

Chapter 10

Adaptive Memory: Fitness-Relevant “Tunings” Help Drive Learning and Remembering

James S. Nairne

Our capacity to learn is an evolved trait. Few would disagree with this broad claim, but its implications are rarely considered by mainstream educators or scholars in psychological science. As evolved adaptations, learning and memory systems were “selected” by nature because of their fitness-enhancing properties: Traits that increase the likelihood of successful reproduction, either through promoting survival or successful mating strategies, persist and gain traction in an evolving population. From an evolutionary perspective, learning is important because it produces behavior that ultimately enhances fitness (Klein, Cosmides, Tooby, & Chance, 2002; Paivio, 2007).

If our retention systems were “built” using nature’s criterion—the enhancement of fitness—then one might reasonably expect to find the footprints of nature’s criterion in current functioning. It was undoubtedly beneficial for our ancestors to learn and remember the locations of food, the actions of predators, the behaviors of prospective mating partners, and so forth (Nairne & Pandeirada, 2008). One might anticipate, then, that we would remember better when dealing with fitness-relevant problems than with more evolutionarily recent or irrelevant problems, such as remembering the quadratic formula. In this chapter, I review evidence consistent with this reasoning and demonstrate what appear to be content biases or “tunings” in acquisition and retention.

To preview a simple case, we have shown that animate concepts (e.g., *baby*) are easier to learn and remember than inanimate concepts (e.g., *violin*). For students to learn effectively, our educational strategies should fit the natural design of cognitive systems, so one might profitably use natural tunings to facilitate the learning process where feasible. Indeed, we have shown that it is easier to learn foreign language vocabulary when a novel word is associated with an animate translation target

J.S. Nairne (✉)

Department of Psychological Sciences, Purdue University,
703 Third Street, West Lafayette, IN 47907, USA
e-mail: nairne@purdue.edu

(VanArsdall, Nairne, Pandeirada, & Cogdill, 2015). Although it is premature to make broad claims about the application of our research to educational settings, an evolutionarily informed education science has great potential (see Geary, 2002, 2008).

Here, I have chosen to focus on three specific cognitive tunings that are relevant to learning and memory—survival processing, animacy, and potential contamination. In each case, I will demonstrate that fitness-relevant processing leads to excellent retention—better retention, in fact, than what is obtained from most known encoding strategies. From an evolutionary perspective, of course, this result is hardly surprising given that memory evolved subject to nature’s criterion. But our findings remain controversial among mainstream cognitive researchers, who tend to believe retention systems are few in number and domain-general, operating in much the same fashion regardless of the input or learning problem.

Memory Is Functionally Designed

Although psychological scientists often make a fuss about evolutionary influences and assume that ancestral selection pressures are either unidentifiable or irrelevant to current functioning, in some sense we are all evolutionary psychologists (although, admittedly, this conclusion might come as a surprise to some). For example, everyone agrees that nature supplied us with basic sensory and perceptual equipment, “tuned” to process particular kinds of input in particular ways, along with basic learning, retention, and inferencing systems. Events that occur contiguously in time and space tend to become associated, and the learning process follows well-defined rules (e.g., Rescorla & Wagner, 1972). No learning theorist would claim that the principles of contiguity, or even informativeness (Kamin, 1969), are “learned” or require experience. Instead, we agree that natural selection crafted a cognitive toolkit that enables people and other species to learn about the important signaling properties of events (Rescorla, 1988).

Nature also supplied us with “crib sheets” that specify the kinds of stimuli that are important to learn about (Ermer, Cosmides, & Tooby, 2007). It is easier to associate neutral stimuli with fitness-relevant events. Bells are easily conditioned to food or shock, but not to bricks or books. The term *unconditioned stimulus*, by definition, refers to an event that automatically elicits a response in the absence of any learning or conditioning. Neither dog nor human needs to be taught to drool to food, or to withdraw reflexively from shock. We know as well that tastes are easily associated with stomach upset, but not to other events such as foot shock (Garcia & Koelling, 1966). These tunings or biases are assumed to be part of our inherited learning equipment. Similar tunings almost certainly exist in other cognitive systems as well, such as a tendency for our attentional systems to be captured by animate motion, novelty, or threat (Scholl & Gao, 2013) or for babies to orient more readily to faces than to wall hangings (Kanwisher, 2010).

Given these widely accepted assumptions, which can be found in any introductory textbook in psychology, it is curious why psychologists and educators do not use evolutionary reasoning as a centerpiece of their research agenda. The reason lies

partly in the fact that cognitive psychologists, at least those who study learning and memory, rarely think functionally about their subject matter. Cognitive analyses are typically structural, meaning that the focus is on explaining empirical results that are associated with a particular task—the “how” of remembering—rather than on the function and purpose of the phenomena under investigation—the “why” of remembering (see Nairne, 2005). Memory textbooks are filled with examples of mnemonic effects—e.g., spaced practice is better than massed practice, practicing retrieval benefits long-term retention, forming an interactive visual image aids recall, and so forth—but little, if any, attempt is ever made to explain why our memory systems actually work that way.

The structuralist tradition originated with Ebbinghaus (1885/1964) who tried to reverse engineer memory by systematically analyzing his own attempts at memorizing material. Through a series of heroic self-studies, Ebbinghaus was able to compile a set of empirical regularities, such as the negatively accelerated forgetting function, that remain of interest to psychologists today. As I have argued elsewhere (Nairne, 2015), this approach makes a certain amount of sense, but it is difficult to reverse engineer without knowledge of function. You can query a device—get it to “behave”—but there is no obvious way of determining what the observed behavior means, or even if it is relevant to the system’s ultimate design. Reverse engineering is meaningful only in the context of solving a functional problem. Our understanding of the organs of the body, for example, advanced significantly once considerations of function were taken into account (e.g., the heart is a pump).

Just like the organs of the body, which evolved to solve specific adaptive problems (e.g., filtering impurities from the blood), our cognitive capacities likely show similar functional specificity. For some cognitive systems, such as the sensory systems, we know this to be true. Cells in the retina are specialized to process particular forms of electromagnetic energy and the various components of the visual pathway are specialized as well (e.g., Ungerleider & Haxby, 1994). Well-known problems need to be solved, such as extracting color, distance, and maintaining constancy, and recognition of these problems, in turn, enabled researchers to establish solid criteria against which to measure progress (Shepard, 1994). In the case of learning and memory systems, however, the problems to be solved are not immediately obvious. We can all agree that it is adaptive to remember, but the particular mnemonic problems that drove the evolution of learning and retention systems have remained unspecified.

The research that I will be describing shortly was motivated from a functional perspective—that is, we began by assuming that our retention systems were crafted to solve specific problems in the environment, much like other structures in the body. We assumed as well, given what we know about nature’s criterion, that our capacity to remember developed at some point in our ancestral past because it helped solve problems related to survival and reproduction. An organism with the capacity to remember the location of food, or categories of potential predators or mating partners, is more likely to survive and reproduce than an organism lacking this capacity. Thus, to the extent that our retention systems are specialized, they are specialized to solve problems related to survival and reproductive fitness.

There is another point about our research program that is worth noting at the outset. Evolutionary psychologists are often criticized for concocting post-hoc adaptive explanations of behavior—so-called “just-so stories”—where observed behaviors are interpreted in terms of their possible adaptive consequences. There are few constraints in this type of reasoning, meaning that one can develop convincing adaptive stories for just about any empirical effect (Gould & Lewontin, 1979). Our research relies instead on a kind of forward engineering in which functional questions take the driving role. Rather than attempting to “explain” existing empirical phenomena, we focus on the recurrent adaptive problems that our memory systems presumably needed to solve, such as remembering the location of food, and then generate a priori predictions about mnemonic behavior. For example, we have proposed a memory bias for animate things. Animate things are inherently relevant to fitness—e.g., as predators, prey, or mating partners—and therefore should be noticed and remembered well. This is not a just-so story; it is an empirical prediction that can then be rigorously tested in the laboratory.

The Mnemonic Value of Survival Processing

As just noted, our functional evolutionary perspective generates a straightforward empirical prediction: People should be able to learn, retain, and transmit fitness-relevant information especially well. In addition to an animacy bias, for example, there should be a general survival information bias in learning and retention. One can interpret cue-to-consequence effects in this way—associations between taste and gastric distress are easily learned, often in a single trial and after long delays (see Domjan & Galef, 1983). Conditioned fear responses are acquired more rapidly and extinguish more slowly to evolutionarily relevant stimuli, such as spiders and snakes, than to neutral stimuli (e.g., flowers; Ohman & Mineka, 2001). People can also retain the spatial locations of ancestral predators (snakes) with greater accuracy than modern threats (guns; see Wilson, Darling, & Sykes, 2011).

There are, in fact, many examples of fitness-relevant stimuli that are remembered well. The transmission of urban legends and oral narratives such as epic ballads (Rubin, 1995) is a case in point. Many urban legends revolve around survival-relevant information, especially food contamination (e.g., a Kentucky fried rat or razor blades in Halloween candy; see Erickson & Coultas, 2014). Stubbersfield, Tehrani, and Flynn (2015) recently demonstrated a survival transmission bias using a version of the classic “telephone” game (also known as “Chinese Whispers”). People were asked to read and recall urban legends previously rated as high in survival-relevant information or control material that was survival-neutral. A linear transmission chain design was used, in which each participant in the chain was presented with material that had been recalled by a previous participant; only the participants at the beginning of the chain read the original legends. Across the different recall generations, the survival-relevant legends were recalled more accurately, meaning that the original legend material was maintained in the recall output, compared to the control

materials. Interestingly, legends containing social information, such as a father and daughter accidentally having cybersex, were maintained best of all, although one could certainly consider social information to be fitness-relevant as well.

There is also a well-established connection between emotions and memory. Emotional stimuli are often remembered well and biological relevance appears to be an important component of the emotional memory advantage (Sakaki, Niki, & Mather, 2012). Stimuli that are related to survival and reproduction (e.g., sexual images or predators) capture more attention and induce more automatic processing than social stimuli that have been matched for arousal and valence (e.g., smiling people or pictures of neo-Nazis). Flashbulb memories (Brown & Kulik, 1977) are typically survival-relevant as well. These are highly vivid and confident memories surrounding unusual and emotionally driven events, such as the terrorist attacks in the United States on September 11, 2001. Flashbulb memories consist primarily of “where and when” information, rather than details about the event itself—in other words, where was I and what was I doing when I first heard about the terrorist attacks. Several studies have tracked these memories over years (e.g., Hirst et al., 2015) and, although recall is often inconsistent (and inaccurate) over time, people continue to report elaborate recollections and especially high confidence in their memories after a decade.

Data such as these clearly support a survival information bias. But the concept of fitness-relevance can be rather slippery, primarily because “relevance” is apt to be context-dependent. Think about a pencil. Normally, we would not consider a pencil to be survival-relevant, and we would not expect it to receive any special mnemonic boost, but pencils can be relevant under the right circumstances. If you were suddenly attacked while holding a pencil, it becomes survival-relevant as a weapon, or perhaps a pencil could be used to write notes that were ultimately fitness-relevant. As Nairne and Pandeirada (2008) put it: “food is survival relevant, but more so at the beginning of a meal than at its completion; a fur coat has high *s*-value at the North Pole, but low at the Equator” (p. 240). Consequently, it is unlikely that we evolved brains filled with content-specific “survival” information; instead, what likely evolved was a sensitivity or tuning to survival *processing*. Once an attribution is made about a survival situation, perhaps engendered by the sudden appearance of a predator, evolved mnemonic machinery kicks into gear and subsequently processed material is remembered well. As I discuss shortly, there is now considerable empirical evidence to support this assertion.

The Survival Processing Paradigm

In 2007, we developed a laboratory procedure to investigate the mnemonic value of survival processing (Nairne, Thompson, & Pandeirada, 2007). Participants were asked to imagine themselves stranded in the grasslands of a foreign land. The instructions specified that, over the next few months, they would need to find steady supplies of food and water and protect themselves from predators. Individual words

were then shown, one at a time, and people were asked to rate the relevance of each word to this imagined survival scenario. After the rating period, and a short distractor task, a surprise retention test was given, either free recall of the rated words or a recognition test. For control comparisons, we included a standard deep processing task (rating words for pleasantness) along with an equally complex scenario that was fitness-irrelevant (moving to a foreign land) (see Table 10.1). Strong retention advantages were found for the words processed with respect to the survival scenario.

This survival processing advantage turns out to be quite robust and it has now been replicated in a number of laboratories across the world. The survival advantage holds up well against a variety of control conditions—even against what are typically thought to be the “best of the best” encoding conditions such as forming a visual image or relating information to the self (Nairne, Pandeirada, & Thompson, 2008). Notice in Fig. 10.1, for example, that survival processing produces significantly better retention than intentional learning, where people are purposely trying to learn and remember the material for a later test. The survival advantage has been demonstrated in small children (Aslan & Bäuml, 2012), in elderly populations (Nouchi, 2012), and in populations suffering from cognitive impairment (Pandeirada, Pinho, & Faria, 2014). The effect remains robust in both within- and between-subject designs, in intentional and incidental learning environments, and for both pictures and words. The basic effect has been replicated as well as a part of the Open Science Project (Müller & Renkewitz, 2015).

Notice we are not directly comparing fitness-relevant and fitness-irrelevant events or stimuli in this paradigm—e.g., snakes versus flowers or emotional versus nonemotional events. Instead, we are comparing memory for exactly the same stimulus when that stimulus has been processed with respect to survival or not. This kind of design has certain methodological advantages over the research discussed in the previous section. For example, it solves what are known as item-selection problems. When comparing across stimuli, such as snakes versus flowers, it is important to ensure that the stimuli have been adequately matched across all mnemonically relevant dimensions except for survival relevance—this can be difficult to achieve. Obviously, since the same stimuli are used in both the experimental and control

Table 10.1 Scenarios used in Nairne et al. (2007)

Survival: In this task, we would like you to imagine that you are stranded in the grasslands of a foreign land, without any basic survival materials. Over the next few months, you’ll need to find steady supplies of food and water and protect yourself from predators. We are going to show you a list of words, and we would like you to rate how relevant each of these words would be for you in this survival situation

Moving: In this task, we would like you to imagine that you are planning to move to a new home in a foreign land. Over the next few months, you’ll need to locate and purchase a new home and transport your belongings. We are going to show you a list of words, and we would like you to rate how relevant each of these words would be for you in accomplishing this task

Pleasantness: In this task, we are going to show you a list of words, and we would like you to rate the pleasantness of each word

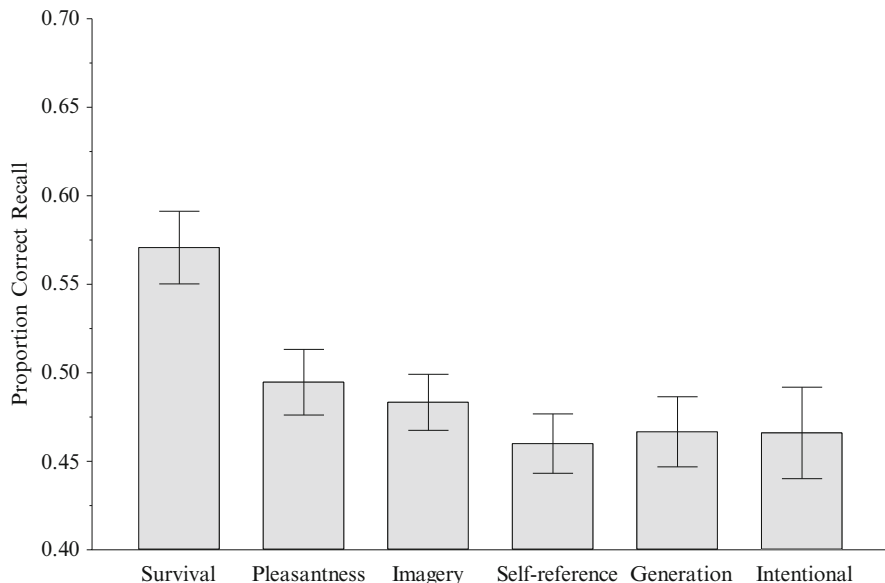


Fig. 10.1 Average proportion correct free recall for the various conditions in Nairne et al. (2008)

conditions, matching the stimuli is not a concern. Our design captures the context-dependent nature of survival relevance as well. One of the interesting findings from our research is that even stimuli that are rated as irrelevant to the survival scenario are often remembered well (although stimuli rated as relevant are typically remembered better). It is the spotlight of survival processing that matters.

Still, one might suspect that there is something about the survival scenario, rather than fitness-relevancy per se, that affords richer processing. For example, we might have chosen a scenario that is unusually complex, novel, arousing, or difficult. Few participants are familiar with grassland scenarios, so survival processing might require an especially deep or meaningful form of processing, at least compared to rating an item for pleasantness or moving to a foreign land. However, the survival scenario has now been compared to many different control scenarios, some specifically designed to equate for possible confounding factors. Kang, McDermott, and Cohen (2008) controlled for the novelty and excitement of the grasslands scenario by comparing it to a robbery control in which people rated the relevance of words to planning a bank robbery. Röer, Bell, and Buchner (2013) tried to equate for distinctiveness by using an “afterlife” control in which people imagined that they had died and were searching for new companions and interesting things to do in the afterlife. Bell, Röer, and Buchner (2013) tested whether the survival scenario might simply induce negative affect by comparing it against a “suicide” control scenario. Strong survival processing advantages were obtained in each of these cases, effectively ruling out accounts that appeal to the unusual or novel features of the survival scenario.

However, the best evidence against these kinds of alternative interpretations comes from studies using matched control scenarios. In these cases, people are asked to rate the relevance of items to *exactly the same activities*, but in a context that is either fitness-relevant or not. Nairne, Pandeirada, Gregory, and VanArsdall (2009) asked people to rate the relevance of words to a hunting scenario, one in which they were required to hunt big game, trap small animals, and fish, but either to survive or to win a hunting contest. Both scenarios required tracking and hunting for food, in exactly the same way, but only the survival version was designed to induce fitness-relevant processing. Significantly better recall performance was found in the survival-based hunting condition. In another experiment, people were asked to search for and find edible food, either to survive or to win a scavenger hunt; again, exactly the same activities were included in each scenario, but framing the scenario around survival produced a stronger mnemonic effect. Ceo (2008) asked people to search for and find apples to eat, either to survive or for a picnic while vacationing at a fancy resort. Again, exactly the same activities were involved in both the survival and the control scenario, but the survival framing produced the best recall.

Matched scenario designs have also been used to investigate spatial memory (Nairne, VanArsdall, Pandeirada, & Blunt, 2012). Remembering that food has been seen in a particular area, or that potential predators are likely to be found in a given territory, should increase the chances of subsequent survival. Consequently, we anticipated that survival processing would enhance memory for the location of items. Participants were shown pictures of food or animals located at various positions on a computer screen. The task was to rate the ease of collecting the food or capturing the animals relative to a central fixation point. The main manipulation was whether people were collecting the items for survival or to win a hunting or scavenging contest. Later, surprise retention tests showed that people remembered the locations of the items better when the collection or capturing task was described as relevant to survival.

Collectively, these data indicate that the survival processing advantage is probably not an artifact of the particular scenario or rating task involved. Instead, the evidence is consistent with a “front-end” adaptation that is activated selectively by survival situations. When confronted with a survival situation, people naturally engage in a rich and elaborative form of processing, one that yields excellent long-term retention. The adaptation acts generally, in the same way that other front-end adaptations work in the body. Consider the fight-or-flight response as a case in point. The fight-or-flight response is unlikely to be a learned phenomenon, although experience might shape the ultimate response. Most would consider it to be an evolved adaptation designed to prepare an organism to respond effectively when danger is present. It is triggered by the attribution of perceived danger, but what constitutes “danger” is context-specific. There might be natural triggers in the environment, such as a snake or a looming object, but the response system is clearly flexible enough to be triggered by a variety of situations. Survival processing may represent a similar kind of process—a front-end adaptation that, once triggered, relies on other evolved mnemonics to achieve an adaptive end.

The Mnemonic Value of Animacy

Animacy is another prime candidate for an evolved “crib sheet” or tuning in remembering. Animacy, defined roughly as the distinction between living and nonliving things, plays a central role in psychological science—for good reason. From an evolutionary perspective, of course, it is important to attend selectively to animate things because animate entities represent potential food, predators, mating partners, or competitors. In fact, some have argued that primates possess unusually large brains for body size primarily because of the computational demands of complex social systems (i.e., the social brain hypothesis; Dunbar, 2007). To the extent that language evolved, it evolved to solve problems arising from social interactions with animate agents (e.g., Pinker, 1994).

Developmentally, the animate–inanimate distinction appears to be a skeletal principle that organizes children’s experiences from a very early age (Opfer & Gelman, 2011). Babies very quickly show differences in looking times between people and artifacts (e.g., Klein & Jennings, 1979) and early in the first year seem to understand that animate things, but not inanimate things, are capable of self-propelled movement (Markson & Spelke, 2006). By age 3 or 4, preschool children are remarkably accurate in distinguishing between living things, such as animals, and inanimate objects; they draw a richer set of inferences from animals than from artifacts as well (Heyman & Gelman, 2000). Not surprisingly, animacy plays an important role in language development and in the general structure of language overall (e.g., Silverstein, 1976).

There appear to be perceptual tunings for animacy as well, or at least to cues reliably associated with animacy. New, Cosmides, and Tooby (2007) found that people could more quickly and accurately detect changes to visual scenes when the change involved animate (people and animals) rather than inanimate objects. The animate advantage remained even when the inanimate changes were large and quite discriminable on their own (e.g., the presence or absence of a large building). People also readily impart animacy to inanimate objects that move in animate ways (Heider & Simmel, 1944) and attribute animacy to inanimate objects moving in a random fashion as long as other cues are evocative of animacy (e.g., the wolfpack effect in which chevrons move randomly but are “pointed” at a central display; Gao, McCarthy, & Scholl, 2010).

We would expect then to find similar animacy biases in learning and remembering. Barrett and Broesch (2012) found a content bias for learning about dangerous animals in children that held for both city-dwelling children from Los Angeles and for Shuar children from the Amazon region of Ecuador. There are also animacy-specific semantic deficits in brain-damaged patients. Some patients lose the ability to name living things, such as animals, but not nonliving entities (Caramazza & Shelton, 1998). However, few, if any, studies have actually manipulated animacy experimentally. For example, one could select animate and inanimate items that have been carefully matched along mnemonically relevant dimensions and test whether the animate items are easier to remember. Alternatively, one could take novel items, such as nonwords, or inanimate items and encourage people to process

those items from an animate perspective. We have used both of these strategies in our laboratory, as I discuss shortly.

Initially, however, we wanted to see whether animacy significantly predicts recall using regression techniques (Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013). Multiple regression is often used as a statistical tool for identifying variables that contribute to some criterion. Rubin and Friendly (1986) tried to predict free recall performance using normative data for a number of word properties, such as meaningfulness, frequency of occurrence, and concreteness. Animacy was not a factor considered in their analysis, so we coded the Rubin and Friendly words for animacy (living vs. nonliving) and reanalyzed the data using animacy as an additional predictor variable. We discovered that animacy was one of the strongest contributors to the explainable variance. Animacy correlated strongly with recall ($r=0.42$) and its incremental importance (the unique contribution of the variable to R^2) was nearly twice that of its nearest competitor, imagery. These data suggested to us that animacy is indeed a potent mnemonic variable.

We next manipulated animacy experimentally, seeking to establish a causal link between animacy status and retention. First up, we carefully matched sets of animate (e.g., turtle) and inanimate words (e.g., purse) along ten mnemonically relevant dimensions (e.g., imagery, emotionality, familiarity, meaningfulness, etc.). We then asked people to study and remember the words for a free-recall test. The animate and inanimate words were intermixed in a list and people were given 5 s to study each item. Figure 10.2 shows the results of the free recall test for each of three study and test trials. As the figure shows, there was a strong recall advantage for the animate items on each of the three study-test trials. Shortly after we published our initial study, our findings were replicated in a different lab, using a different word pool, and the animacy advantage was found to hold for pictures of animate entities and on a recognition memory test as well (Bonin, Gelin, & Bugaiska, 2014).

We have also investigated the mnemonic value of *animacy processing* (VanArsdall, Nairne, Pandeirada, & Blunt, 2013). Instead of directly comparing the recall of animate and inanimate words, we asked people to process novel stimuli (nonwords) as either living or nonliving things. In these experiments, people were shown pronounceable nonword “names” (e.g., FRAV) along with properties characteristic of either living (e.g., enjoys cooking) or nonliving (e.g., has a hollow center) things. For each nonword and its assigned property, the task was simply to classify the object as a living or nonliving thing. Every nonword was processed as either a living or a nonliving thing across participants, effectively eliminating any item selection concerns. Following the classification task, a memory test was given for the rated nonwords (either free recall or recognition). Once again, there was an animacy advantage—the nonwords classified as animate were recalled and recognized better than those classified as inanimate. Our data suggest that merely thinking about an object in an animate way may have mnemonic consequences over the long-term.

These animacy advantages certainly reinforce the notion that our cognitive systems are tuned to detect and remember animate things. Such a tuning makes evolutionary sense because animals and people are apt to be fitness-relevant—e.g., it is much more important to remember the sudden appearance of a predator or a potential

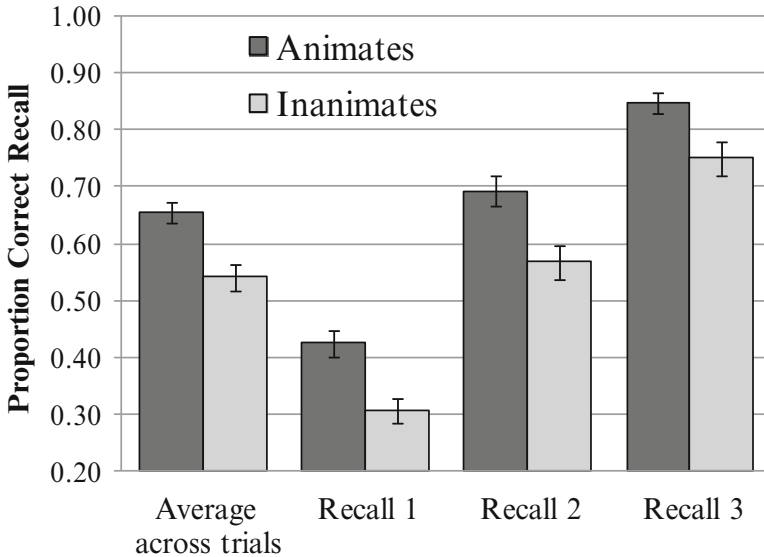


Fig. 10.2 Proportion correct recall averaged across the three recall trials, and for each recall trial, for animates and inanimates in Exp. 2 of Nairne, VanArsdall, Pandeirada, Cogdill, and LeBreton (2013). Error bars represent standard errors of the mean

mate than it is to remember, say, a random twig blowing across the ground. To the extent that the computational demands of complex social systems helped drive the evolution of cognitive systems, at least in part, we would anticipate increased processing of animate entities. As with survival processing, we need memory-based “crib sheets” that help us attend to and remember those things pertinent to improving the chances of survival and reproduction.

The Mnemonic Value of Potential Contamination

Our laboratory has also been interested in exploring the mnemonic value of contamination, which likely represents yet another content-based memory tuning. Considerable work has been conducted on the emotion of disgust, which promotes avoidance of pathogen-laden substances. Disgust is often classified as a “basic” emotion, and there is considerable cross-cultural consistency in the expression of disgust (Ekman & Friesen, 1974). There also appears to be a relatively straightforward relationship between cues that evoke disgusting reactions and cues that signal disease (Curtis, de Barra, & Aunger, 2011). People generally find body byproducts disgusting, such as feces, urine, vomit, or blood, and these things are recognized sources of bacteria and disease. For this reason, disgust is classified as an evolved disease-avoidance adaptation with considerable survival value (Oaten, Stevenson, & Caser, 2009).

Given their obvious relevance to fitness, then, we would expect disgusting objects to be remembered well. As emotional stimuli, particularly stimuli with negative valence, pictures or descriptions of disgusting objects are indeed remembered well (e.g., Croucher, Calder, Ramponi, Barnard, & Murphy, 2011). One finds enhanced source memory for disgusting things as well, meaning that we can remember whether an object or a person exhibited disgusting attributes. In a study by Bell and Buchner (2010), people were shown pictures of faces accompanied by descriptions of disgusting behavior (e.g., “this person eats dog meat”), neutral information (e.g., “this person is a gardener”), or pleasant behaviors (e.g., “this person bakes fresh cookies”). Later, the faces were shown again and people were asked to indicate whether each face had earlier been associated with disgusting, neutral, or pleasant behaviors. The best source memory was found for the faces associated with disgust.

There appears to be something special about disgust as well, over and above the fact that disgusting objects are arousing and are negatively valenced (Chapman, Johannes, Popenk, Moscovitch, & Anderson, 2013). Chapman and colleagues carefully matched fearful and disgusting photographs for valence and arousal and found a significant retention advantage for the disgusting objects (e.g., body products such as feces or vomit) compared to the fearful images (e.g., animal threats, disasters). The retention advantage held even when attentional differences were controlled between fear and disgust along with response biases. The authors suggested that disgust enhancement may draw on distinctive neural mechanisms that improve memory over and above the enhancements that are produced by general emotional arousal.

One reason why disgusting objects may indeed be “special” is their potential for contamination, which likely represented a common threat to one’s fitness. Neutral objects that come in contact with an object of disgust can themselves become contaminated. There is substantial anecdotal and laboratory evidence showing that people are extremely sensitive to potential contamination. For example, as documented by Rozin and colleagues, people are reluctant to interact with objects that have simply come in contact with disgusting things (e.g., Rozin, Millman, & Nemeroff, 1986). People are unlikely to drink juice from a glass that had previously been “contaminated” with a dead and sterilized cockroach, even though everyone was informed that the juice was perfectly safe to drink. People are reluctant to wear clothes that have previously come in contact with a disliked person, such as Hitler or a serial killer.

Obviously, these proclivities make evolutionary sense because avoiding potentially contaminated things increases the chances of survival. But we were interested in the mnemonic consequences of contamination. We know people remember disgusting objects better than neutral objects, but does the memory enhancement extend to things that have simply come in contact with something that is disgusting? To investigate this issue, we asked a simple question: Will people remember items that have been touched by a sick person better than items touched by a healthy person? Anecdotally, this certainly seems true. Most of us are reluctant to handle things

that have recently come in contact with a sick person which implies some sort of mnemonic salience.

In our experiment, people were shown pictures of everyday objects along with a descriptor signifying the health status of a person who had recently “touched” the object. For example, a picture of a ball was shown along with the statement “person with a constant cough” or the statement “person with a straight nose.” After every third item, the three preceding items were shown again and people were required to classify whether each had been touched by an obviously sick person or by a person without any obvious symptoms (i.e., a healthy person). This immediate test was included simply to ensure that people paid attention to the descriptor. After a series of these presentations, everyone was asked to recall all of the items seen in the experiment. The final free recall test was unexpected.

Performance on the immediate test was excellent and near ceiling, as expected, and no differences were found between the sick and healthy conditions. Again, these tests were designed simply to ensure that people paid attention to the descriptors. Performance on the surprise free recall test, however, revealed a strong recall advantage for the items paired with a “sick” descriptor. Even though people were not expecting a final memory test, those items that were classified as having been touched by a sick person were remembered significantly better than the “healthy” control. We have extended the finding to source memory as well. Not only do people remember the “contaminated” object better overall, but if asked to identify who touched the object, a sick person or a healthy person, people are better at identifying that the object was touched by a sick person. Regardless of the proximate mechanisms that underlie these advantages—e.g., perhaps people have a stronger emotional reaction to the contaminated items—the net result is clearly adaptive. Remembering potentially contaminated items can help us to avoid those items in future interactions.

Conclusions and Implications for Educational Practice

The default position among most psychologists is that learning and memory processes are general and equipotential. It is accepted that memory and other cognitive systems are the product of an evolutionary process and confer evolutionary advantages, but the imprint of nature’s criterion on system functioning is either ignored or assumed to be irrelevant. Instead, the guiding premise of most psychologists and educators is that the same basic cognitive mechanisms apply, in the same fashion, regardless of the materials involved or the particular task at hand. In the case of learning, for example, causal connections among stimuli are assumed to be governed by a few basic principles, such as contiguity or informativeness, and the specific content of the events involved is rarely, if ever, considered as a factor. Constraints are sometimes grudgingly acknowledged, such as flavor-illness associations, but often only as after-thoughts or in special sections of textbooks.

Throughout this chapter, I have advocated an alternative viewpoint, namely, that our learning and retention systems are biased or “tuned” to specific kinds of content or forms of processing. And, more important, those biases or tunings are the direct result of cognitive systems that evolved to solve adaptive problems—specifically, problems related to survival and reproduction. The simplistic view that our brains evolved solely to acquire and retain “information,” or form connections among any two stimuli that happen to occur contiguously, cannot be correct because information, by itself, has no fitness consequences. One needs to discriminate among *kinds* of information—those that are relevant to fitness and those that are not (Geary, 2005). Otherwise, we would very quickly run into problems of computational explosion, or mnemonic clutter, as many evolutionary psychologists have discussed (e.g., Ermer et al., 2007).

The fact that we may have evolved brains that are “tuned” to learn about certain kinds of content, such as animate agents or potentially contaminated objects, does not mean that our learning and retention systems lack flexibility. On the contrary, we need the capacity to learn about a wide variety of events, as well as relationships among events, because fitness-relevance is often context-specific. It would be wrongheaded to think that our brains are simply filled with built-in content—such as a list of predators or food types—although particular predator characteristics may have shaped the evolution of some systems. Some have argued that the visual system evolved, at least in part, to solve the problem of detecting snakes in the grass (e.g., Isbell, 2006). Instead, what likely evolved were content-sensitive forms of processing; for example, as discussed earlier, when information is processed in a survival context, or one is searching for animate or agentic properties in a stimulus, mnemonic machinery operates particularly efficiently resulting in excellent long-term retention.

From an educational perspective, of course, this means that it should be easier to acquire and retain information that is processed from a fitness perspective. As Geary (2008) has noted, children are inherently motivated to learn about information that is “biologically primary” or evolutionarily salient. To some extent, then, we can encourage educators to frame their lesson plans in a manner that takes advantage of natural learning biases of the type discussed in this chapter; similar arguments have been made about teaching mathematical skills, that is, one should develop learning tasks that fit snugly with our naturally developing “number sense” (see Berch, 2005). One can imagine framing content around fitness-relevant situations, for example, or developing work problems that make use of agents, survival problems, or even general social contexts. Of course, whether evolved biases will help or hinder performance will depend on the problem context. As Geary (2008) has stressed, much of what needs to be learned in the classroom is evolutionarily novel and may conflict with our natural intuitions (e.g., Newtonian mechanics).

At this point, we cannot make broad claims about the applicability of our laboratory studies to the classroom, but we have shown that fitness-relevant processing can facilitate the learning of a wide variety of stimuli, including novel foreign language words. In one study using the procedure adopted for our contamination studies, people were shown Swahili words paired with either fitness-relevant or

fitness-irrelevant descriptors. For example, the word “kaburi” might appear with the descriptor “could be thrown to distract a predator” or the word “gutu” with the descriptor “could be packed carefully in a box.” For each of the words, people were required to decide whether it was relevant to a survival or a moving situation. At the end of the experiment, everyone then received a surprise recognition test for the words. Swahili words that had previously been paired with a survival descriptor were recognized significantly better than words paired with a fitness-irrelevant moving descriptor.

We have also shown that animacy can facilitate the learning of foreign language translations (VanArsdall et al., 2015). Once again people were shown Swahili words, but this time with assigned English “translations.” The task was to learn to produce the appropriate English translation when given the Swahili word as a cue. The Swahili words were not paired with their actual translations; instead, for control purposes we chose translation targets that were either animate or inanimate but otherwise matched on a variety of important mnemonic variables (e.g., rembo-duck vs. sahani-stove). Each word pair appeared for 5 s and people were told to learn the pair such that they could produce the translation (duck) when provided the cue (rembo). The results are shown in Fig. 10.3, for each of three study-test trials. Across all three trials, a strong cued-recall advantage was found for the animate pairs.

The results of our experiments using Swahili words show that it is possible to extend our laboratory procedures to learning situations that might have some applications in the classroom. For example, it might be beneficial during foreign language

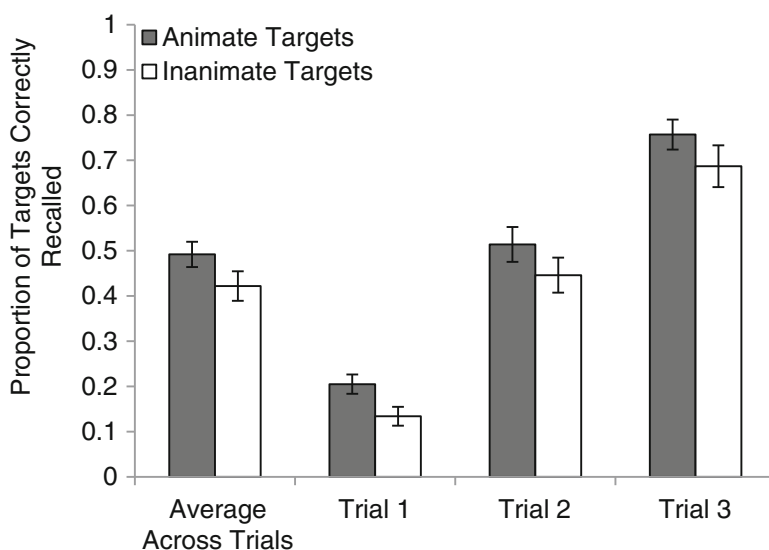


Fig. 10.3 Results from VanArsdall et al. (2015): Mean proportion of targets correctly recalled as a function of trial and word type. Data are shown averaged across the three cued recall trials and separately for each trial. Error bars represent standard errors of the mean

learning to start with vocabulary with references to animate agents or other fitness-relevant concepts. Prokop and Fancovicova (2014) recently showed that children find it easier initially to learn about plants with colors that signal ripeness (e.g., red vs. green) and particularly plants with relevance to survival (e.g., whether or not the plant was toxic). Even 6-month-old infants are apparently “prepared” to use social information to learn about the edibility of plants compared to learning about artifacts (Wertz & Wynn, 2014). Such natural tendencies can certainly be exploited to help the transition from simple learning contexts to more complex ones.

Besides recognizing and exploiting inherent content biases, adopting an evolutionary perspective in the classroom has another tangible benefit. It forces one to think functionally about the learning process. As discussed earlier, most psychologists and educators simply try to reverse engineer learning: People are asked to learn and remember material and then one looks for regularities in the empirical patterns. Although many effective training strategies have been discovered through reverse engineering—e.g., distribute rather than mass study periods, practice active retrieval of material rather than passive study (see Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013)—one rarely gets much insight into why our learning systems work this way. Again, our learning and memory systems almost certainly evolved to solve specific adaptive problems. To understand those systems completely, one needs to understand the selection pressure that shaped their development.

Similar benefits accrue from thinking functionally as an instructor. At the university level, students are often mystified by the coverage they find in their classes because teachers, like researchers, consistently favor the “what” over the “why.” When learning is covered in introductory psychology courses, for example, students hear extended discussions about drooling dogs and key-pecking pigeons, but connections are rarely drawn between classical and instrumental conditioning and the kinds of learning problems people face on a daily basis. As William James once said, it is difficult to understand a house by focusing on its bricks and mortar—one needs to know what the house is for, what the house is designed to do, and it is only in this functional context that bricks and mortar make sense. The same reasoning applies to students in the classroom—before they can understand the mechanics of a psychological process, they need to know what the psychological process is *for* (see Nairne, 2014). Both in research and in the classroom, thinking functionally is a vital component of success.

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