The Virtues of Ignorance

Lisa K. Son

Barnard College

Nate Kornell

Williams College

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Please address correspondence to:
Lisa Son, Department of Psychology
Barnard College
3009 Broadway
New York, NY 10027
lson@barnard.edu

Abstract

Although ignorance and uncertainty are usually unwelcome feelings, they have unintuitive advantages for both human and non-human animals, which we review here. We begin with the perils of too much information: Expertise and knowledge can come with illusions (and delusions) of knowing. We then describe how withholding information can counteract these perils: Providing people with less information enables them to judge more precisely what they know and do not know, which in turn enhances long-term memory. Data are presented from a new experiment that illustrates how knowing what we do not know can result in helpful choices and enhanced learning. We conclude by showing that ignorance can be a virtue, as long as it is recognized and rectified.

Keywords: Metacognition, Memory, Learning, Ignorance, Knowledge

- "The greatest obstacle to discovery is not ignorance, it is the illusion of knowledge." (Boorstin; Quoted by Edward Bond in *Washington Post*, 29 January, 1984)

Atul Gawande, a surgeon and author based in Boston, writes about seeing a patient who appeared to have *cellulitis*, an infection that can be treated with antibiotics (Gawande, 2002). Yet Gawande did not feel confident. He had recently seen a patient who had *necrotizing fasciitis*, a rare and often deadly disease sometimes called the "flesh-eating bacteria." Because of his uncertainty, Gawande called in another surgeon, who suggested taking a biopsy. The biopsy showed that it was indeed necrotizing fasciitis. Due to Gawande's knowledge about his own uncertainty, the illness was detected early, and the patient survived and did not have to have her leg amputated.

The topic of this paper is people's knowledge—or uncertainty—about their own knowledge. In Part 1, we summarize various situations where an individual may not recognize his lack of knowledge. In Part 2, we summarize some advantages of withholding information, and in Part 3 we present new data and summarize previous research on the value of recognizing one's ignorance.

Recognizing one's uncertainty is not always a life or death matter, as it was for Gawande. The ability to know that one may *not* know is important in countless situations, from the profound to the mundane. Take, for instance, the common case of studying for a test that will be take place in a few days. During study, the learner must make a myriad of decisions, such as what materials to study, for how long to study each set of materials, and which strategies to use (e.g. Son & Kornell, 2008, in press). If the learner is overconfident in his knowledge, then a progression of harmful choices may occur: The learner is likely to discontinue further study, and, to his surprise, perform poorly on the test later.

Why might an individual feel overly confident? In Part 1, we address this question by proposing that people may (incorrectly) associate more knowledge, or expertise, with confidence. In other words, we show that having too much information can be perilous in that it sparks an illusion of knowing more than is actually known.

Part 1: The Perils of Too Much Information

A. More information leads to overconfidence

Oskamp (1965) published a study that is a classic example of the perils of too much information. He tested three groups of participants: (a) clinical psychologists, (b) psychology graduate students, and (c) advanced undergraduate students. Their task was to read a case study about Joseph Kidd, first reported by White (1952) in the book, "Lives in Progress." Pieces of the case were organized chronologically and presented to the participants in 4 sequential stages: brief demographic information[1], Kidd's childhood, Kidd's high school and college years, and, finally, army service and life up to age 29. After reading the information in each stage, participants had to answer 25 multiple-choice questions regarding the case study. In addition, they had to indicate how confident they were that their answers were correct. Mean accuracy on final test was quite low, ranging from 26% to 28% correct, and remained flat across the 4 stages. That is, with the increasing information provided about the case, there was no noticeable improvement in

[1] Sample of demographic information: "Joseph Kidd (a pseudonym) is a 29 year old man. He is white, unmarried, and a veteran of World War II. He is a college graduate, and works as a business assistant in a floral decorating studio." (Oskamp, 1965)

test performance. However, confidence judgments went from 33% in Stage 1 to 53% in Stage 4, suggesting that increasing information increased confidence (see Figure 1). In addition, there were no significant differences between groups; clinical psychologists were no more accurate than undergraduates. Thus, not only did people's confidence increase disproportionately to actual performance increases, but experts were just as likely as novices to fall under an illusion of knowing when simply provided with more information.

---------------------------- Insert Figure 1 Here -----------------------------

B. Expertise leads to overconfidence

Oskamp's data provide evidence that confidence increases as one attains more information, even if the accuracy of one's judgments does not increase. This suggests that in some cases, expertise might breed overconfidence. For example, if a cricket fan who had never heard of Clive Lloyd was asked "Was Clive Lloyd a famous cricket player," might knowing a lot about cricket influence her answer? We hypothesized that experts might be unwilling to admit that they do not know. In an informal study, experts[2] in two fields -- mathematics and history -- were provided with a list of categories and item names, and the task was to say whether a given name belonged to a particular category. For instance, when given the following information: "Mathematician - Johannes de Groot", people had to say whether Johannes de Groot was a famous mathematician. They could choose from 3 responses: *Yes*, *No*, or *Don't Know*.

Three categories were tested: mathematicians, historians, and athletes. Each participant was tested for 90 trials, randomly presenting 30 trials from each of three

[2] Participants were members or visitors at the Institute for Advanced Study at Princeton.

categories. Within each of the 30 trials, a third were actual members of the category (e.g. Mathematician - Johannes de Groot); another third were members of a different category (e.g. Mathematician - Cy Young); and the final third were names of made-up[3] people (e.g. Mathematician - Benoit Thoron).

Interestingly, experts responded "Don't Know" significantly *fewer* times on trials in which their own topic of expertise was being tested. That is, historians said that they "didn't know" fewer times on historian trials than on athlete or mathematician trials; mathematicians said that they "didn't know" fewer times on mathematician trials than on athlete or historian trials. Crucially, instead of saying they did not know, experts often said “yes” about made up names. For example, mathematicians said “yes” 19 times about made up mathematicians but only 7 times about made up historians; historians said yes 8 times about made up historians but only 4 times about made up mathematicians. Thus, experts were fooled into endorsing falsehoods because they failed to admit that they did not know.

C. More information hurts one's judgments of learning

Thus far we have presented evidence that expertise can lead to overconfidence—and even to people claiming to know "facts" that are not true. In this section, we discuss another downside of having too much information: being given too much information can be perilous for monitoring one's progress during learning.

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[3] All of the made-up names were checked with experts in the field who were not participants in the study to ensure that they were indeed names who were not famous in the categories of math, history, or sports.

Monitoring learning is a critical skill for all learners. A common example, as introduced above, is predicting how well one will do on an upcoming test. For example, if I have a test tomorrow on Spanish vocabulary, I might ask myself "will I remember that *ventana* is Spanish for *window*?" Often this question comes up when studying using flashcards, a ubiquitous study tool. One advantage of flashcards is that they naturally allow self-testing: One can look at the Spanish word, try to recall the translation, and then flip the card over. On the other hand, a potential disadvantage is be that it is possible to flip the card over quickly, read the translation, and, without really being able to recall the answer, recognize it as correct and therefore wrongly judge the word as “learned,” or memorable for tomorrow's test.

The above flashcard strategies — both the good and the potentially bad ones — were tested empirically using a method known as the cue-only versus the cue-target task (Dunlosky & Nelson, 1992). Essentially, this task involved examining the benefits of letting people test themselves as they study. Participants were presented with noun-noun cue-target pairs (e.g. ocean-tree). Then each item was presented again—either immediately or after a delay—so that people could make a judgment of learning (JOL), or a prediction about their future memory for that item. The JOL was phrased, as is typical in such experiments, like so: How confident are you that in about 10 minutes from now you will be able to recall the second word of the pair when prompted with the first? (The possible responses were: 0%, 20%, 40%, 60%, 80%, 100%.) Half of the participants were in the cue-only condition; they were presented with only the first word from each pair (ocean-???) when making the JOL. The other half were in the cue-target condition; they were presented with the entire pair (ocean-tree) when asked to make the JOL. Thus, there were 2 main variables of interest—(1) time of judgment: immediate or delayed, and (2) type of flashcard strategy: cue-only or cue-target. In three of the conditions, full information was available at the time of the JOL: Either the cue and target were both presented, or the JOL was made immediately after the cue and target had been presented. Only the delayed cue-only condition allowed the participant to test him or herself before making the JOL.

The key analysis was to see whether people gave higher JOLs to items that they remembered than they did to items that they forgot on the final test. One might assume that having more information would be helpful. But, on the contrary, those people who had *less* information available when making their predictions stood out compared to the other three groups; they were much more accurate at predicting their later memory performance. The authors concluded by advising that people should monitor their learning by making JOLs (1) after some delay from study, and (2) in the presence of the cue alone. In other words, it won't help to "cheat" when using flashcards. Peeking at the answer on the back of the card, while providing more information, is likely to lead to incorrect judgments about how well that item will be retained on a later test. In short, providing too much information seems to prevent people from monitoring their learning accurately.

D. Newly learned information leads to hindsight bias

Another example of the peril of knowledge during learning can be found in the case of *hindsight bias*. Hindsight bias (Hawkins & Hastie, 1990; Hoffrage & Pohl, 2003) occurs when people who have just learned the answer to a particular question vastly overestimate its predictability or obviousness, as compared to the estimates of others who must guess without advance knowledge, or even as compared to one's own previous lack of knowledge. Hindsight bias is also sometimes called the *I-knew-it-all-along effect* (Wood, 1978). Insight problems provide a clear example; a problem may be extremely difficult to solve if one does not know the answer. If one is told the answer, though, the problem might then seem as “easy as pie.”

Recently, Han and Son (in preparation) tested whether people are prone to hindsight bias using a visual identification procedure. Two groups of students were tested: college undergraduates and children in 5th grade. The procedure was as follows: Each participant was presented with a picture. The picture, though, was very blurry (blurred using Adobe Photoshop's "Gaussian Blur" technique). The individual's task was to type in what the object was. If they did not know the answer, the same picture was presented again in a slightly clearer form. Slightly clearer pictures were presented sequentially until the object was identified accurately by the participant. As many as 15 versions of the same object could be presented (but typically the object was identified before the final picture was shown).

After participants identified 10 items in this manner, the same items were presented a second time, again starting with the blurriest versions. This time, however, participants were asked “Did you know that this was a bird? Yes or No.” The participant's task was to identify at which point he or she had successfully identified the object. If the participants had not exhibited any hindsight bias, they would have claimed to have identified the objects at the point where they had *actually* identified the objects. Results showed that both groups of participants thought they had identified the birds sooner than they had, demonstrating a hindsight bias. Thus, these and other results show, a danger of too much information is that people of various ages lose the ability to judge how difficult it was to learn what they now know.

Part 2: The Benefits of Withholding Information

How can illusions of knowing be offset? In Part 1, we presented the perils of having too much information or knowledge: overconfidence, inaccurate monitoring, and hindsight bias. In part 2, we summarize a key solution to counteracting these perils: *withholding information*.

A. Withholding information helps learning

Above, we discussed an advantage of testing oneself using flashcards (rather than "cheating" by looking at the answer): Doing so leads to accurate monitoring of learning. Tests have another important benefit: tests promote learning (Bjork, 1988; Carrier & Pashler, 1992; Roediger & Karpicke, 2006a, 2006b). Withholding an answer, instead of providing it up front, can be a useful way to avoid the peril of too much information. In some situations, such as when using flashcards, people seem want to test themselves; in other situations, they seem view testing as an impediment to their learning (e.g., Roediger & Karpicke, 2006a; Kornell & Son, 2009). Kornell and Son (2009), for instance, found that people believe that learning is more successful when "cheating" by looking up the answers than when self-testing. They also found that when people choose to self-test, they do so mainly when they know they can come up with the answer successfully (see Son, 2005, for similar findings in children).

Testing oneself on questions one can answer makes intuitive sense. Kornell, Hays, and Bjork (2009) recently investigated the benefits of testing when one *cannot* answer—indeed, when one has never learned the information being tested—which may seem like the worst possible time to withhold information. In six experiments, participants were asked to learn in one of two ways, via "presentation" trials or "test" trials followed by a presentation of the correct answer. In two of the experiments, the participants were asked general information questions (e.g., *What is the last name of the first person to step foot on the moon? / Armstrong*). Unbeknownst to the participants, half of the questions were fictional, meaning that they did not have real answers (e.g., *What is a community of green beetles called? / Village*). In four of the experiments, the participants were asked to learn word pairs (e.g., *pine-needle*). The probability that a person would produce the second word in these pairs, when given the first word, was only about 5 in 100, but such pairs are often perceived as highly associated (see Koriat, Fiedler, and Bjork, 2006). The results showed that being tested (and then being shown the answer) was more effective than simply being shown the question and answer, *even when participants could not answer the test question successfully on their own*. This was true on immediate tests and on a test given 38 hours later; it was also true even when the total time spent on an item was held constant, and thus test time was taken at the expense of time that could have been used to study. These findings suggest that even when withholding information may seem like an extraordinarily bad idea, doing so can enhance long-term learning (see also Izawa, 1970).

Richland, Kornell, and Kao (2009) conducted a series of five experiments along similar lines using richer textual learning materials. Their participants studied a passage about colorblindness caused by brain damage—cerebral achromatopsia—excerpted from Oliver Sacks's book *An Anthropologist on Mars* (Sacks, 1998). The participants were allowed to read questions about the passage for two minutes and then read the passage for eight minutes, or they were simply allowed to read the passage for 10 minutes. Thus, again, test time was taken at the expense of study time. Furthermore, in all conditions the information that was to be tested later was highlighted, using either bolding or italics, so that participants would know equally well, in all conditions, which information they should pay the most attention to. The results supported Kornell et al.'s (2009) results; pretests were more effective than equal time spent studying, even when any question the participants answered correctly on the pretest was excluded from the analyses. In their last experiment, Richland et al. found that a pretest led to more learning when participants were instructed to try to answer the pretest questions than when they were asked to try to remember the same questions. This finding suggests that it is the attempt to answer the question, and the cognitive processing that doing so entails, that makes pre-testing effective.

Both of these experiments (Kornell et al., 2009; Richland et al., 2009) point to the same conclusion: Even when people never knew the answer to a question—which seems like the last situation in which to withhold information—providing too much information is perilous, and it is better to let people try to figure out the answer for themselves.

B. Withholding information helps learning in monkeys

Withholding information does not only enrich human learning; it appears to enhance learning in non-verbal animals as well. Kornell and Terrace (2007) investigated the effect of withholding information from two Rhesus Macaque monkeys. The monkeys were rewarded for touching five pictures in a certain order on a touch-sensitive computer monitor. Each week they learned a new list of five pictures. They were rewarded with a tone for every correct picture press; if they completed the whole sequence they were given a food reward. The monkeys learned two types of list. On some lists the monkeys were shown which pictures to press as they progressed through the sequence. On other lists, that information was withheld and the monkeys had to figure out the order via trial and error. The first three days on each list served as training, and, unsurprisingly, performance levels were higher when the answers were provided than when they were withheld. On the fourth day, in order to measure the animals' learning, all lists were tested without any “hints.” Suddenly the benefits of withholding information emerged: The monkeys had become proficient on the lists that they had studied for three days without help, but they had learned little or nothing when they were being told what to press. Thus there was a complete reversal; the “hint” conditions went from being the best during training to being the worst during the test; the conditions that initially seemed least effective led to the most long-term learning. These findings fit the "desirable difficulties" pattern of results (Bjork, 1994), in that withholding information, which made training relatively difficult, decreased performance during training but simultaneously increased retention on a later test. More generally, these findings demonstrate the benefits of withholding information in non-verbal animals.

Part 3: The virtue of realizing your ignorance

We have established that too much information can often hurt learning. We now turn to the virtues of recognizing one's ignorance. This skill is important whenever one has imperfect information—that is, constantly. Recent problems in the global economy, in fact, might have been ameliorated if bankers (and others) had recognized that they were risking incredible sums based on imperfect information. As Will Rogers said, “When ignorance gets started it knows no bounds” (e.g. Carter, 2005). Below we describe 2 examples of the rewards of recognizing what you do not know.

A. When a monkey knows that it does not know

To benefit from knowing what one does not know requires two things: Knowing what one does not know and making good choices on that basis. A growing body of research suggests that monkeys know when they do not know (Hampton, 2001; Kornell, Son, & Terrace, 2007; Smith & Washburn, 2005; see also Kornell, 2009; Terrace & Son, 2009, for reviews). Using a variation on the paradigm described above (Kornell & Terrace, 2007), Kornell et al. (2007) investigated monkeys' ability to seek more information when they were unsure, the way a doctor might order more tests when he or she is unsure of a diagnosis. Kornell et al.'s monkeys learned lists of four pictures, which they had to press in a certain order to be rewarded. On some trials the monkeys could ask for more information by pressing a "hint" icon on the screen; doing so made a flashing border appear around the next correct picture in the sequence. To discourage hint abuse, the reward for hint-aided trials was a banana-flavored pellet; the reward for a hint-less trial was a more desirable M&M candy. The monkeys asked for fewer hints on lists they knew better and they decreased their hint-requests as they mastered each individual list. Both findings suggest that the monkeys acquired two abilities; knowing when they were unsure and making appropriate decisions based on that knowledge.

B. When a human knows that it does not know

Not knowing has advantages, as illustrated above, but it also has obvious drawbacks. An important virtue of ignorance is that recognizing it is often the first step in doing something to obtain more knowledge. Thomas Jefferson stated it clearly: “He who knows best knows how little he knows” (c. 1801-09). As the monkeys sought to obtain more information, a person should be able to seek more information appropriately and benefit from doing so.

We conducted an experiment designed to test the benefits of recognizing one's ignorance. College students studied sixteen word-synonym pairs (e.g. ignominious – shameful). The words were presented one at a time, like flashcards, on a computer. As participants studied, they made JOLs. Then they were allowed to select half of the items to be re-studied later. The participants were split into two conditions: One condition respected the learner choices; the other dishonored the learner's choices by allowing them to re-study those items that they had not chosen to study. During the restudy period, the eight to-be-re-studied cues were presented on the screen simultaneously, and the participant could allocate time to the items freely. Clicking on any particular item made the target synonym appear until it was pressed again to make it disappear. Participants had one minute to study all eight items. After a distractor task, a final cued-recall test was conducted.

To benefit from lacking knowledge, the learner must know when he or she does not know. As far as item selection, participants chose to study the items that they had rated as being most difficult. Participants also allocated the most time to the difficult items during the restudy period, at least in the honor condition; when they were asked to study the items they had not selected, there was no clear pattern of study time allocation.

The primary goal was to investigate learning benefits. As Figure 1 shows, performance was generally higher in the honor condition than in the dishonor condition. As expected, people in the dishonor condition performed much more poorly on the judged difficult items since their choices to re-study the difficult items were not honored.

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The results of this study show that people (1) knew what they did not know, (2) sought more study time on the items they did not know, and (3) benefited from their choices (see also Kornell and Metcalfe, 2006). In sum, accurate knowledge about one's lack of knowledge led to effective study decisions.

General Discussion

We began this paper with the surgeon Atul Gawande, who recognized his uncertainty and, as a result of his willingness to display a lack of knowledge, saved a patient's life. We then outlined why lacking knowledge is often a virtue. It is often the inability to *recognize* one's ignorance that can be perilous. As Benjamin Franklin stated: ”Being ignorant is not so much a shame, as being unwilling to learn” (Poor Richard's Almanack, 1755).

In this paper we have reviewed reasons why a lack of information can be good. In Part 1, we showed that a profusion of knowledge, in the form or expertise, can lead to illusions, and even delusions; that providing answers can reduce people's ability to judge what they know; and that knowledge makes people think they "knew it all along" even if they did not. Withholding information can act as an antidote for such illusions, and, as we explain in Part 2, it can also enhance learning in both humans and monkeys. Finally, in Part 3, we provided evidence for how recognizing one's ignorance can lead to good decisions that increase learning, again in both humans and monkeys.

We also reported data from two experiments in this paper. In the first, we showed the perils of knowing too much about a topic. Historians and Mathematicians who were asked to classify a series of names as famous figures in various fields fell victim to an illusion of knowing; when asked about their own field, these experts tended to label *made-up* names as well known (more than they did when asked about other fields), seemingly because they were unwilling to say they did not know.

In the second experiment we reported in this paper, we showed a benefit of recognizing one's ignorance. Participants made accurate judgments about their own learning, used those judgments to make appropriate study decisions, and benefited accordingly. They learned more than they learned when their study choices were not honored. These findings, which are consistent with previous result on the judgment-choice-learning outcome chain (e.g., Kornell & Metcalfe, 2006), demonstrated the potential virtues of controlling one’s own study.

Although controlling one’s study can boost learning, as we found here, it can also have less positive consequences. In Atkinson's (1972) study, learner-controlled strategies—where people knew that they did not know a particular subset of items, and subsequently chose those items for further study—resulted in poor performance relative to computer-controlled strategies—where more intermediate, not the most difficult, level items were selected for study. Subsequent studies also showed that although people seemed to be behaving in a logical way (studying the very difficult items), their payoff was trivial—they were said to be *laboring in vain* (Mazzoni et al., 1990; Mazzoni & Cornoldi, 1993; Nelson & Leonesio, 1988). These data highlight the difficulty of optimizing one's learning strategy (see Son & Sethi, 2006, 2009, for reasons for suboptimal learning strategies). For instance, it isn't enough to know that you lack knowledge on a particular topic; you also need to know whether that knowledge can be gained in any realistic amount of time. If it can't be, then you should not waste time studying what cannot be learned. Instead, a more intermediate range of items should perhaps be studied (e.g., Metcalfe & Kornell, 2003).

Even when people decide that they want information withheld from them—that is, that they want to be tested—they are not necessarily aware of the benefits that will result. Kornell and Son (2009) conducted two experiments in which participants were asked to study a list of word pairs in two ways: by reading the word pairs twice each, or by reading each pair once and then being tested on the pairs. When asked which study technique helped them learn more, most participants said that reading was better than self-testing—that is, the participants wanted more, not less, information. Ironically, and luckily, participants still chose to test themselves. Their goal, apparently, was not to enrich their learning but rather to gauge what they did and did not know. Fortunately for the participants, by testing themselves they were unwittingly helping themselves learn. These findings exemplify three important themes of the current paper: That withholding information has benefits for learning, that those benefits are often counterintuitive, and that finding ways to identify one's ignorance is a valuable pursuit.

Learning, or the accumulation of information in memory, is arguably one of the most complicated mental processes in any species. Ironically, providing people and animals with *less* information can result in *more* learning. It can also enable them to identify what they have and have not learned. In short, ignorance can be a virtue when people are encouraged to recognize their lack of knowledge and remedy it. As Confucius said, "Real knowledge is to know the extent of one's ignorance" (c. 551-478 BC).

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Figure Captions

Figure 1. A demonstration of increasing overconfidence: Performance and confidence for each of the 4 sessions of newly learned and tested material. Figure created from the Oskamp's (1965) data.

Figure 2. Final test performance for the honor and dishonor conditions as a function of JOL.

Figure 1

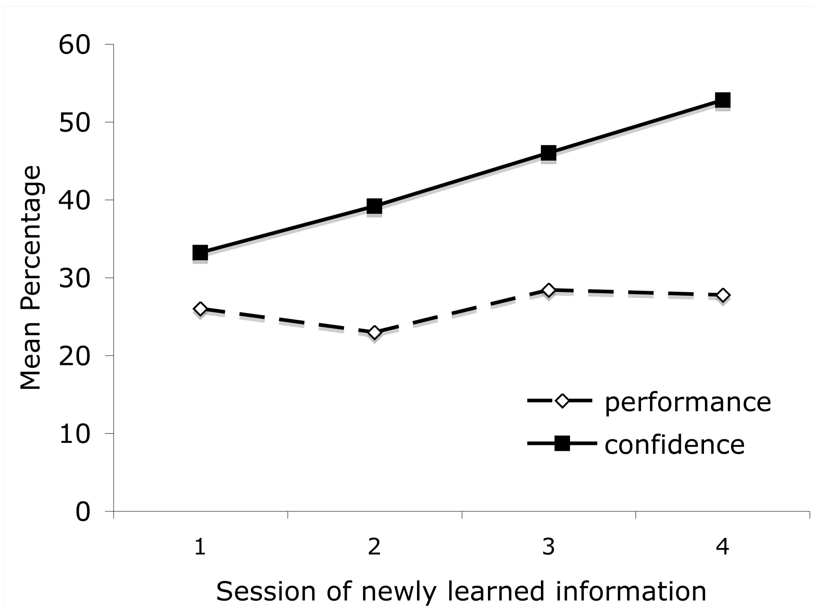
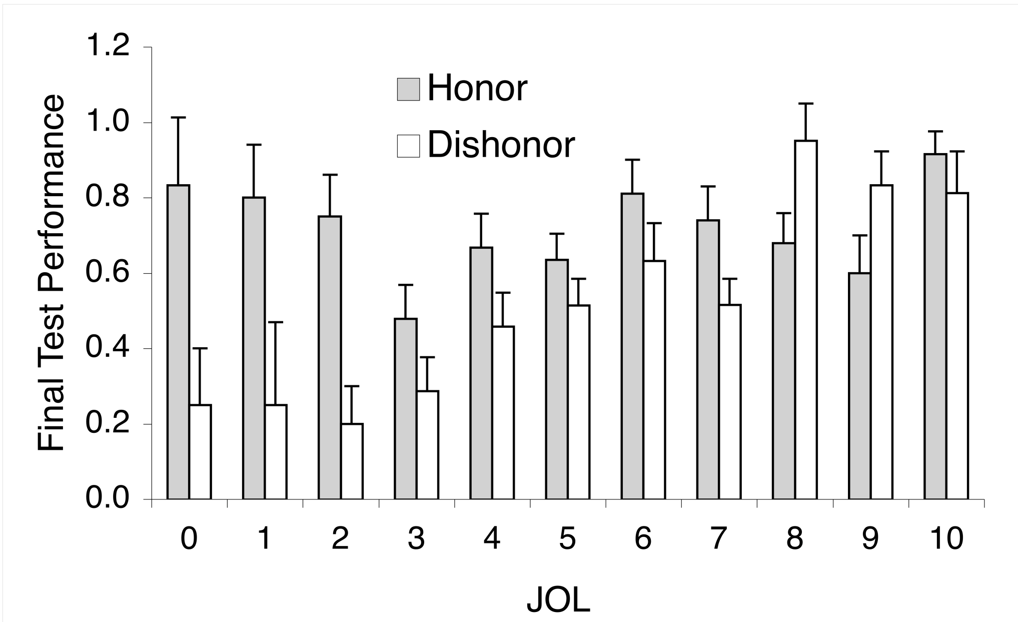

60
50
40
30
20
10
0
Mean Percentage
performance
confidence
1
2
3
4
Session of newly learned information

Figure 2


1.2
1.0
0.8
0.6
0.4
0.2
0.0
Final Test Performance
Honor
Dishonor
0
1
2
3
4
5
6
7
8
9
10
JOL