The Journal of Psychology, 2002, *136*(5), 469–492

Memory for Animal Tracks: A Possible Cognitive Artifact of Human Evolution

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ABSTRACT. Although many human behaviors are held to have adaptive significance, specific examples of behaviors that represent direct holdovers from the ancient world have been few, particularly in the cognitive realm. In the present research, the authors tested the hypothesis that such cognitive examples might in fact exist and be experimentally verifiable. They suggested that human predispositions to learn basic aspects of hunting with relative ease might be "left over" from human evolution in the pre-agricultural past. This hypothesis was tested in 3 experiments with reference to the learning and recall of animal tracks, an activity of probable high adaptive significance within the area of visual memory. Undergraduate students selected at random learned and recalled animal tracks with significantly greater ease than they recalled other animate and inanimate items. A single exception lay in relatively unfamiliar kitchen implements, which were recalled with greater facility than were animal tracks, consistent with current theoretical considerations. Results indicate that direct behavioral holdovers from the ancient world may exist in the cognitive realm and that these may be accessed experimentally and predictably under appropriate conditions.

Key words: animal tracks, evolution of cognition, memory

JUST AS THE MORPHOLOGICAL STRUCTURES of living organisms have evolved in response to ecological demands, behaviors and psychological structures can also be seen as adaptations to environments, in some cases to environments that no longer exist (e.g., Cosmides, Tooby, & Barkow, 1992; Michel & Moore, 1995). Much complex human behavior is thought to come from archaic biological roots (Bailey, 1987), especially from the hunter-gatherer adaptations of the pre-agricultural world. This is logical; about 90% of the human beings who ever lived were hunter-gatherers (Bailey, 1987; Lee & DeVore, 1968), and the hunter-gatherer lifestyle was the only way of life 10,000 or 15,000 years ago.

Our modern world is a relatively recent invention, in terms of both geological and anthropological time, and so it is not surprising that numerous behavioral holdovers from the ancient world may exist. Suggested examples of such holdovers include the innate nature of sucking and rooting (e.g., Eibl-Eibesfeldt, 1970), smiling (Gray, 1958; Hass, 1970), and portions of both play fighting and real fighting (Aldis, 1975). This last might have been important in the generation of preparedness for hunting; it has been noted that in at least some species, play fighting includes many of the skills needed for successful hunting in the natural world (see Smith, 1982).

Understanding the evolution of psychology presents problems that may be minimal or nonexistent for students of morphological evolution. Romanes (1882) noted that unlike morphological structures, psychological structures are only visible via their "behavioral ambassadors," the behaviors that may or may not represent holdovers from the ancient world. This fact has necessarily rendered the entire study relatively indirect.

Evolutionary theory has informed the study of psychological and behavioral considerations for over a century. The evolutionary perspective in psychology has ranged from Darwin's early study of the inheritance of facial expressions (Darwin, 1872/1896) to the possible evolutionary roots of violence (e.g., Bailey, 1987), to studies of cognition as a result of the need to understand dominance hierarchies in the ancient world (e.g., Cummins, 1998), to the general mapping of brain and mind through the study of evolved functional organization (Tooby & Cosmides, 2000), and to many other areas and fields. Investigators in virtually all of the behavioral sciences have sought to explain psychological phenomena in evolutionary terms. Yet virtually all have encountered a common difficulty: The investigator is forced to deduce the adaptive significance of behaviors from their possible roles in ancient ways of life, which may not be well understood. The evolution of behavior has proven largely intractible to more formal, testable experimental science. How would one set up an experiment to manipulate the accomplished past?

This problem has proven especially acute in the study of cognition. A large number of theoretical studies of the evolution of cognition have been conducted (e.g., Byrne, 1999; Cummins & Allen, 1998; Godfrey-Smith, 2002; Langer, 1996; Plotkin, 2001; Richardson & Boyd, 2000; Tooby & Cosmides, 2000; Whiten, 2000). These researchers have most typically derived their explanations of how cognition evolved (generally in a well-informed and sophisticated fashion) from analyses of such concerns as the probable responses of hominids to

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This research was supported by a grant from the College of Science and Mathematics, California State University, Fresno.

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conditions of the ancient world, the behavioral adaptations of modern infrahuman primates, or the archaeological record (e.g., Parker & McKinney, 1999). However, as in other fields of psychology, there has typically been no way to test possible competing evolutionary explanations of cognitive phenomena on an experimental basis. This, among other difficulties, has led at least one scholar to suggest that no matter how sophisicated our evolutionary models become, it may never be possible to understand cognitive evolution at all (Lewontin, 1998).

Thus, there is a challenge to cognitive scientists at this point in the history of evolutionary psychology: to demonstrate the existence of specific cognitive adaptations to ancient conditions of living and to do so in an experimental, predictive manner, without the need for post hoc reasoning about probable adaptive significance. We conducted three experiments in a single constrained area to investigate the possibility of a specific cognitive predisposition or adaptation for the tracking of animals in the service of subsistence hunting. Such a predisposition, if extant, would lie psychologically in the realm of long-term visual memory.

Memory for visual materials can be long lived and effective. In an early study, Rock and Engelstein (1959) examined memory for a single abstract shape and found that respondents were still able to recognize the shape 1 month after encoding, although the ability to draw it declined. In another early study, Nickerson (1965) found that recognition memory for 600 scenes and events was 92% accurate after 1 day's retention, and 63% after 1 year. Shepard (1967), using 612 color pictures as stimulus items, found recognition accuracy of 99.7% 2 hours after encoding and 57.7% 120 days later. Standing, Conezio, and Haber (1970), in a study using 2,560 pictures, found recognition performance after several days to be an amazing 90%, and Standing (1973) even found strong memory performance using a set of 10,000 pictures. Haber and Standing (1969), again using 2,560 pictures, found accuracy of 85% after 2 to 4 days.

Many of these estimates of human visual memory capacity seem staggeringly high, and the work has been criticized for the extreme heterogeneity of methods used to obtain these estimates. For example, Goldstein and Chance (1971) used a different method and found somewhat lower levels of long-term retention over a 48-hour period, 71% for faces, 48% for inkblots, and 33% for snowflakes. This result suggested (as is now well known) that the level of meaning present in a given visual stimulus item naturally contributes to its memorability. However, as Baddeley (1986) pointed out, all of the estimates of visual memory capacity have been considerably higher than the 14% that would have been predicted, for example, by chance, in the Goldstein and Chance work, even for relatively nonmeaningful configurations.

So, human visual memory is actually quite good under most experimental circumstances. Memory for things that are meaningful and familiar is of course best (see Sharps & Wertheimer, 2000), and memory for gist and general configuration is better than memory for specific details (e.g., Ahlberg & Sharps, 2002;

Bartlett, 1932; Rubin & Kontis, 1983). In general, and in the absence of mitigating factors such as extreme stress or prior misleading experience (e.g., Sporer, Malpass, & Koehnken, 1996), visual memory for gist- or gestalt-level configurations is quite good, especially recognition memory, which may depend more on gist-level features. We may say, then, that there is solid evidence that human beings possess strong biologically based predispositions for visual memory.

What are the underlying dynamics of visual memory? Although a full consideration of this issue is precluded here by space limitations, ultimately this question comes down to issues inherent in mental imagery. The concept of the image was familiar to Aristotle, and of course to the Greek and Roman mnemonists, who used imagery as a matter of course in their construction of artificial memory aids (Yates, 1966). The idea of the image has cropped up periodically in epistemological and psychological study ever since. Wilhelm Wundt (e.g., 1897) and a number of other early experimental psychologists expressed a strong interest in the concept of imagery; and in spite of early denials of the existence of imagery as such (e.g., Watson, 1913, 1924) and in spite of attempts to formulate imageric memory in terms of purely "propositional" frameworks (e.g., Pylyshyn, 1973), there is no real question at this point that pictorial information is processed differently on many dimensions than are other types of representations.

Paivio (1966, 1971, 1975, 1990; Paivio & Csapo, 1969, 1973; Paivio & Yuille, 1967, 1969) has of course shown that much of this difference may lie in the dual coding of pictures, which come equipped both with mnemonically useful visual detail and with verbal labels. However, dual coding is of course more likely to operate in the creation of "picture superiority effects" in recall frameworks in which meaningful items are used. In recognition frameworks, especially those requiring recognition of unfamiliar, abstract, or perhaps nameless stimulus items (e.g., Goldstein & Chance, 1971; Rock & Englestein, 1959), other factors must come into play, primarily the visual distinctiveness of the visual features presented by the given stimulus item.

Imageric memories can preserve many of the characteristics that were present in the initial pictorial stimuli, including scale, relative location (e.g., Kosslyn, 1980; Kosslyn, Ball, & Reiser, 1978), and orientation (Shepard & Metzler, 1971; see Sharps, 1990, for review). This is not, of course, to say that imageric representations are direct one-to-one models of initial stimulus configurations, even at a gist or gestalt level (see Bartlett, 1932). Pictures are not the same as images (e.g., Jolicoeur, Regehr, Smith, & Smith, 1985; Sharps, 1990; Sharps & Nunes, 2002), and the distinction between the processing of verbal and pictorial information may be better conceptualized in terms of different levels of feature-intensive information and organization (Sharps & Nunes, 2002; also see Hunt & Einstein, 1981) than in terms of a photographic or direct-transfer model. However, the inclusion of distinctive pictorial details in a given memory task has been shown repeatedly to elevate memory performance significantly, to the degree, for example, that the memory performance of elderly adults can be enhanced to parity with that of the young in a variety of visual–spatial and pictorial paradigms (Sharps, 1990, 1991, 1997, 1998; Sharps & Antonelli, 1997; Sharps, Foster, Martin, & Nunes, 1999; Sharps & Gollin, 1987, 1988; Sharps & Martin, 1998; Sharps, Martin, Nunes, & Merrill, 1999; Sharps & Nunes, 2002; Sharps & Price-Sharps, 1996). There is no real question at this point that people can make use of distinctive visual detail, as well as of dual coding, to enhance visual memory performance to relatively high levels.

This is true for both men and women. Much has been made over presumed visual–spatial deficits in women. Men subjectively report being able to rearrange details of visual situations in their minds and to be comfortable with more dynamic aspects of imagery, whereas women report forming static pictures of scenes and being more comfortable with less dynamic aspects of imagery (Harshman & Paivio, 1987; Paivio & Harshman, 1983). However, it is obvious that this type of report can be readily biased by socioculturally mediated personal expectation; performance data are perhaps more compelling in this area than are data derived from personal reports. With regard to performance data, many authors have suggested that differences in pictorial memory between men and women lie specifically in the realms of spatial relations, spatiotemporal tasks, and mental rotation (Linn & Petersen, 1986; McGee, 1979; Schiff & Oldak, 1990; Smith & McPhee, 1987).

At the same time, however, it has been shown that even within the mental rotation framework, probably the research technique most used over the years to address these questions (e.g., Caplan, MacPherson, & Tobin, 1985; Sharps, 1990), researchers have elicited exactly the same performance from men and women simply by de-emphasizing the spatial nature of the task to the respondents (Sharps, Price, & Williams, 1994; Sharps, Welton, & Price, 1993). In short, it has been empirically demonstrated that many of the sex differences in spatial task performance, seen as the primary contributor to sex differences in visual memory, may be laid at the door of gender-related expectations. Furthermore, true biologically based sex differences in visual cognition would not be expected in the realm of memory for static images (Harshman & Paivio, 1987; Paivio & Harshman, 1983), but rather in more dynamic visual–spatial processing. Therefore, in the cognitive processing of things that stay put, so to speak, including animal tracks, we would not anticipate identifiable differences in performance between the two sexes in general.

In summary, and on the basis of the available literature on pictorial and visual memory, we can say with some confidence that human beings are biologically prepared to exhibit strong visual memory and that this predisposition should extend in relevant areas to both sexes. Why would we expect a predisposition within this overarching type of psychological activity to exist for the retention and retrieval of animal tracks?

Although it is certainly true that many other activities and ways of life were important to ancestral hominids and to pre-agrarian peoples (e.g., Morgan, 1972), there is no real question that hunting was an important activity in the very ancient world (e.g., Bicchieri, 1972; Gamble, 1994; Laughlin, 1968; Wenke, 1999). It has been shown that humans in natural surroundings devote a significant proportion of their time and energy in obtaining high-protein food (e.g., Kaplan & Hill, 1985). The primary sources of high-protein food in the ancient world came from hunting and fishing. Although there is certainly no question that plant foods formed an important, indeed probably the major, part of ancient peoples' diets (e.g., Gamble, 1994; Nelson & Jurmain, 1988), hunting was important, and so were the skills it required.

This fact is of considerable relevance in the search for specific cognitive adaptations. The detection, pursuit, engagement, and ultimate killing of animals such as deer, bison, Irish elk, or steppe mammoth (e.g., Kurten, 1971) required a tremendous variety of cognitive skills, especially in the visual–spatial realm. Hunting requires the progressive development of memory skills and knowledge of animals and environment (Campbell, 1979; Laughlin, 1968; Washburn & Lancaster, 1968). Indeed, the few groups of hunter-gatherers worldwide who survived into the 20th century often exhibited extraordinary knowledge of animal behavior and extraordinary skills in the tracking and pursuit of game (e.g., Clastres, 1972; Damas, 1972; Lee, 1972; Silberbauer, 1972; Thomas, 1959). The hunting niche would absolutely have required knowledge of tracks and tracking, probably as far back in human evolution as the early hominids (e.g., homo habilis; Mithen, 1996, p. 104). These abilities would have been especially important during periods of maximum glaciation, when plant foods were rare or effectively nonexistent for many human populations.

Even given the importance of these skills, however, is it reasonable to suggest the possibility of biologically based predispositions in their favor? Obviously, most hunting skills were learned, passed on from generation to generation by master hunters to novices. However, in examining the behavior of other mammals that track prey, specifically dogs, one is struck by the fact that certain types of hunting skills vary by breed. It has been known for some time that hounds, who are poor retrievers, are nevertheless spontaneously "interested" in other animals' tracks (Whitney, 1948), as evidenced by the level of spontaneously directed visual and olfactory attention to tracks on the part of the dogs. In contrast, setters, who are good retrievers, show much less attentiveness toward tracks. This suggests that the skills or predispositions involved in the cognitive processing of animal tracks may to some degree, in at least some mammals, be derived in part from the basic biocognitive architecture of the brain. It therefore seems at least conceivable that some such predisposition may exist in the human.

This hypothesis, one that can be tested by experiment, forms the crux of the present research. Human hunters also track animals, and they were forced by circumstance to do so efficiently for the vast majority of humanity's time on this planet. A predisposition to learn the tracks of different animals with relative ease would have been of considerable value in the ancient world. If such a predisposition existed, then one would expect animal tracks, even for modern people, to be learned with relative ease compared with many other forms of visual stimuli. We tested this possibility in the three experiments of this study. If our hypothesis is correct, our results would show that biobehavioral holdovers from the ancient world not only exist in the cognitive realm but can be predicted and experimentally verified without post hoc reasoning.

EXPERIMENT 1

Experiment 1 required respondents to learn and recall, in list format, 100 items from each of five categories. Animal tracks obviously constituted one of the categories. Two other categories were derived from theoretical considerations concerning gender and the cognitive skills underlying ancient hunting. It has been suggested that adaptations for hunting would tend to be present only in men, as the men in modern and historic societies have tended to be both the hunters and the warriors (e.g., Smith, 1982; Wilson, 1975). However, as Mithen (1996) suggested, even the earliest hominids must have been flexible in exploiting food resources. It seems very unlikely, over the thousands of millennia of hominid evolution, that hunting was the exclusive prerogative of men across subspecies and across all ancient cultures, and even more unlikely that women were never forced by circumstances to be able to duplicate those skills. Furthermore, we have already seen that the differences in visual–spatial abilities that do exist between the sexes, beyond those caused by personal and societal expectation, are likely to operate in the realm of dynamic visual–spatial manipulation, rather than in the realm of static recall of images such as animal tracks. Therefore, we suggest that the expected superiority of track recall over that of other stimuli would not be confined to men.

However, to provide some test of the effect of gender roles on recall in this type of paradigm generally, we used two types of gender-contrasting stimuli as well: kitchen items (more likely to be related to women's pursuits) and armored vehicles (more likely to be related to men's pursuits). If gender were to prove important for recall per se in this type of experiment, one would expect significant interactions of stimulus type with gender, given the inclusion of these relatively gender-typed categories.

Neither of these two categories, of course, represents the living world, whereas animal tracks do; we therefore included two categories of living items—trees and seashells. We used these categories in an effectively simple experiment: Respondents were asked to learn and recall 100 items, divided equally among the five unrelated categories of kitchen things, armored vehicles, trees, seashells, and animal tracks. Respondents' recall of these items was then measured and compared.

Method

Participants

We recruited 25 college students (14 men, mean age = 19.79 years, *SD* = 1.63; 11 women, mean age = 24.27, *SD* = 11.59) at random from the Department of Psychology subject pool at the California State University in Fresno. All respondents received course credit for participation. All provided informed consent and were debriefed at the end of the experiment. A Snellen eye test was used to screen prospective respondents. All were shown to have visual acuity of at least 20/40, more than sufficient to resolve visual stimulus items of the sizes we used.

Materials and Procedure

We selected 100 stimulus items from a variety of published sources. (A complete list of the items used may be obtained from the authors, and a representative sample is provided in Table 1). These items were commercial-quality pictures used as illustrations in readily available books and catalogs. We used the following sources:

1. 20 pictures of military armored vehicles (armored fighting vehicles, or AFVs; Trewhitt, 1999)
2. 20 pictures of sea shells (Zim & Ingle, 1989)
3. 20 pictures of kitchen utensils (Fein, 2001; Fesco, 2000)
4. 20 pictures of trees (Greenaway, 1995)
5. 20 pictures of animal tracks (Sheldon, 1998), scanned using Adobe Photoshop software, creating black-and-white images of the same approximate sizes

All of these items were rated as unfamiliar by a panel of graduate students who were blind to the purpose of the experiment. This included the kitchen items, which were utensils seldom used or used in esoteric cooking specialties. Although the animal tracks were taken from a book on the tracks of animals indigenous to California, we were careful to use tracks from animals that have large-scale distributions throughout other regions of North America as well.

It was necessary to render these items as uniform as possible. We used Adobe Photoshop to create uniform gray-scaling for all the images. The AFVs and trees were seen in profile projection; the tracks and most kitchen utensils were seen in overhead projection (obviously, there is no profile projection for an animal track); the seashells were a mix of projections, primarily overhead. The projections for all five stimulus types provided the maximum amount of information, in terms of visible features, for each type of stimulus item.

All items used were realistic gray-scaled drawings rather than outline drawings. In other words, all of the items reflected the features that would be seen in a real-world view of their corresponding real-world counterparts. None of the items possessed distinctive high-contrast boundaries that would have lent them an air of artificiality. We took care to avoid differences in visual distinctiveness both among the items used and among the five categories. (Interested investigators can obtain samples of the items used from the first author.)

These images were rendered as 2 in. × 2 in. slides for projector presentation. Projection was accomplished by means of an automated Lafayette Instruments projection tachistoscope apparatus interfaced with an electronic timer, projecting on a white screen. The items were projected sequentially for respondents as a list.

We constrained the order of presentation to avoid the accidental grouping of items by category that tends to occur with random assortment. We used a repeated-category order to maximize the mixing and the distribution of items from different categories throughout the list. With 100 items from 5 categories, this allowed for 20 repeated five-category subsets. The order of category presentation within each five-category subset was determined at random. For Experiment 1, the order was animal tracks followed by cooking utensils, then seashells, trees, and AFVs. This order was repeated throughout the list, with within-category items assigned randomly to the 20 five-category sets. Thus, the first 5 items were a track, a utensil, a shell, a tree, and an AFV, followed in the second set of 5 items by a different track, utensil, shell, tree, and AFV, followed by a third set of 5 items in the same category order, and so on through 100 items.

Again, the assignment of a particular track, utensil, or other item to the appropriate category position within each of the 20 five-item sequences was random. This constrained order not only provided maximum mixing of items and maximum item spread but also resulted in a thoroughly random distribution of items within category across the entire list. Of course, this system might conceivably have created some form of mnemonic sequencing for respondents on the basis of the specific repetition of category order used here. This admittedly remote possibility, however, was controlled by the use of different category orders, and of course by different random assignments of items within category, in Experiments 2 and 3.

We tested the respondents in small groups. They were informed that they would see a number of pictures and that they were to remember them because they would be asked about them later. The items were then presented for 5 s each, with a 2-s interval between items. Each item was named as it was presented by a female experimenter who was blind to the purpose of the experiment. After the presentation of all items, a 10-min period was allowed to elapse during which respondents engaged in an interpolated arithmetic task to control for the effects of idiosyncratic rehearsal. (We chose 10 min because it was a relatively short period that would nevertheless result in sufficient time to provide for major transfer from working into long-term or secondary memory.)

At the end of this period, respondents were shown the items again, for 8 s each, and were asked to name each item in writing, as it was presented, on a prenumbered answer sheet. (The 8-s time interval was based on pilot data demonstrating a comfortable but not excessive length of time for viewing and writing the name of each item.) Following this task, we asked respondents to indicate in writing both their interest and experience in hunting, tracking, animals, the outdoors, cooking, cooking utensils, seashells, the sea and sea animals, trees, forests and forest matters, tanks and armored vehicles, and military matters. Respondents rated their interest in and experience with each of these topics on separate Likert-type scales, using 1- to 7-point continua.

Scoring was rigorous and identical among the five categories. For a given item to be counted as correct, a recognizably spelled variant of the correct noun had to be provided (see Table 1). Where an adjective was required (e.g., *white* poplar or *pinto* abalone), provision of the adjective alone was insufficient to count as correct; the primary noun (e.g., poplar or abalone) was required. Descriptions of items were not accepted. These uniform scoring techniques prevented any putative effects of category from being attributable to the scoring procedures themselves.

Results

The results of this experiment are shown in Table 2. The effect of stimulus type on recall was significant, $F(4, 92) = 91.57, p < .001$. However, as predicted, neither the effect of respondent gender, $F(1, 23) = 1.29, p = .268$, nor the interaction of gender with stimulus type, $F(4, 92) = 1.42, p = .232$, was significant.

TABLE 1
Samples of Stimulus Items

Animal tracks	Armored vehicles	Kitchen items	Seashells	Trees
Porcupine	Sherman	Nutcracker	Atlantic slipper	Elm
Gray fox	Conqueror	Whisk	Pinto abalone	Orange
Pocket mouse	M1 Abrams	Citrus zester	Waved astarte	Sweet gum
Raccoon	Sexton	Cream whipper	Northern quahog	White poplar
Mule deer	Churchill	Buffet fork	Sunrise tellin	Dawn redwood
Badger	Panzer IV	Mandolin	Rough limpet	Beech
Jack rabbit	Scimitar	Pastry server	Calico clam	Monterey pine
Black bear	M2 Bradley	Baster	Blue mussel	Western hemlock
Beaver	Leopard I	Wok	Dove	Red maple
Coyote	Merkava	Cookie press	Cowry	Summit cedar

TABLE 2
Means and Standard Deviations for Levels of Recall of Each Stimulus Item for Experiments 1, 2, and 3

	Experiment		
Stimulus item	1	2	3
Animal tracks			
M	5.44	3.96	4.32
SD	3.71	2.32	2.96
AFVs			
M	1.12	1.61	1.50
SD	1.33	1.07	1.20
Seashells			
M	1.12	1.50	0.82
SD	1.54	1.26	0.86
Trees			
M	2.08	2.68	3.14
SD	1.98	1.59	1.98
Cooking utensils			
M	10.08	9.71	8.00
SD	3.62	3.41	3.88

Although the interaction of gender and stimulus type was not significant, we examined the scores by gender for each category; the average difference in scores across categories between the genders was 0.95, less than 1 point. Thus it is not possible that the lack of gender effects was an artifact of sample size.

Because of the within-subjects nature of the experiment, we used a series of predicted comparisons to further evaluate the effect of stimulus type. We made four paired-samples comparisons, comparing the recall of animal tracks with the recall of items from each of the other four categories, at a relatively low capitalization-on-chance level of .19 (see Keppel, 1982; Winer, 1971). The results of this analysis demonstrated that cooking utensils were remembered at a higher level than were animal tracks, $t(24) = -6.13$, $p < .001$, but that animal tracks were recalled at significantly higher levels than were seashells, $t(24) = 6.52$, $p < .001$; trees, $t(24) = 5.27$, $p < .001$; or AFVs, $t(24) = 6.12$, $p < .001$.

We used Pearson correlations to evaluate the levels of interest and experience with regard to recall performance on the five categories. Interest in cooking correlated significantly ($p < .05$) with recall of cooking utensils, probably because of greater familiarity among those with strong culinary interests with relatively obscure utensils such as those used in this study. We also observed significant correlations ($p < .05$) between recall of seashells and both interest and experience in that topic. However, no such effects of interest or experience with tracking or hunting were correlated with recall of animal tracks, and AFVs and trees were similarly without such correlations.

Discussion

The results of this experiment were consistent with the hypothesis advanced. Kitchen utensils were better recalled than animal tracks. However, animal tracks, with which students generally professed very little familiarity and in general virtually no interest, were recalled at a significantly higher level than items of any of the other categories. This is at least consistent with our hypothesis regarding the human predisposition toward biological preparedness for hunting.

This advantage was not confined to men; no gender effect or interaction of stimulus type with gender was in evidence. In fact, women's recall of tracks (M = 6.00, SD = 3.16) was slightly higher than that of men (M = 5.00, SD = 4.40). Although this result is at odds with the simplistic and much criticized "man the hunter" concept (see Nelson & Jurmain, 1988), as suggested earlier, it is surely much more characteristic of human beings as believable living creatures who must have shown considerable flexibility in gender roles at many points in the past in order to survive (see Mithen, 1996).

Why were kitchen utensils better recalled than animal tracks? Two possibilities come to mind. First, even though these were relatively esoteric kitchen items, they were things that people might have encountered, albeit sporadically, in the course of their everyday lives. Armored fighting vehicles, different types of seashells, different kinds of animal tracks, and different types of forest trees are not so typically encountered, and when they are encountered, their names tend to remain obscure because they are not used in everyday life. Therefore, the potential low-grade familiarity of respondents with obscure kitchen items, relative to their familiarity with the other four item types, might have been sufficient to result in the observed pattern of results.

However, there is a second possibility. Bransford and Johnson (1973) demonstrated that both verbally and pictorially based prior frameworks for recall enhanced memory for new material, including material that was unfamiliar and disorganized without the prior frameworks. Sharps and Nunes (2002) suggested that similar considerations obtain in both the verbal and visual–spatial realms and that the manifestation of these effects depends largely on the demand characteristics of the given cognitive task. Kitchen and cooking matters provide an everyday context, a prior framework for recall that most people understand, and this may have allowed our respondents to organize their recall of kitchen items with salutary effects on memory.

In contrast, the lack of experience of the average person with the organizing principles that might govern the other categories of stimuli would not make such organization possible and would therefore be expected to reduce recall. The data are at least consistent with this perspective, although a definitive test must await further research.

It would appear that the results of this experiment were entirely in line with the hypothesis proposed, and that when confronted with unfamiliar visual stimuli including animal tracks, people remembered the tracks better than they do the other stimuli in general, suggesting some form of biological preparedness for doing so. Are there other reasonable alternative explanations for these effects?

Differences in label specificity between categories of stimulus item could have resulted in this pattern of effects. However, the strict and conservative scoring rules applied uniformly across categories probably preclude this as a possibility here.

Differences in distinctiveness among the features of the stimulus set could also have produced this pattern of effects. However, as detailed earlier, we took care to minimize such differences to the degree visually and technologically possible. Moreover, the animal tracks were certainly not the most distinctive items in terms of identifiable features. AFVs have guns, turrets, or treads; kitchen things have handles, blades, or prongs; even trees have leaves, branches, and trunks. However, few if any people in the modern world are conversant with the traditional names of different parts of animal's tracks, and some parts of tracks do not apparently have names. Thus any differences along this line that may have existed in this stimulus set operate against the hypothesis offered, which was supported by these data anyway. We therefore ruled out this alternative explanation for our results.

A reviewer of an earlier version of this article suggested that superiority of memory for animal tracks might have been derived from a combination of familiarity and educated guessing. The reviewer suggested that one might make a good guess as to what a track of a fox or rabbit might look like but would not have known the names of different types of armored vehicles. This is certainly a reasonable consideration. However, an examination of Table 1 shows that we used a variety of relatively similar tracks. Most people could probably guess that a given track came from a deer rather than from a fox, of course; but to provide accurate guesses to differentiate fox from coyote, porcupine from raccoon, and squirrel from pocket mouse, and to do so consistently across respondents, appears very unlikely if not effectively impossible.

Given all of these factors, it seems that the most likely and parsimonious explanation for these effects lies in the hypothesis we advanced. However, these effects could certainly also have been derived from stimulus order, as previously suggested, or conceivably from a sampling error. Therefore, we replicated Experiment 1 with a new subject group, using different orders of stimuli. This was the subject of Experiment 2.

EXPERIMENT 2

Method

Participants

We recruited 28 college students (7 men, mean age = 20.29 years, *SD* = 2.14; 21 women, mean age = 24.61, *SD* = 9.47) at random from the same source as for Experiment 1. These gender proportions reflected random selection from the composition of the classes, which at that time was predominantly female.

Materials and Procedure

Materials and procedure were identical to those of Experiment 1, with two exceptions: First, an examination of the data from Experiment 1 revealed several specific items that caused confusion among respondents (e.g., two types of cedar trees, a hare track and rabbit track that were confused by several respondents, a German AFV called a Hummel that was rendered as a "hummer" by several respondents). These items were removed. Because the number of confusing or difficult items was not identical between categories (although in all five categories there were 3 or fewer), additional items were removed at random so that 3 items were removed from each category, leaving 17 items per category, for a total of 85 items.

Second, a new item order was established, using the same type of constrained-order system as in Experiment 1. The order of the five categories for each of the 17 five-item sequences afforded by the 85 items was again selected at random. The new order, used in Experiment 2, placed a cooking utensil first, then an animal track, then a shell, an AFV, and a tree in each group of five. Individual items were then reassigned within this new category order. The reassignment pattern placed the last group of 5 items from Experiment 1 as the first group of 5 items for Experiment 2, the first group from Experiment 1 as the last for Experiment 2, and so on, using, of course, the new five-category order for each group of 5 items. This constrained order yielded the same advantages as that of Experiment 1 but provided a completely different order of items and moved the relative locations of individual items from the front to the back of the list and vice versa.

Results and Discussion

The results of this experiment (see Table 2) repeated those of Experiment 1 with reference to recall. The effect of stimulus type was significant, $F(4, 104) = 67.62$, $p < .001$, whereas the effect of gender, $F(1, 26) = 0.68$, $p = .42$, and the interaction of stimulus type with gender, $F(4, 104) = 0.75$, $p = .56$, were nonsignificant, as in Experiment 1. Also as before, cooking utensils were recalled at a higher level than were animal tracks, $t(27) = -9.74$, $p < .001$, but tracks were better recalled than shells, $t(27) = 5.79$, $p < .001$; trees, $t(27) = 2.68$, $p = .012$; and AFVs, $t(27) = 5.28$, $p < .001$.

Although the interaction of gender and stimulus type was again not significant, we examined the scores by gender for each category; the average difference in scores across categories between the two genders was 0.72, again less than 1 point. Thus the lack of gender effects cannot reasonably be attributed to sample size, even with the small male sample used in this experiment.

There were no significant correlations between experience, interest, and recall performance for cooking utensils or for shells, as in Experiment 1, nor were there any for AFVs or trees. However, recall of animal tracks was significantly correlated with interest and experience in both tracking and hunting ($p < .05$).

Experiment 2 repeated the major findings of Experiment 1. Although the absolute difference in average score between animal tracks and trees, shells, and AFVs was smaller than in Experiment 1, it was nevertheless significant and points to a relatively consistent, replicable advantage in the recall of animal tracks over other, similarly unfamiliar kinds of stimuli. However, to make absolutely certain of our results at least within this task framework, we made an additional attempt to replicate them in Experiment 3.

EXPERIMENT 3

Method

Participants

We recruited 28 respondents (11 men, mean age = 24.09 years, *SD* = 5.26; and 17 women, mean age = 23.06, *SD* = 6.35) at random from the same source as for Experiments 1 and 2.

Materials and Procedure

Materials and procedures were exactly the same as in Experiment 2, except that another new order was used for stimulus presentation. This new order was created using a different, simpler scheme: we simply reversed the order of Experiment 2, item by item, so that Item 1 from Experiment 2 was now Item 85, Item 85 from Experiment 2 was now Item 1, Item 2 from Experiment 2 was now Item 84, and so on.

Results and Discussion

The results of this experiment, also shown in Table 2, repeated the major results of Experiments 1 and 2. The effect of stimulus type was significant, *F*(4,

104) = 47.86, $p < .001$. Neither the effect of gender, $F(1, 26) = 0.74$, $p = .398$, nor the interaction of gender with stimulus type, $F(4, 104) = 1.80$, $p = .134$, was significant. Recall of cooking utensils was again superior to that of animal tracks, $t(27) = -0.27$, $p < .001$, and recall of animal tracks was again significantly higher than recall of seashells, $t(27) = 7.11$, $p < .001$; trees, $t(27) = 2.93$, $p < .007$; and AFVs, $t(27) = 5.63$, $p < .001$.

Once again, we examined scores by gender for each category; the average difference in scores across categories between the two genders was 0.62, again less than 1 point. Thus the lack of gender effects was not an artifact of sample size.

The pattern of correlations with interest and experience was again inconsistent. In this experiment, recall of animal tracks was correlated significantly with interest and experience in tracking, and with experience in hunting. Memory for cooking utensils was correlated significantly with experience with utensils; memory for shells was correlated significantly with interest and experience both in shells and in oceanic animals; and memory for trees was correlated with experience with them and with forest matters (all *p*s < .05). Thus, although the results concerning memory for stimulus type were entirely consistent throughout these three experiments, the degree to which interest and experience were correlated with recall of these items varied considerably.

GENERAL DISCUSSION

The results of the three experiments were consistent. As suggested by the hypothesis of a predisposition for the relative ease of learning animal tracks, memory for animal tracks was shown in each study to be superior to memory for other types of items. The single exception to this was kitchen utensils, which were recalled at a higher level than were tracks in all three experiments. As discussed previously, this result may have been caused by a greater low-level familiarity with these esoteric kitchen items or simply by a normal familiarity with cooking and kitchen procedures, which might have provided a framework within which to organize recall. Kitchens and cooking are relatively familiar to people living in America. Armored vehicles, different types of trees, and seashells are far less so, and animal tracks are clearly unfamiliar to the vast majority of modern people who live in the relatively urbanized world of the 21st century. Nevertheless, the tracks were consistently remembered better than the trees, the shells, or the tanks.

Are there better explanations for these results than a cognitive predisposition rooted in the hunting-gathering past? Several reasonable competing explanations were considered earlier and were shown to be unlikely in view of the methods and results of these studies. But let us consider alternative possibilities. Could the order of presentation have been responsible for these results? Three separate orders were used, derived in two different manners among the three experiments; order effects are exceedingly unlikely. As remarked by a reviewer of an earlier version of this article, the changes in order made over the course of the three experiments, combined with the consistent pattern of results obtained, renders an explanation in terms of order of artifacts untenable.

Could there have been something special about the categories of unfamiliar items chosen, so that these results are specific to these categories? This is possible, and additional research should be conducted to rule this out, but the fact remains that trees, shells, and armored vehicles are unrelated in the extreme and effectively constitute a random representation of the nearly infinite numbers of relatively unfamiliar categories that could have been chosen. It is improbable, therefore, that these predicted effects could have been stimulus specific; the level of coincidence that would have been required is literally incredible. The fact that identical results were obtained three times, from three different groups of respondents, must also lend credibility to these results.

Could differences in respondents' levels of interest or experience in hunting, or for that matter in trees, shells, or tanks, have been responsible for these results? That is perhaps the most realistic alternative explanation, but the data are against it. The patterns of correlations between interest, experience, and recall performance within category were inconsistent, in fact wildly variable, among the three experiments. In the first experiment, no correlation between track recall and interest or experience in hunting or tracking was observed at all. Interest and experience were not good markers of recall in this task framework. The fact that no gender effect or interaction of gender with stimulus type was observed in any of the experiments, experiments that used relatively sex-typed armored vehicles and kitchen items as stimuli, tends to bear this out. Interest and experience, in this study and within this research framework, were simply not involved in the production of these results.

Does not the fact that kitchen items were retrieved at a higher level than were animal tracks invalidate the original proposition? No. Table 2 shows that the superiority of track recall over memory for AFVs, trees, and shells was relatively modest. This is entirely what would be anticipated in a rational consideration of the possibilities. We are suggesting an inherited predisposition from the ancient world, a predisposition for which there has been no selective pressure for many thousands of years. During this enormous span of time, the brain mechanisms underlying this predisposition would have had numerous other demands placed on them, demands that could readily have weakened or altered any such predisposition.

It would make no sense to expect a strong effect here, one that could override the memory structures formed by individuals throughout their lives or override the specific learning in which individuals have engaged in their everyday world. The effect of any such predisposition should be modest, as was the result in the present work. Whether the kitchen item superiority effect derived from low-grade familiarity with the items or from a prior framework for recall, one would expect this "kitchen" information, learned first-hand during the individual respondent's lifetime, simply to overwhelm the ancient psychological structure being suggested here. Again, the results of these experiments are consistent with these considerations.

As to the question of why women as well as men have this predispostion, this has been answered earlier; flexibility in the face of ecological exigency is necessary, and one would expect ancient humans to have been relatively flexible in their responses to their world (Mithen, 1996). Such flexibility would have occurred across genders and has already been shown in potentially related realms: Women's spatial abilites can be shown experimentally to be far better than used to be expected (Sharps, Price, & Williams, 1994; Sharps, Welton, & Price, 1993). Women, at different times in prehistory, would have had to have been able to exploit the same food sources as men; it is unreasonable to expect that the cognitive abilities needed to do so would not exist.

A reviewer of an earlier version of this article remarked that "any ability *must* be inherited equally by both genders, whether useful to both or not, unless transmitted in whole or part by the 23rd pair of chromosomes." This of course does not mean that no relevant sex differences in this realm exist; the relevant genes could very well be located on those chromosomes. However, "genetic" transmission of behaviors, either gender-related or otherwise, cannot be direct. DNA forms RNA, which in turn forms proteins. It is the organization of these proteins with reference to the internal physiological environment and the external ecological environment that relates to behavior and development. Nothing in the present article should be construed to suggest a direct inheritance of some sort of track-specific visual structure or specific animal-tracking genes. The pathways to an evolutionarily mediated psychological predisposition, such as the one suggested in the present work, must of necessity be circuitous and indirect.

Nevertheless, whatever the mechanisms of behavioral transmission across the generations ultimately prove to be, the simplest, most comprehensive, and most parsimonious explanation of the present findings seems to be the one that was originally suggested: a cognitive "holdover" from the ancient world, a predisposition for learning animal tracks. This explanation is strengthened when one considers the fact that similar mechanisms have been experimentally demonstrated in the realm of the affective processes of emotions and preferences. Orians and Heerwagen (1992) provided evidence that modern peoples' preferences for landscapes in art are entirely consistent with the concept of emotional evolution in specific environments. Orians (1986) showed that savannah environments had considerable ecological advantages for ancient peoples, and it has been demonstrated (see reviews in Balling & Falk, 1982; Ulrich, 1983, 1986) that human beings exhibit strong and consistent preferences for photographs of savannah-like environments and for art that depicts such environments, although of course there are experience-based preferences as well (Orians & Heerwagen, 1992).

There is even evidence (Orians & Heerwagen, 1992) of human aesthetic preferences for trees whose structure would facilitate climbing and hiding, preferences that obviously would not derive from typical living conditions in the modern urbanized world. Although tree climbing might be a learned preference—as children climbing trees—such tree climbing is hardly universal in modern urbanized settings, and Orians's data are derived from populations on three separate continents. If aesthetic and emotional preferences can be derived from the ancient world, it would seem odd if some types of cognitive structures cannot. The most parsimonious explanation of the present results is that a predisposition for learning and recalling animal tracks is derived from just such a source.

What is the nature of this predisposition? At this time, it is not possible to tell whether this predisposition lies in the encoding, consolidation, and retrieval of visual representation; in the area of visual perception and pattern recognition; or even in the synergistic action of cognition with motivation. An understanding of these questions will require a considerable amount of research in the future.

Also, we are certainly not advocating some sort of radical "man the hunter" concept as the major force or "master pattern" (Laughlin, 1968, p. 304) in human evolution. Both the fossil record and careful analysis argue against this relatively naive perspective. Nor are we arguing for a return to a strict sociobiological interpretation, in which the vast majority of possible behaviors are believed to serve as adaptations (see Wilson, 1975). A quarter of a century of careful thought, experimentation, and analysis of sociobiological concepts has shown that many structures and behaviors may not represent adaptations at all (e.g., Orians & Heerwagen, 1992), and some may of course be actively maladaptive.

The degree to which these findings will extend and extrapolate to other research frameworks, procedures, and populations remains an open question and will require additional research to evaluate. It is also certainly true that items from categories that are potentially more familiar to respondents, or that may provide prior frameworks for recall, would be expected to be recalled at higher levels than would animal tracks, as was seen in the present research with kitchen items. However, at this point we are able to demonstrate that animal tracks were better recalled than other types of relatively unfamiliar stimulus items, chosen without any form of perceptible relationship to tracks or tracking from the literally infinite corpus of other categories. To our knowledge, this reflects the first experimental demonstration of a specific cognitive capability predicted by evolutionary considerations. Future research will be needed to clarify the mechanisms by which such adaptations operate and to identify other such adaptations in other areas of cognition.

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Original manuscript received September 10, 2001
Final revision accepted December 19, 2001