Scrabble players show that they have superior abilities (compared to a much younger, high-ability group of college students) in selected verbal and visuospatial tasks. These results offer hope for the large number of baby boomers who are approaching their own older adult years with trepidation. These results may be generalized with caution to other domains that share variance with the abilities that were studied here, but they are good news, even if they are not as strong as we had hypothesized they would be.

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