Integrating Advice and Experience: Learning and Decision Making With Social and Nonsocial Cues

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When making decisions, people typically gather information from both social and nonsocial sources, such as advice from others and direct experience. This research adapted a cognitive learning paradigm to examine the process by which people learn what sources of information are credible. When participants relied on advice alone to make decisions, their learning of source reliability proceeded in a manner analogous to traditional cue learning processes and replicated the established learning phenomena. However, when advice and nonsocial cues were encountered together as an established phenomenon, blocking (ignoring redundant information) did not occur. Our results suggest that extant cognitive learning models can accommodate either advice or nonsocial cues in isolation. However, the combination of advice and nonsocial cues (a context more typically encountered in daily life) leads to different patterns of learning, in which mutually supportive information from different types of sources is not regarded as redundant and may be particularly compelling. For these situations, cognitive learning models still constitute a promising explanatory tool but one that must be expanded. As such, these findings have important implications for social psychological theory and for cognitive models of learning.

Keywords: decision making, advice taking, social influence, cognitive learning models

When making important decisions, people usually gather information from many types of sources before choosing a course of action. Suppose you endeavor to invest in the stock market for the first time. You might read columns by a number of market analysts who recommend different stocks and also examine the financial information of a number of stocks yourself. How might you learn to weight such information in deciding how to invest your nest egg?

Despite its real-world relevance, the impact of diverse information sources on decision making constitutes a rather sparse area of scientific inquiry. One likely reason for the near absence of such work in the literature is that the question spans research areas (e.g., persuasion, decision making, trust formation, marketing, learning, memory, gossip). Our aim in this work was to bridge the gap in research on decision making (see Ranganath, Spellman, & Joy-Gaba, 2010) by adapting a paradigm developed in the cognitive cue learning literature to examine a more complex informational context in which advice and nonsocial cues are encountered together. Such an endeavor has the potential to inform both social psychological theory and cognitive models of learning.

Social Information: Existing Research From Social Psychology

The general topic of how we use information provided by multiple social sources has strong roots in the social psychological tradition. Early work focused on how groups of individuals come to be influential, demonstrating a general "power in numbers" effect (see Krech, Crutchfield, & Ballachey, 1962) in which, other things being equal, the amount of influence increases as the number of persuasive entities increases, at least to a point (Latané, 1981). The exact manner by which persuasive influence from multiple sources is synthesized to determine a response has also been the subject of some investigation, and this has led to the development of models that quantitatively combine the influence of group members (e.g., by weighted averaging; see Budescu & Rantilla, 2000; Budescu, Rantilla, Yu, & Karelitz, 2003).

There are numerous models of how people make decisions based on information from others (e.g., Hutchins, 1991; Kennedy

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& Eberhart, 2001; Nowak, Szamrej, & Latané, 1990; for a review, see Mason, Conrey, & Smith, 2007). Most such models assume either that all information sources receive equal weights or that the weights are unequal but fixed (e.g., some sources being more persuasive than others). These models generally leave unexplained the processes by which perceivers actually assign weights to information sources. There are two sophisticated models that assume individuals learn to heed the input of some sources more than others through an adaptive weighting process by which people learn the appropriate degree of "trust" for or importance of particular social sources through experience (see Lee & Dry, 2006; Van Overwalle and Heylighen, 2006).

Despite these advances, a missing piece in this literature is an understanding of how people learn to rely on the diverse information sources that are typically available in daily life; that is, we generally encounter advice not in a vacuum but along with additional information that is directly available to us. There is some evidence that even when direct information is available, we continue to seek input from others. For example, people utilize gossip from third parties to help them form impressions of target individuals, even when they have direct behavioral information about the targets (Craik, 2008; Smith & Collins, 2009; Sommerfeld, Krambeck, Semmann, & Milinski, 2007). However, the simultaneous availability of the two types of information (advice and direct experience) can cause tensions. To illustrate this point, one need only recall the footage from Asch's (1951) groundbreaking studies on conformity in which perplexed participants tried to reconcile what was in plain view (direct evidence) with the very incongruous perspective of their fellow (confederate) participants (advice, in a sense, although it is not usually framed as such). These experiments often led participants to decide against their own perceptual experience and adopt the wisdom of the group instead. However, one cannot simply conclude that advice always trumps experience; there is also evidence to suggest that when experience and advice conflict, people do not weigh social input enough (Soll & Larrick, 2009). Thus, despite the long history of research on how we rely upon information from those around us, the question of how people integrate nonsocial cues from the environment with the available advice from others has yet to be fully addressed. Just as multiple social sources exert particular influence to the extent that they are perceived as diverse (Harkins & Petty, 1981, 1987), diversity of information types (i.e., availability of advice obtained socially as well as directly observable nonsocial cues) may play an important and unique role in decision making.

Nonsocial Information: Cognitive Models of Learning

In a process quite independent of the social psychological work we have described, cue learning has been investigated extensively in research on cognitive learning models (Kruschke, 2001b, 2003; Mackintosh, 1975; Rescorla & Wagner, 1972). These models characterize how people associate cues with particular responses or outcomes (e.g., how people learn through experience that a particular set of symptoms usually signals coming down with a cold or that opening a certain computer program leads to a frozen screen). Such models conceptualize learning as the strengthening of associations between predictive cues (e.g., the series of computerized tasks that preceded the crash) and outcomes over time and the weakening of associations between nonpredictive cues (e.g., the color of shirt worn that morning) and outcomes. This literature has greatly deepened psychological understanding of how people learn about the predictive power of cues. However, despite the breadth of such research and the importance of its theoretical contributions, existing work has been limited to experimental paradigms using a single type of cue with no information about the source of the cue. As such, it remains unclear how this work applies to the process of learning which social sources of information are worth one's attention.

Beyond the question of the relevance of such learning models to the social context alone, a more mysterious question is whether these models accurately characterize learning when both advice from people and nonsocial cues are available. This context describes many real-world situations in which people receive advice and also gather information themselves. Here people must learn over time both which sources of advice and which nonsocial cues are important and also which ones are best ignored. The current understanding of this process is quite limited.

The present research addressed these questions by adapting research paradigms from the attentional cue learning literature (Kruschke, 2001b, 2003). We began by employing such a paradigm (and testing its associated learning phenomena) to investigate the relevance of cognitive learning models for how people learn the reliability of social sources of advice. After establishing the applicability of these processes for the learning of reliable social sources of advice, we further adapted our paradigm to address a question previously uninvestigated in the literature: how learning processes may change when nonsocial cues and advice are encountered together and integrated to make decisions.

Adapting a Cue Learning Paradigm

The cognitive learning models we have described test hypotheses using well-established paradigms and have identified particular learning phenomena that are robust under various conditions. We adapted a cue learning paradigm in which participants learn the proper responses to simple cues (Medin & Edelson, 1988) from research on the EXIT model of attentional learning (Kruschke, 2001b, 2003). Our adaptation allowed the application of this work to a very different context: how people learn over time which social sources of information are reliable. This adaptation involved substantial methodological changes to the traditional paradigm (reconceptualizing "cues" as the identities of sources providing information). Such a change added an additional level of complexity to the structure of the design in that participants had to learn not just what information was available but also what its source was. The shift to information received from social sources is not trivial. Different processing strategies are suggested, for example, by studies showing that separate areas of the brain are utilized to process information that ostensibly comes from another person and that generated by a computer (Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003).

We began our work by applying this cue learning paradigm adaptation to the learning of social sources of information (Study 1). We then employed this paradigm to examine the process of learning in situations where people receive information both from social sources (advice) and from nonsocial sources (cues; Studies 2 and 3).

EXIT Model Learning Phenomena: Highlighting and Blocking

Our work focused upon testing for the particular learning phenomena predicted by the EXIT model (which typically serve to demonstrate that attentional learning processes have occurred). We utilized both learning phenomena traditionally used to test the EXIT model to assess our findings: blocking and highlighting.

Blocking: General explanation. *Blocking* (Kamin, 1968) occurs when a new cue is introduced alongside a cue whose meaning has already been learned. Because the new cue is redundant (providing no additional information beyond the original cue), learning about it is blocked. For example, assume a diagnostician begins by learning that a number of patients about whom she knows only one symptom, a skin rash, all have a specific disease. New patients are subsequently encountered about whom two symptoms are known, a skin rash and swollen glands, and they turn out to have the same disease. Under these circumstances the diagnostician will not learn the predictive power of swollen glands very well, because the skin rash supplies all the necessary information for a correct diagnosis. As a result, attention to this new cue will be blocked. Blocking has been shown in contexts ranging from animal learning (Kamin, 1968) to cognitive mapping in humans (Hardt, Hupbach, & Nadel, 2009). There are various theoretical interpretations of blocking. Many posit that changes in associative strength of the stimuli account for blocking (Rescorla & Wagner, 1972), and others suggest it is accounted for by changes in attention (Kruschke, 2001b; Kruschke & Blair, 2000; Mackintosh, 1975). A strong argument has been made for higher order reasoning being involved in cognitive learning phenomena, including blocking (De Houwer, Beckers, & Vandorpe, 2005). Regardless of these varying theoretical interpretations of the effect, the phenomenon itself is basic and robust.

Highlighting: General explanation. *Highlighting* is a phenomenon complementary to blocking, which can be explained by the attentional learning model (the EXIT model; Kruschke, 2001b, 2003) but not by extant nonattentional learning models (see Kruschke, 2001b). Highlighting occurs when a person focuses extra attention on a cue that changes the meaning of a previously learned cue, as happens when a learned association is no longer correct (or an unexpected outcome occurs) when a new cue is added alongside a known cue. This attentional highlighting is analogous to the literal highlighting of a piece of information: The importance of the new cue (the cue that changes the rules, so to speak) is amplified (an extensive review of highlighting is provided by Kruschke, 2009). For example, imagine that you have learned that a skin rash predicts disease A. Now you begin to encounter some patients with a skin rash and also muscle aches, and they turn out to have a different disease, B. The additional cue of muscle aches is highlighted, or given particular attention, because it changes the meaning of the previously learned cue (i.e., "Skin rash indicates disease A unless it co-occurs with muscle aches, in which case it is disease B").

Because highlighting is not predicted by other learning models (Kruschke, 2001b), this phenomenon specifically indicates that the kind of attentional learning specified by the EXIT model has occurred. When the outcome of a trial indicates that a previously learned cue–outcome association is now misleading, perceivers are thought to shift their attention toward the newly predictive cues (the muscle aches in our example) and away from less predictive cues (e.g., the skin rash).

Highlighting and Blocking of Social Sources: Potential Evidence From the Literature

Although blocking and highlighting effects are generally studied in simple associative learning paradigms (e.g., learning to associate fictitious symptoms and diseases in a diagnosis paradigm), such phenomena have potential relevance to social psychological findings. For example, research indicates that multiple sources advocating the same position tend to have decreasing impact as their numbers increase (Nowak et al., 1990). This is consistent with the blocking principle in that the later sources (who offer redundant information) receive less weight. However, other evidence suggests that information weighting in the social context may be more complicated. For example, sometimes multiple sources advocating a position are not ignored as redundant; rather, as a set they become more influential than a single source (Centola, 2010; Centola & Macy, 2007). Additionally, as described earlier, social sources appear to have a greater impact when they are perceived as diverse (Harkins & Petty, 1981, 1987). In light of these seemingly contradictory findings, we were interested in the possibility that blocking effects may occur with homogenous source types (e.g., when advice is encountered in the absence of directly available information) but not with diverse or dissimilar source types (e.g., when advice and nonsocial cues are simultaneously available). Highlighting has potential relevance to social psychological phenomena as well, as we argue in the Discussion section. However, existing research (to our knowledge) has never tested highlighting effects in a social context.

The Current Research

The current research began by assessing whether the learning phenomena of blocking and highlighting occur when cues are the identities of the social sources providing information (Study 1) and then investigated how such processes change when advice and nonsocial cues are learned together (Studies 2 and 3). Thus, in the first study we examined whether social sources would be blocked and highlighted in the same manner as that demonstrated by nonsocial cue learning research. In the last two studies we further adapted our attentional learning paradigm to a context in which individuals encountered nonsocial cues as well as advice from other people. Throughout these studies, we drew together cognitive learning models and social psychological theory in an effort to extend and deepen our understanding of both.

Study 1: Social Sources as Cues: Learning the Accuracy of Advisers

Our purpose in Study 1 was to examine whether the reliability of social advisers would be blocked and highlighted in the way previously demonstrated with nonsocial cues (Kruschke, Kappenman, & Hetrick, 2005). Each participant completed two procedures designed to test blocking and highlighting, respectively. Each procedure consisted of a series of trials modeled on the design utilized in studies on attentional learning (e.g., Kruschke et al., 2005; this design was originally developed to test the use of base-rate information, see Medin & Edelson, 1988). We expected that as all the information participants received was from the same type of source (advice, in isolation from other kinds of information), learning in this adapted paradigm would be analogous to established findings for the learning of nonsocial cues. For this reason, we hypothesized that both blocking and highlighting would occur.

In each procedure, participants made a series of decisions about which of two stocks (always denoted with the neutral labels "Stock X" and "Stock Y") would perform best. On each trial, participants received conflicting stock recommendations from fictitious stock advisers (e.g., "Adviser Evans recommends Stock X", "Adviser Garcia recommends Stock Y") and were prompted to make a choice of which stock would perform best.

Method

Participants and general procedure. Participants were 45 Indiana University psychology students (19 female, 26 male) who received partial course credit for taking part in the computerized experimental task programmed with E-Prime Version 2.0.

After they had provided informed consent to take part in a "reasoning game," participants were seated at computers in individual cubicles. They were given instructions that they would evaluate stock adviser recommendations in order to pick the stocks that would gain value.

All participants completed both the blocking and highlighting procedures, in counterbalanced order. In order to ensure the two procedures were treated as separate tasks, we instructed participants that each procedure was independent and involved a separate set of advisers. Unique adviser names were used for each one.

Each procedure was split into three phases: the early training phase, the late training phase, and the testing phase. The order of trials within each phase was randomized. On each trial, participants viewed stock recommendations and were prompted to choose either Stock X or Stock Y. Each adviser was denoted by a common last name, with particular names randomly assigned for each participant. The label for the particular stock recommended by each adviser (i.e., whether it was labeled as Stock X or Stock Y) was randomized for each trial. On training trials, participants' stock selections were followed by feedback as to whether the chosen stock was the better performing one. On test trials, no feedback was provided.

Blocking procedure. In the early training phase of the blocking procedure (eight trials; see Table 1), participants learned the accuracy of four advisers (Advisers A, F, R, and V). The critical knowledge was that Adviser A (the potential blocking adviser) always suggested the correct response (a necessary precondition for blocking of subsequently introduced advisers to occur). During this phase, participants received advice from two conflicting advisers (either Advisers A and R or Advisers F and V) on each trial, one of whom suggested the correct stock (Advisers A and F) and the other of whom suggested the incorrect stock (Advisers R and V). To ensure that learning of the advisers' accuracy occurred, we repeated this phase until participants provided 15 out of 16 correct responses on two consecutive repetitions (not including the initial set).

On each late training trial (eight trials) participants were presented advice from four advisers at a time, two of whom suggested Stock X and two of whom suggested Stock Y. On half the trials, Advisers A and B suggested the correct stock, and Advisers R and S suggested the incorrect stock. These trials allowed participants to learn that Adviser B was accurate, but this knowledge was not required, as the previously learned Adviser A supplied all information needed for an accurate response. On the other half of the trials, Advisers C and D suggested the correct stock, and Advisers T and U suggested the incorrect stock. A total of eight advisers (Advisers A, B, R, S, C, D, T, U) appeared in this phase. Two of them (Advisers A and R) continued from the early training phase, and the remaining six were new to participants. This phase was repeated in the same manner as the early training phase to ensure learning.

During the testing phase, 32 trials assessed whether blocking occurred (also included were eight late training phase trials, four of each type). On these trials, no feedback was provided beyond that the response had been recorded (i.e., on testing trials there were no correct and incorrect answers; rather, we were interested in participant responses to novel combinations). If learning was determined solely by the number of times an adviser was correct, the accuracy of Advisers B, C, and D (see blocking procedure, Table 1) would be equally well learned. However, if blocking occurred, learning of Adviser B's accuracy would be blocked (because Adviser B's advice was redundant, given that Adviser A was already known to be accurate). On each testing trial, participants were presented with two conflicting recommendations. Sixteen of these trials were meant to assess whether blocking had occurred.

Table 1
Study 1 Blocking and Highlighting Design

Phase	Procedure			
	Blocking		Highlighting	
Early training	$A_X R_Y \rightarrow X$,	$F_X V_Y \rightarrow X$	$E_X G_X P_Y Q_Y \rightarrow X$,	$H_X I_X N_Y O_Y \rightarrow X$
Late training	$A_X B_X R_Y S_Y \rightarrow X$,	$C_X D_X T_Y U_Y \rightarrow X$	$E_X G_X P_Y Q_Y \rightarrow X$,	$E_X J_Y \rightarrow Y$
Testing	$B_X D_Y \rightarrow$? [Y],	$B_X C_Y \rightarrow$? [Y]	$G_X J_Y \rightarrow$? [Y]	
	$A_X D_Y \rightarrow$? [X],	$A_X C_Y \rightarrow$? [X]		

Note. Each cell indicates source → correct answer. Each $\text{Letter}_{\text{subscript}}$ combination indicates an $\text{Adviser}_{\text{advice}}$ pairing. For simplicity, this table indicates only one recommendation (either Stock X or Stock Y) per adviser, but recommendations were actually randomized across trials. For the testing phase, the hypothesized response tendencies are shown in brackets.

On these trials a recommendation from Adviser B (the potentially blocked adviser) was presented alongside a contradictory recommendation from either Adviser C (eight trials) or Adviser D (eight trials). Giving less weight to Adviser B (the redundant adviser who was potentially blocked as a reliable source of information) than to the other, equally correct advisers (Advisers C and D) would demonstrate that the learning of Adviser B as a reliable source had been blocked.

The remaining 16 trials in the testing phase were intended to rule out a lack of learning (or heightened attention to Advisers C and D) as an alternative explanation for a blocking effect. On these trials, Adviser A (the potential blocking source) was presented in conflict with Adviser C (eight trials) or Adviser D (eight trials). If learning had occurred and participants were sensitive to the frequency of accurate suggestions, Adviser A's suggestion should be followed over those of Advisers C and D more frequently than chance. Such a finding would demonstrate both that (a) Adviser A was well learned as an accurate adviser (a precondition for blocking to occur) and (b) the blocking effect was indeed driven by blocked attention to Adviser B rather than by heightened attention to Advisers C or D.

Highlighting procedure. In the early training phase of the highlighting procedure (four trials), participants had the opportunity to learn the accuracy of eight advisers (E, G, H, I, N, O, P, and Q). The critical knowledge was that the pair of Advisers E and G provided accurate predictions of the correct stock (a necessary precondition for highlighting to occur). In this phase, participants received advice from four advisers at a time. On half the trials, Advisers E and G recommended the correct stock, and Advisers P and Q recommended the incorrect stock. On the other half of the trials, Advisers H and I recommended the correct stock, and Advisers N and O recommended the incorrect stock. To ensure learning, we repeated this phase until participants responded correctly to 11 out of 12 trials on three consecutive sets (not including the initial set).

In the late training phase (16 trials) eight trials from the early training phase were presented, interspersed with eight new trials in which Adviser J suggested the correct stock and Adviser E suggested the incorrect stock. This allowed participants to learn that the known Adviser E was no longer reliable when in conflict with the novel Adviser J, providing an opportunity for Adviser J to be highlighted as a reliable source of information.

During the testing phase, eight trials assessed whether highlighting had occurred (interspersed with four of each type of late phase trial). On the testing trials, Advisers J and G made contradictory recommendations. Highlighting would be demonstrated by a preference for Adviser J over Adviser G. In other words, highlighting would be evidenced by heightened attention toward Adviser J over another equally accurate adviser, because this source signaled a change in the previously learned information.

Results

Participants had two response options (Stock X or Stock Y) on each trial in Study 1. Blocking and highlighting effects were assessed by calculating the proportion of expected response choices compared to selections of the alternative response, producing a 0 to 1 scale. A proportion of expected responses that is significantly greater than .5 constitutes evidence that the learning phenomenon of interest (i.e., blocking or highlighting) occurred.

All results reported are collapsed across experimental order of procedures (blocking first vs. highlighting first), as analyses with order in the model showed that it did not influence the results ($ps > .2$).

Blocking. If blocking occurred, the advice given by Advisers C or D in the testing phase should have been followed more frequently than that given by Adviser B (i.e., more than 50% of the time). Because Adviser B provided redundant information during the training trials, this adviser's reliability should not have been as well learned as that of other equally reliable and frequent sources of information.

A *t* test showed that, as hypothesized, participants followed the advice from Advisers C and D over Adviser B more often than chance ($M = .66$, $SD = .34$), $t(44) = 3.19$, $p < .005$, indicating blocking. To demonstrate that the effect is truly driven by blocked learning of Adviser B's accuracy (and not extra attention to Adviser C and D or a lack of learning in general), we needed to confirm that the reliability of Advisers C and D was not learned better than that of Adviser A, whose advice was correct on more trials and the learning of which is a precondition for Adviser B to be seen as redundant. A *t* test corroborated this: Participants followed the advice from Adviser A more often than chance when paired with Adviser C or D ($M = .81$, $SD = .24$), $t(44) = 8.51$, $p <$ .001.

Highlighting. If attentional highlighting occurred, participants would have followed the advice from Adviser J over that from Adviser G more frequently than would be expected by chance (i.e., more than 50% of the time). In other words, because the addition of Adviser J changed a previously learned rule about reliability (i.e., participants learned that Adviser E was no longer accurate when in disagreement with Adviser J), Adviser J should receive more attention than Adviser G, who was accurate on more trials, because Adviser J signaled a change in the previously learned information. A *t* test showed that, as expected, highlighting occurred. Participants followed the advice of Adviser J over Adviser G more often than would be expected by chance ($M = .79$, $SD = .35$), $t(44) = 5.43$, $p < .01$.

Discussion

Study 1 examined the way people learn the reliability of advisers by adapting a traditional cue learning paradigm from the cognitive psychology literature. This experiment was quite different from the traditional cue–response learning experiments from which it was adapted: Because the advisers directly specified the outcomes they favored, it required a different type of learning (source reliability rather than cue–response associations). Thus, instead of learning which cue predicted which response, participants learned whose advice was accurate. Obtaining the traditional learning phenomena of blocking and highlighting with such a paradigm adaptation supports the applicability of attentional cue learning to this very different context. In other words, models devised to account for the learning of reliable cues in the environment appear to also account for the manner by which we learn to attend to the people who provide good advice.

With Study 1 having validated the applicability of our cue learning paradigm adaptation for the context of learning the reliability of social sources, we were able to move forward to investigate a particularly interesting question: how people integrate information and use it to make decisions when it is received from social sources (as advice) and as nonsocial cues (as raw information) concurrently.

Study 2: Advice and Nonsocial Cues: Source Diversity Eliminates Blocking

In Study 2 we investigated whether the same learning phenomena occur when advice and nonsocial cues are encountered together. Scattered evidence seems to suggest differences in cognitive processes between situations in which a single type of information is encountered and situations in which multiple types of sources are available (Asch, 1951; Bonaccio & Dalal, 2006; Sommerfeld et al., 2007). However, a systematic examination of how a combination of information from different types of sources might impact cue learning and decision making is missing from the literature.

Our cue learning paradigm adaptation seemed a particularly well-suited context in which to investigate this question. We suspected that learning in this context of nonsocial and social advice might deviate from the process that occurs when either is investigated in isolation. Such isolation of source type characterizes the traditional cue learning studies (limited to nonsocial cues; e.g., Kruschke, 2003) as well as our Study 1 (limited to social sources). We hypothesized that the combination of advice and nonsocial cues might be a unique context in which redundant information would not be ignored. In other words, we expected that when advice was paired with nonsocial cues in the same design, the robust and well-established phenomenon of blocking (which is predicated on a lack of learning redundant information) might no longer occur. Our reasoning hearkens all the way back to the Asch conformity paradigm (Asch, 1951). When people were confronted with inconsistency between clearly visible cues (the perceived length of lines) and the unanimous judgments of others, they were upset and confused by the contradiction. However, even a single ally agreeing with the real participant greatly reduced confusion and conformity—far from being treated as redundant and ignored! We propose that agreement between directly available nonsocial cues and advice from another person leads to perceived corroboration rather than redundancy. Because blocking depends on this lack of learning of redundant cues (whereas highlighting involves an increase in attention to a cue that changes a learned pattern), only blocking should be disrupted by this new context in which nonsocial and social information are combined. For this reason, we expected that when advice and nonsocial cues were introduced together, highlighting effects would occur but blocking effects might not.

To address these ideas, we employed in our second study a disease diagnosis paradigm in which not only social advice but also nonsocial cues were included to test for the learning phenomena of interest (i.e., blocking and highlighting). We expected this experiment to replicate the same highlighting effect obtained in Study 1, because a source of information that signals a change to learned responses should garner extra attention regardless of the diversity of types of information included (i.e., advice, nonsocial cues). Our predictions for blocking were very different. We anticipated that in the context of a diversity of information source types blocking might be weak or absent, because varying types of information supporting the same conclusion might be seen as mutually informative, rather than redundant. If this were the case, the traditional finding of blocked learning of a redundant source of information would not occur.

Our paradigm also allowed us to examine whether the phenomena of interest occur equally strongly regardless of which type of information source (advice or nonsocial cue) was in the dominant role (i.e., the initially learned cue that would potentially block other information or the meaning-changing cue that would potentially be highlighted over other information). Obtaining stronger highlighting and blocking effects when advice was in the dominant role would signify attentional biases toward social sources of information compared to nonsocial cues, and obtaining stronger effects when nonsocial cues were in the dominant role would imply attentional biases toward directly available information compared to advice. Because our cue learning paradigm adaptation allowed us to test not only the occurrence but also the degree of blocking or highlighting, we were thus able to compare the relative strength of such effects.

Method

Participants and general procedure. Participants were 117 Indiana University psychology students (72 female, 45 male) who received partial course credit for participation. As in Study 1, participants completed two procedures testing for blocking and highlighting, respectively. However, in this experiment two versions of each procedure were employed. One version of the blocking procedure created the opportunity for a nonsocial cue to block learning of a redundant source of advice (termed the *cue-dominant blocking procedure*), and a second version of the blocking procedure created the opportunity for advice to block the learning of a redundant nonsocial cue (termed the *advice-dominant blocking procedure*). Likewise, one version of the highlighting procedure created the opportunity for a nonsocial cue to be highlighted when paired with sources of advice (termed the *cue-dominant highlighting procedure*), and a second version of the highlighting procedure created the opportunity for a source of advice to be highlighted when paired with nonsocial cues (termed the *advice-dominant highlighting procedure*; see Tables 2 and 3 for the designs of each procedure).

Participants were assigned to either the cue-dominant or the advice-dominant condition of the experiment. Each participant completed the corresponding highlighting and blocking procedures (with order counterbalanced). To ensure that the two procedures were treated as separate tasks, we instructed participants that each procedure was independent and used unique adviser names, symptom words, and disease words.

Over the course of the experiment, participants learned to diagnose various diseases based on the available information about symptoms (nonsocial cues) and the diagnoses ostensibly made by previous study participants (social advice). Participants were instructed that their task was to learn to correctly identify the diseases based on the information available. They were also told that the advisers may or may not have had enough information to make a correct diagnosis; thus, part of the task was to learn whether each adviser was reliable or not. These “previous participants” were fictitious, and the advice was predetermined by the

Table 2
Study 2 Blocking Design

Phase	Procedure			
	Cue-dominant		Advice-dominant	
Early training	$A \rightarrow X$,	$B \rightarrow X$	$5_X \rightarrow X$,	$6_Y \rightarrow Y$
			$7_X \rightarrow W$,	$8_Y \rightarrow Z$
Late training	$A1_X \rightarrow X$,	$C2_Y \rightarrow Y$	$F5_X \rightarrow X$,	$G9_Z \rightarrow Z$
	$D3_X \rightarrow W$,	$E4_Y \rightarrow Z$	$H7_X \rightarrow W$,	$I10_Z \rightarrow Y$
Testing	1_X2_Y (conflicting) $\rightarrow$? [Y]		FG (conflicting) $\rightarrow$? [Z]	
	AC (conflicting) $\rightarrow$? [X]		5_X9_Z (conflicting) $\rightarrow$? [X]	

Note. Each cell indicates source → correct answer. $\text{Number}_{\text{letter}}$ sources indicate Former $\text{Participant}_{\text{advice}}$. Letter sources (A through I) indicate a symptom (nonsocial cue). Either one or two sources were presented on each trial. For the testing phase, expected response tendencies are shown in brackets.

study design. Symptoms and diseases were represented by arbitrary 5-letter words in order to avoid any influence of participants' prior beliefs about symptom–disease relationships (this convention is commonly employed by cognitive learning researchers).

On each trial, participants were presented with symptoms and/or diagnosis advice as well as a set of four response options, in a manner like the following:

> *Symptom APPLE is present.*
>
> *Participant Hall says it is disease FROST.*
>
> *Which disease do you believe this indicates?*
>
> *FROST SKATE HOUSE WORLD*

Participants responded on each trial by typing the first letter of their choice on the keyboard. During the training phases (termed the early training phase and the late training phase, in line with Study 1), filler trials in which filler advisers gave incorrect suggestions were also employed. These trials were included in order to make the learning of advisers' names necessary to succeed at the task (if the advice was always correct, learning who provided accurate advice would be unnecessary). The advisers and symptoms presented in these filler trials were not included in the testing phase. As in the initial study, participants received corrective feedback for each response during the training trials, but the only feedback participants received on test trials was that the response had been recorded. The designs of the procedures are delineated in Tables 2 and 3 (see Appendix A for methodological details).

Results

On testing phase trials, two of the four response options had never been the correct answer in the context of the information presented (we termed these *irrelevant responses*). Of the remaining two responses (which we termed *relevant responses*), one was termed the *expected response* if blocking or highlighting occurred, and the remaining option was termed the *alternative response.*

In the absence of highlighting or blocking, the expected and alternative responses should be chosen with equal frequency. For this reason, we tested for highlighting and blocking effects through the weighted mean proportions of expected response choices. These proportions were calculated by subtracting the number of alternative responses from the number of expected responses and dividing the result by the total number of relevant responses (producing a scale of -1 to 1, an established convention for dealing with such data; see Kruschke et al., 2005). A mean proportion of expected responses significantly greater than zero constitutes evidence that the phenomenon of interest occurred (i.e., that participants chose the expected response significantly more frequently than the alternative response).

Blocking. If blocking occurred, the diagnosis suggested by the potentially blocked source of information (Cue F in the advice-dominant version; Participant 1 in the cue-dominant version) should have been selected significantly less frequently than the diagnosis suggested by the other source of information (Cue G or Participant 2, for the advice and cue-dominant versions, respectively). A *t* test on the mean proportion of expected responses showed no blocking effect (M = $-.05$, SD = .75), $t(116)$ =

Table 3
Study 2 Highlighting Design

Phase	Procedure			
	Cue-dominant		Advice-dominant	
Early training	$1_X2_X \rightarrow X$,		$BC \rightarrow X$	
Late training	$1_X2_X \rightarrow X$,	$A1_X \rightarrow Y$	$BC \rightarrow X$,	$B3_Y \rightarrow Y$
Testing	$A2_X$ (conflicting) $\rightarrow$? [Y]		$C3_Y$ (conflicting) $\rightarrow$? [Y]	

Note. Notation same as Table 2. Two sources were presented on each trial.

−0.72, $p = .48$, nor was there a difference by version (advice-dominant vs. cue-dominant; $t < 1$). To support the conclusion that this was indeed a lack of blocking and not simply a lack of learning, we needed to demonstrate that learning had indeed occurred. One way we assessed this was by confirming that the blocking information sources (Participant 5 and Cue A, in the advice-dominant and cue-dominant versions, respectively) were attended to more than (equally accurate) information sources introduced in the late training phase (Participant 9 and Cue C), because the blocking information sources appeared on many more trials. A t test showed that, as expected, participants chose the response suggested by the blocking source of information more often than chance ($M = .42$, $SD = .64$), $t(116) = 7.04$, $p < .001$.[1] A second manner of assessing learning was to examine how often participants selected one of the relevant responses (either the expected or alternative response) rather than either of the two irrelevant response options. A relevant response option was selected on 86% of the trials, which was significantly higher than chance (50%), $t(116) = 18.09$, $p < .001$. This indicates participants indeed learned the information. Taken together, these results suggest that despite learning the relevant information in the task, participants did not ignore a redundant source of information when it was paired with a different type of information source (i.e., advice vs. nonsocial cue). In other words, blocking did not occur in the context of diverse information sources.

Highlighting. Highlighting would be indicated if participants selected the disease suggested by the potentially highlighted information source (Participant 3 or Cue A, for the advice-dominant and cue-dominant versions, respectively) more frequently than the alternative information source (Cue C or Participant 2). A t test collapsing across condition showed that, as expected, participants selected the expected option more frequently than the alternative option ($M = .69$, $SD = .56$), $t(116) = 13.38$, $p < .001$. Although highlighting occurred in both conditions, an interesting finding emerged: There was a difference in degree of highlighting, $t(115) = 2.62$, $p < .05$, such that the highlighting effect was more extreme in the cue-dominant version of the highlighting procedure ($M = .80$, $SD = .48$) than in the advice-dominant version ($M = .59$, $SD = .62$). Taken together, these findings demonstrate that highlighting occurred in Study 2 both when advice was in the dominant role and when a nonsocial cue was in the dominant role. However, our results suggest that such effects were stronger in the latter case than in the former one.

Discussion

Study 2 examined how the combined presence of multiple types of information sources (i.e., nonsocial cues and advice) impacts the learning phenomena of highlighting and blocking. This experiment differed from Study 1, in which the only available information was advice from others. Because blocking depends on ignoring information seen as redundant, we anticipated that such effects might be weak or absent in this experiment, where different types of information sources were paired. We expected that highlighting effects, on the other hand, would occur in a manner similar to that found in the initial study.

Indeed, we did not find evidence of blocking. In this context of diverse types of information sources, concurring sources of information were not ignored as redundant; rather, attention was maintained toward both. Such a finding is unusual; blocking is considered to be a basic learning phenomenon and would be predicted by most cognitive models of learning (Kruschke, 2001a, 2001b; Rescorla & Wagner, 1972). Our results suggest that a context in which both advice and nonsocial cues are present leads people to learn about a new information source, even when the information it supplies indicates the same conclusion as a source already known to be accurate. Our result may parallel other findings regarding conditions in which blocking effects can be weak, for example, when people believe redundant information might be useful in the future or when they are instructed to learn about an environment without an explicit goal (Beckers, Miller, De Houwer, & Urushihara 2006; Bott, Hoffman, & Murphy, 2007; De Houwer et al., 2005; Hardt et al., 2009). Our result also resonates with those of Asch (1951) and Harkins and Petty (1981), who have shown that people attend to diverse information sources even when they corroborate information that is already available. However, because blocking is typically found in cue learning paradigms, it was important to replicate our findings for the blocking procedure.

One unexpected finding in Study 2 was that highlighting was stronger when a nonsocial cue was in the dominant position than when advice was in the dominant position. This result could suggest that when advice and experience conflict, people may give more attention to information they interpret themselves (Soll & Larrick, 2009). However, because this difference in strength of highlighting was not specifically predicted, it warranted replication as well.

The disease paradigm was both a strength and a weakness of Study 2. One strength is that it was modeled after a paradigm in which Kruschke and colleagues have consistently found blocking (e.g., Kruschke, 2001a; Kruschke et al., 2005). Our finding that traditional blocking effects were not obtained with this paradigm gives weight to our conclusion that the two types of information sources we included (advice and nonsocial cues) are the reason redundant information was not ignored.

However, one possible weakness of Study 2 is that the learning required to successfully utilize the nonsocial cues and the advice was somewhat unique to each case. In the case of nonsocial cues, participants had to learn which disease the symptom indicated (a cue–response association, as in previous research on the EXIT model). In the case of advice, however, participants had to learn which previous participants were reliable sources of information and which were not (the learning of source accuracy, as in Study 1). Thus, the learning task with advice was one of associating accuracy with a name, whereas that with nonsocial cues was one of associating a word (a symptom) with a particular response (a disease). As a result, one could argue that it is unclear whether the

[1] This was the only test on which an order effect was obtained. The learning effect here was stronger when the blocking procedure was performed second ($M = .53$, $SD = .62$) rather than first ($M = .30$, $SD = .65$), $t(115) = 1.99$, $p < .05$; however, in both conditions the results were significantly greater than zero (ts > 3, ps < .005). This finding implies that participants in both order conditions were sensitive to the number of times a source of information was accurate in the blocking procedure, but that this sensitivity was greater when blocking appeared after the highlighting procedure. Despite the order effect, it is clear that participants in both order conditions indeed learned the information, which was the primary goal of this analysis.

type of information (nonsocial cues vs. advice) or the type of learning (cue–response associations or advice accuracy) best explains our unique results in Study 2.

With these considerations in mind, we designed a third study in which the participants relied upon advice and nonsocial cues (both of which varied in their accuracy) in order to correctly guess targets' political affiliations. In addition to providing an opportunity to replicate our Study 2 findings and address that study's limitations, this third study allowed us to investigate the phenomena of interest in the context of an even more realistic, interpersonal judgment: perceived political party affiliation.

Study 3: Learning the Accuracy of Advisers and Nonsocial Cues Over Time

Unlike the first two studies (in which the learning of accuracy was necessary only for social sources of advice and not for the nonsocial cues), Study 3 employed a paradigm that required participants to learn the accuracy both of advice sources and of nonsocial cues in order to make correct decisions. Our primary goal in this experiment was to replicate our Study 2 findings using an approach that disentangled the type of information source (advice vs. nonsocial cues) from the type of learning (accuracy vs. cue–response associations). We were also interested in whether our unanticipated Study 2 finding of the differential strength of highlighting effects by dominance condition (advice-dominant or cue-dominant) would replicate.

In this experiment, we utilized highlighting and blocking procedures analogous to those employed in Study 2 (cue-dominant blocking and highlighting and advice-dominant blocking and highlighting). As in Study 2, participants were assigned to one of the two information-dominance conditions, and the associated highlighting and blocking procedures were completed in counterbalanced order. On each trial, participants guessed the political party affiliation (Republican or Democrat) of targets based on political stances (nonsocial cues) and party affiliation choices made by fictitious previous participants (advice). Nonsocial cues were political stances that have strong cultural associations with particular political parties (e.g., "pro gun control," "pro small government"). Employing such information allowed us to vary the accuracy of nonsocial cues as well as the accuracy of advisers. For advice, accuracy entailed the correctness of the party affiliation suggested by the advisers. For nonsocial cues, accuracy entailed whether participants' preexisting associations between political stances and party affiliations (e.g., "pro small government" → Republican) would lead to correct decisions.

Method

Participants and general procedure. Participants were 77 Indiana University psychology students (40 female, 37 male) who received partial course credit for participation. The general procedure was essentially the same as that used in Study 2, except that participants had only two response options (Democrat or Republican).

On each trial, participants received nonsocial cues about a target person's stance on either one or two political issues (e.g., "This person is pro life") and/or advice from one or two fictitious previous participants (e.g., "Participant Ellis says this person is a Republican"). Participants guessed the political affiliation of each target person only once. In Study 3, both nonsocial sources and advice varied in accuracy; therefore, misleading information of both types was included in the experimental design (i.e., if all advice and cues were accurate, learning of accuracy would be rendered unnecessary). We delineate the design of the four versions of the procedure in Tables 4 and 5 (see Appendix B for complete methodological details). In addition, in Study 3 we measured learning of inaccurate as well as accurate cues and advisers.

Results

In Study 3, participants had only two response options (Democrat or Republican). Blocking and highlighting effects were thus assessed by calculating the proportion of expected response choices compared to selections of the alternative response, producing a 0 to 1 scale. A proportion of expected responses that is significantly greater than .5 constitutes evidence that the learning phenomenon of interest (i.e., blocking or highlighting) occurred.

Blocking. If blocking occurred, the potentially blocked sources of information (Cues G and I or Participants 1 and 3, for the advice-dominant and the cue-dominant versions of the procedure, respectively) should have been learned less well than other sources of information presented equally often (Cues H and J or

Table 4
Study 3 Blocking Design

Phase	Procedure			
	Cue-dominant		Advice-dominant	
Early training	$A_{(X)} \rightarrow X$, $D_{(X)} \rightarrow Y$,	$B_{(Y)} \rightarrow Y$ $E_{(Y)} \rightarrow X$	$5_X \rightarrow X$, $7_X \rightarrow Y$,	$6_Y \rightarrow Y$ $8_Y \rightarrow X$
Late training	$A_{(X)}1_X \rightarrow X$, $D_{(X)}3_X \rightarrow Y$,	$C_{(Y)}2_Y \rightarrow Y$ $F_{(Y)}4_Y \rightarrow X$	$G_{(X)}5_X \rightarrow X$, $I_{(X)}7_X \rightarrow Y$,	$H_{(Y)}9_Y \rightarrow Y$ $J_{(Y)}10_Y \rightarrow X$
Testing	$1_X2_Y \rightarrow ?$ [Y], $A_{(X)}C_{(Y)} \rightarrow ?$ [X],	$3_X4_Y \rightarrow ?$ [X] $D_{(X)}F_{(Y)} \rightarrow ?$ [Y]	$G_{(X)}H_{(Y)} \rightarrow ?$ [Y], $5_X9_Y \rightarrow ?$ [X],	$I_{(X)}J_{(Y)} \rightarrow ?$ [X] $7_X10_Y \rightarrow ?$ [Y]

Note. Each cell indicates $\text{source}_{\text{advice}} \rightarrow \text{outcome}$. Letter sources signify nonsocial cues. Number sources signify advisers. Parenthesized responses were implied by existing issue position–party affiliation associations. Nonparenthesized advice was explicitly suggested. Either one or two sources of information were presented on each trial. For the testing phase, expected response tendencies are shown in brackets.

Table 5
Study 3 Highlighting Design

	Procedure			
Phase	Cue-dominant		Advice-dominant	
Early training	$1_X 2_X \rightarrow X$,	$3_X 4_X \rightarrow Y$	$E_{(X)} F_{(X)} \rightarrow X$,	$C_{(X)} D_{(X)} \rightarrow Y$
Late training	$1_X 2_X \rightarrow X$,	$A_{(Y)} 1_X \rightarrow Y$	$E_{(X)} F_{(X)} \rightarrow X$,	$E_{(X)} 5_Y \rightarrow Y$
	$3_X 4_X \rightarrow Y$,	$B_{(Y)} 3_X \rightarrow X$	$C_{(X)} D_{(X)} \rightarrow Y$,	$C_{(X)} 6_Y \rightarrow X$
Testing	$A_{(Y)} 2_X \rightarrow$? [Y],	$B_{(Y)} 4_X \rightarrow$? [X]	$F_{(X)} 5_Y \rightarrow$? [Y],	$D_{(X)} 6_Y \rightarrow$? [X]

Note. Notation the same as Table 4.

Participants 2 and 4, for advice-dominant and cue-dominant versions, respectively). We hypothesized that Study 3 would replicate our Study 2 finding that in the presence of both advice and nonsocial cues, blocking would not occur. A one-sample t test, collapsed across dominance condition (advice-dominant, cue-dominant) did not indicate blocking ($M = .51$, $SD = .26$), $t < 1$, $p = .68$. Again, there was no difference by version, advice dominant ($M = .47$, $SD = .28$) versus cue dominant ($M = .55$, $SD = .23$), $t(75) = 1.42$, $p = .16$.

To rule out the potential alternative explanation that our lack of a blocking effect was actually a lack of learning, we needed to confirm that the blocking information sources (Participants 5 and 7 or Cues A and D, for the advice-dominant and cue-dominant versions, respectively) were attended to more than sources of information introduced later (Participants 9 and 10 or Cues C and F). A one-sample t test, collapsed across dominance condition (advice-dominant, cue-dominant), showed that participants did indeed choose the response suggested by the blocking information source more frequently than would be expected by chance, ($M = .59$, $SD = .27$), $t(76) = 2.90$, $p < .01$.

We also wanted to demonstrate that the failure to obtain blocking could not be explained by a general failure to encode source accuracy. For this reason, we also tested responses for trials in which each information source (each nonsocial cue and each adviser) was presented alone (not shown in Table 4 but described in Appendix B). For all but one of the information sources, participants indeed learned the accuracy of the information (ts > 2.4, ps < .02).[2] Overall, our results provide further support for the notion that traditional blocking effects do not occur in the context of diverse types of information sources and that a lack of learning does not constitute a viable alternative explanation for our finding that blocking did not occur.

Highlighting. If highlighting occurred, the response suggested by the potentially highlighted source of information (Participants 5 and 6 or Cues A and B, for the advice-dominant and cue-dominant versions, respectively) should have been selected more frequently than would be expected by chance. A t test collapsing over dominance condition showed that, as expected, participants tended to choose the response indicated by the potentially highlighted information source ($M = .84$, $SD = .22$), $t(77) = 14.03$, $p < .0001$.[3] Study 3 produced no significant higher order effect by dominance condition. That is, our unanticipated Study 2 finding that the difference in degree of highlighting varied as a function of which type of information (advice, nonsocial cue) was dominant was not replicated in Study 3.

Discussion

The results of Study 3 replicated all of the major findings of Study 2, in that highlighting occurred as expected and blocking did not. Thus, in our adapted paradigm, participants learned to pay extra attention to sources of information that changed learned meanings of information (i.e., highlighting), but they did not ignore redundant information (i.e., blocking). In Study 3, unlike in Study 2, type of information source (social advice vs. nonsocial cues) was not confounded with type of learning (source accuracy vs. cue–response associations), because encoding of accuracy was necessary for both types of information sources. The fact that blocking occurred in Study 1 but not in Studies 2 or 3 provides further support for the notion that the diversity of information source types (concurrently available social advice and nonsocial cues) constitutes a unique learning context. Although attentional learning processes seem to operate with multiple types of information sources (attentional highlighting occurs and learning of source accuracy takes place), the associated processes seem more complex, such that when information from different types of sources agrees it is not ignored as redundant.

General Discussion

In this work we have demonstrated the utility of integrating cognitive models and social psychological theory for providing a deeper understanding of decision making. Our investigation was spurred by the observation that people often use social sources of information (suggestions from others) in conjunction with direct cues from their environment in making decisions. We first examined a situation in which only social sources of advice were available. Study 1 showed that when people learn which social sources are reliable over multiple trials, patterns of learning (i.e., blocking and highlighting effects) occur that are similar to those

[2] The one exception was the incorrect blocked source of information in the advice-dominant blocking procedure, for which the test was in the expected direction but did not reach traditional significance thresholds ($M = .61$, $SD = .41$), $t(36) = 1.7$, $p < .10$.

[3] We obtained a significant higher order interaction by participant gender. Male participants ($M = .79$, $SD = .22$) showed the highlighting effect less strongly than did female participants ($M = .90$, $SD = .20$), $t(75) = 2.25$, $p < .05$. However, highlighting effects were significant within each gender (ts > 7, ps < 0.001), and thus the gender interaction does not affect our general conclusions.

found with associative learning of nonsocial cues (e.g., Kruschke et al., 2005). It appears that when either type of information is learned in isolation (as in the traditional cue learning literature and the advice learning paradigm employed in Study 1), the cognitive learning phenomena of blocking and highlighting occur as usual.

Our results also show that when advice and nonsocial cues must be integrated (as in Study 2 and Study 3), a unique context arises in which learning proceeds differently. Attentional highlighting occurs as predicted based on the cue learning literature, but blocking does not. In this context of both social and nonsocial cues, which we propose often occurs in everyday experience, redundant information is learned rather than ignored. We suggest that this occurs because mutually supportive information from different types of sources is treated as confirmatory rather than as redundant. Moreover, the generality of our findings is supported by the three different paradigms and cover stories employed (stock choices, disease diagnoses, and political affiliation predictions).

Relevance of Cognitive Learning Models for the Use of Advice

This research greatly benefitted from the foundation of work on cognitive learning models. Social psychological research does not usually focus on learning over time, typically focusing instead on how people respond to particular situations. By adapting a traditional cue–outcome association paradigm (in which people learn which cues predict which outcomes) to the context of advice (in which people learn which source's suggestions are reliable), we were able to show that the learning of social source reliability occurs in an analogous manner to the process of associating cues and responses. Most notably, all three studies reported here reliably found attentional highlighting of social advice, a signature prediction of the EXIT model of attentional learning (Kruschke, 2001a, 2001b). In addition, we showed that highlighting occurs even when social advice and nonsocial cues are encountered in combination (as they often are in daily life). As a result, this work demonstrates that principles and methods of associative cue learning are highly relevant for understanding how we learn to use information obtained from others. We argue that the wealth of theory and research in this literature might be used to extend and inform our understanding of how people navigate socially available information to accomplish their goals.

To our knowledge, highlighting has not previously been investigated in social psychology. Our results suggest that this phenomenon is relevant to social psychological processes, and we believe that it may be common in social contexts. For example, consider our initial example of the stock investor. Imagine that you have learned in your investment quest that Adviser Adams makes accurate stock predictions. However, you begin to notice that in the few cases in which Adviser Brown disagrees with Adams, Brown is usually right. The additional cue of Brown as a source is highlighted, and this adviser's recommendation is given particular attention because it changes the meaning of a learned rule (i.e., "Adams is correct . . . except when Brown disagrees"). As a result, Brown will be given more attention than other advisers who are equally (or even more) frequently accurate. This social highlighting effect should have implications for many areas in which people are influenced by social sources, such as conformity, persuasion, or gossip (Mason et al., 2007).

Potential for Social Psychological Insights Into Cognitive Learning Processes

This work demonstrates how the social context can inform our understanding of cognitive learning processes. When social advice was presented alone (in Study 1), learning essentially replicated what has been shown for nonsocial cues. However, when nonsocial cues and social advice were encountered together, learning deviated from established models in that blocking did not occur. From the perspective of traditional attentional learning models, the lack of blocking in this context provides a novel and intriguing insight: People do not regard information as redundant when it originates from a different type of information source than that first learned (social advice vs. a nonsocial cue). Rather than ignore a redundant piece of information (as occurs when either advice or nonsocial cues are encountered alone), it appears, people continue to attend to such information when it comes from a new kind of source. The evidence from these three studies suggests that it is specifically the diversity of information sources that is responsible for the lack of blocking effects, because blocking occurs as usual when information was received from one source type in isolation (i.e., social advice alone, as in Study 1; or nonsocial cues alone, as in the extant cue learning literature). This context of diverse information sources meaningfully expands our knowledge of circumstances under which blocking fails to occur (see Bott et al., 2007; De Houwer et al., 2005; Hardt et al., 2009).

Implications for Social Psychological Theory

Our findings also have important implications for social psychology. The lack of blocking in Studies 2 and 3 suggests that when our experience and the opinions of others agree, the information may be especially compelling (Asch, 1951; Laughlin & Ellis, 1986). Certain social influence work can potentially be reconceptualized as an examination of how people deal with the combination of direct nonsocial information and social information. For example, Hutchins (1991), Smith and Collins (2009), and others have considered situations in which people's own interpretations of a situation (based on direct experience) may be supported or contradicted by information conveyed by others. Rather than ignoring one source of information as redundant, people may conclude that a learned outcome becomes particularly compelling when the two types of sources agree. Further investigation in this arena can look at additional consequences of the postulated mutually supportive role of social advice and direct (nonsocial) information. For example, such work could examine whether a combination of concurring social and nonsocial sources uniquely increases people's judgmental confidence in what those sources suggest.

At the more concrete end of the spectrum, many areas of research can benefit from the knowledge that human attention and learning function differently when both advice and nonsocial information are available. The conclusion that information received from diverse sources is especially compelling dovetails well with the implications of persuasion research, which has demonstrated an increase in participant attention to persuasive messages from diverse social sources (Harkins & Petty, 1981, 1987), and recent cognitive learning research that has shown circumstances in which blocking fails to occur in humans (Bott et al., 2007; Hardt et al., 2009). Theories in both of these areas have favored an information utility explanation, which is compatible with our conclusions. Still, significant questions remain to be explored, such as the potential importance of perceived information utility as a motivator for people.

At the most practical level, our results suggest that information will have greater impact if a diversity of source types (e.g., social and nonsocial) is employed. In the case of a single type of source, information that corroborates existing knowledge may be considered redundant and thus may be ignored (i.e., blocking may occur). However, blocking can be avoided by the employment of multiple information types (i.e., social and nonsocial sources). Moreover, our obtained highlighting effects imply that either social or nonsocial sources of information will be especially influential if their presence suggests a change in meaning (or degree of accuracy) of a known source of information. Future research can also examine broader questions raised by these findings. For example, how do our perceptions of sources' motives (e.g., to help, to mislead) influence learning processes? How might the confidence of social sources influence the manner in which they are encoded as reliable? What factors influence the degree to which people will attend to social sources versus their own direct experience? How might such cognitive learning processes interface with known social psychological phenomena (e.g., stereotyping and prejudice, social comparison, norm formation)?

Conclusion

Folk wisdom tells us "seeing is believing," but as we make our way through the world there is a great deal that we cannot see or see clearly. Social sources often provide a bridge between our minds and the knowledge we seek to obtain. However, very little existing research addresses the process by which we come to believe (or disbelieve) the information obtained from other people. By adapting cognitive learning research paradigms to a social context, we have begun to demonstrate how the learning of such information is both similar to and different from simple cue association learning. However, we have also provided evidence that the social context is unique and that cognitive learning models, although useful, must be expanded to account for the additional complexity brought about when these models are applied to the social world.

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Appendix A

Details of Study 2 Method

Study 2 included two versions of the blocking and highlighting procedures (a cue-dominant version and an advice-dominant version of each). Participants completed either the cue-dominant or the advice-dominant version of the two procedures. As in Study 1, each procedure occurred in three phases: early training, late training, and testing. Tables 2 and 3 illustrate the general study design of each version.

Cue-Dominant Blocking Procedure

In the early training phase of the cue-dominant blocking procedure (eight trials), participants learned the meaning of two nonsocial cues (Cue A and Cue B; see Table 2). The critical knowledge was which response Cue A indicated. Participants were presented a single nonsocial cue on each trial and selected a response. To ensure learning, we repeated these trials until participants correctly responded to 15 out of 16 trials over two consecutive sets (not including the initial set).

On each late training phase (16 trials) participants received corroborating information from a nonsocial cue and an adviser. On four of these trials, a known nonsocial cue (Cue A, the potentially blocking source of information) was paired with a novel adviser (Participant 1, the potentially blocked source of information), who suggested the disease that had already been associated with Cue A. Participant 1's advice was redundant, given the learned association. Three other trial types were presented in this phase (four of each). One of these paired a novel cue (Cue C) with a (novel) accurate adviser (Participant 2_Y). The other two trial types paired a novel cue (either Cue D or Cue E) with an inaccurate adviser (Participant 3_X or Participant 4_Y). This phase continued as in the early phase to ensure learning.

In the testing phase, eight trials presented the potentially blocked adviser (Participant 1) in conflict with another adviser of equal accuracy and frequency (Participant 2; i.e., 1_X2_Y). These trials were intended to assess whether blocking had occurred. Blocking would be indicated by a tendency to rely upon Participant 2 over Participant 1. In the remaining eight testing trials, the potentially blocking source of information learned in the early training phase (Cue A) conflicted with another known accurate source of information presented in the late training phase (Cue C). These trials were intended to assess whether participants learned Cue A as a reliable cue (a necessary precondition for blocking) and were sensitive to the frequency with which sources of information indicated correct responses. Interspersed were 16 late phase trials.

Advice-Dominant Blocking Procedure

In the early training phase of the advice-dominant blocking procedure (16 trials; see Table 2), participants were presented with a single adviser recommendation at a time. In this phase, they learned that two advisers provided accurate predictions (Participant 5_X and Participant 6_Y) and that two other advisers provided inaccurate predictions (Participant 7_X and Participant 8_Y). The critical knowledge was that Participant 5_X always suggested the correct response. To ensure learning, we repeated this phase until participants correctly responded to 15 of 16 trials in two consecutive sets (not including the initial set).

(*Appendices continue*)

On each late training trial (16 trials), participants were presented a cue together with advice from a previous participant. On four trials an adviser known to be accurate (Participant 5_X, the potentially blocking cue) continued to be accurate when presented alongside a novel cue (Cue F, the potential blocking cue). On another four trials a novel accurate adviser (Participant 9) was paired with a novel cue (Cue G). On the remaining eight trials a novel inaccurate adviser (Participant 7 or 10) was paired with a novel cue (Cue H or I). The late training phase trials were repeated in the same manner employed for the early training phase to ensure learning.

In the testing phase trials, participants were presented either with two conflicting cues (Cue F and Cue G) or with two conflicting advisers (Participant 5 and Participant 9) at a time. In eight trials meant to assess whether blocking had occurred, the potentially blocked nonsocial cue (Cue F) and an equally frequently presented nonsocial cue (Cue G) were presented (in conflict). Blocking would be indicated by a tendency to select the response associated with Cue G more often than the response associated with Cue F. The other eight test trials, meant to demonstrate that participants learned the potential blocking source of information (Participant 5_X), paired this adviser with an accurate adviser who was encountered later in the experiment (Participant 9_Z) but who appeared on fewer trials. Interspersed were 16 late phase trials.

Cue-Dominant Highlighting Procedure

The early training phase of the cue-dominant highlighting procedure (four trials; see Table 3) presented two paired advisers (Participants 1_X and 2_X) who agreed upon the correct response. To ensure learning, we repeated trials in this phase until participants correctly responded to 11 of 12 trials in three consecutive sets (not including the initial set).

In the late training phase (32 trials), 16 early training phase trials were presented as fillers, interspersed with 16 novel trials. On these novel trials, an adviser known to be accurate (Participant 1_X) was presented in conflict with a novel nonsocial cue (Cue A, the potentially highlighted cue). On these trials the correct response was novel, not what was suggested by the known adviser (a necessary precondition for highlighting to occur). Thus, the presence of a novel nonsocial cue changed the accuracy of the known adviser.

In the testing phase (eight trials), the potentially highlighted nonsocial cue (Cue A) and an adviser who was accurate on more trials (Participant 2) were presented in conflict (i.e., $A2_X$). These trials were meant to assess whether highlighting had occurred. Highlighting would be indicated by a tendency to rely upon Cue A over Participant 2. Interspersed were 12 earlier phase training trials.

Advice-Dominant Highlighting Procedure

The early training phase of the advice-dominant highlighting procedure (see Table 3) consisted of four trials in which participants learned to associate two nonsocial cues (Cue B and Cue C) with a particular disease diagnosis. This phase was repeated until participants correctly responded to 11 of 12 trials in three consecutive sets (not including the initial set).

In the late training phase (32 trials), 16 trials continued from the early training phase as filler trials. The other 16 trials presented a known nonsocial cue (Cue B) in conflict with a novel adviser (Participant 3_Y, the potentially highlighted source of information). In these trials the novel adviser indicated the correct response. Thus, the presence of a novel adviser changed the associated meaning of a learned nonsocial cue.

The testing phase (eight trials) was composed of eight trials on which the potentially highlighted adviser (Participant 3_Y) conflicted with a nonsocial cue learned to be accurate on more trials (Cue C). These trials were meant to test for highlighting. Highlighting would be indicated if the potentially highlighted source of information was selected more often than would be expected by chance. Interspersed were 12 earlier phase training trials.

Appendix B

Details of Study 3 Method

Study 3 included two versions of the blocking and highlighting procedures (a cue-dominant version and an advice-dominant version of each). As in Study 2, participants completed either the cue-dominant or the advice-dominant version of the two procedures.

Cue-Dominant Blocking Procedure

The early training phase (16 trials; see Table 4) of the cue-dominant blocking procedure allowed participants to learn the accuracy of four nonsocial cues in predicting party affiliations: Cues $A_{(X)}$, $B_{(Y)}$, $D_{(X)}$, $E_{(Y)}$. The critical knowledge was that $A_{(X)}$ was a correct cue and $D_{(X)}$ was an incorrect one. In two sets of four trials, an issue stance—Cue $A_{(X)}$, the accurate potential blocking cue; or Cue $B_{(Y)}$ —was learned to be accurate (i.e., the culturally associated party affiliation was the correct one; e.g., pro-choice → Democrat). In the other two sets of four trials, an issue stance—Cue $D_{(X)}$, the inaccurate potential blocking cue; or Cue $E_{(Y)}$—was learned to be inaccurate (i.e., the culturally associated party affiliation was not the correct one; e.g., “pro-social services” → Republican). To ensure learning, we repeated trials from this phase until participants correctly responded to 31 of 32 trials in two consecutive sets (not including the initial set).

(*Appendices continue*)

On each late training trial (16 trials), a nonsocial cue (issue stance) and an adviser's recommendation (i.e., a previous participant's recommended response) were presented together. The two potential blocking nonsocial cues, Cue $A_{(X)}$ and Cue $D_{(X)}$, from the early training phase were each paired with novel adviser (the potentially blocked sources of information: Participant 1_X and Participant 3_X). On these trials the former participants' suggestions were redundant, given the previously learned information about the cues. This phase also included trials in which a novel nonsocial cue was paired with a novel adviser. One of these pairs—Cue $C_{(Y)}$ and Participant 2_Y—always agreed in suggesting the correct response. The other pair—Cue $F_{(Y)}$ and Participant 4_Y—always agreed in suggesting the incorrect response. Late training phase trials were repeated as in the early phase to ensure learning.

In the testing phase (64 trials), 16 novel trials were employed to assess blocking. In these trials, one of the potentially blocked advisers (Participant 1_X or Participant 3_X) was presented in conflict with an adviser who had been accurate with equal frequency (Participant 2_Y or Participant 4_Y). Selection of the blocked adviser less often than would be expected by chance would indicate that blocking had occurred. To ensure that learning of the blocking information sources had occurred, 16 trials presented one of the nonsocial blocking cues, Cue $A_{(X)}$ or $D_{(X)}$, in conflict with a nonsocial cue introduced in the late training phase, Cue $C_{(Y)}$ or Cue $F_{(Y)}$. Finally, to test whether people learned which sources of information suggested the correct response option and which suggested the incorrect response option, we presented 32 trials in which each of the eight sources of information was presented alone (in four trials each). Interspersed with these testing trials were 16 late phase training trials, four of each type.

Advice-Dominant Blocking Procedure

The early training phase of the advice-dominant blocking procedure (16 trials; see Table 4) led participants to learn that two advisers (Participant 5_X, the accurate potential blocking adviser; and Participant 6_Y) always suggested the correct response and that two advisers (Participant 7_X, the potential inaccurate blocking adviser; and Participant 8_Y) always suggested the incorrect response. The critical knowledge was that Participant 5_X was always correct and that Participant 7_X was always incorrect. The trials from this phase were repeated until participants correctly responded to 31 of 32 trials in two consecutive sets (not including the initial set).

In the late training phase (16 trials), participants received both advice and a nonsocial cue. On eight of these trials, the two known advisers (Participant 5_X and Participant 7_X) were each paired with a novel nonsocial cue, the potentially blocked sources of information Cue $G_{(X)}$ and Cue $I_{(X)}$. These trials allowed participants to learn the accuracy of the cues but did not require this knowledge, as the previously learned former participant supplied all the information needed for an accurate response. In addition, this phase included eight trials on which a novel nonsocial cue was paired with a novel adviser. One of these pairs (Cue $H_{(Y)}$ and Participant 9_Y) always agreed in suggesting the correct response. The other pair (Cue $J_{(Y)}$ and Participant 10_Y) always agreed in suggesting the incorrect response. Late learning phase trials continued as in the early phase to ensure learning.

In the testing phase (64 trials), blocking was assessed by 16 trials in which one of the potentially blocked nonsocial cues, Cue $G_{(X)}$ or Cue $I_{(X)}$, was presented in conflict with a nonsocial cue that had been correct with equal frequency, Cue $H_{(Y)}$ or Cue $J_{(Y)}$. Blocking would be indicated if participants followed the blocked cue less often than would be expected by chance. To ensure that the blocking advisers (Participant 5_X and Participant 7_X) were learned better than advisers encountered less often, 16 trials presented blocking advisers in conflict with advisers introduced in the late training phase (9_Y and 10_Y). Finally, to test whether people learned which advisers suggested the correct response option and which ones suggested the incorrect response option, we presented 32 trials in which each of the eight advisers was presented alone (each adviser was presented four times). Interspersed with these testing trials were 16 late phase training trials, four of each type.

Cue-Dominant Highlighting Procedure

The early training phase of the cue-dominant highlighting procedure (eight trials; see Table 5) allowed participants to learn that one pair of advisers (Participants 1_X and 2_X) always agreed in suggesting the correct response and that another pair of advisers (Participants 3_X and 4_X) always agreed in suggesting the incorrect response. To ensure learning, we continued this phase until participants provided correct responses on 15 out of 16 trials for two consecutive sets (not including the initial set).

In the late training phase (64 trials), 32 trials continued from the early testing phase as fillers. The remaining 32 trials presented a known adviser (Participant 1 or Participant 3) conflicting with a novel nonsocial cue; this was the potentially highlighted cue, Cue $A_{(Y)}$ or Cue $B_{(Y)}$. In both cases, the addition of the potentially highlighted cue changed the meaning of the known cue. On trials involving the known accurate adviser (Participant 1_X), it was the novel cue, $A_{(Y)}$, and not the known adviser that indicated the correct response. On trials involving the known inaccurate adviser (Participant 3_X), it was the adviser and not the novel nonsocial cue, $B_{(Y)}$, that indicated the correct response. Thus, the presence of a novel nonsocial cue changed the accuracy of a learned adviser.

In the testing phase (16 trials), each test trial presented conflicting recommendations from a potentially highlighted nonsocial cue, Cue $A_{(Y)}$ or Cue $B_{(Y)}$, and an adviser who had been learned on more trials (Participant 2_X or Participant 4_X). Highlighting would be indicated if participants selected the highlighted cue more often than would be expected by chance. Interspersed with these testing trials were 16 late phase training trials, four of each type.

Advice-Dominant Highlighting Procedure

The early training phase of the advice-dominant highlighting procedure (eight trials; see Table 5) allowed participants to learn that one pair of nonsocial cues, Cues $E_{(X)}$ and $F_{(X)}$, always agreed in suggesting the correct response, and another pair, Cues $C_{(X)}$ and $D_{(X)}$, always agreed in suggesting the incorrect response. This phase was repeated until participants responded correctly to 15 out of 16 trials on two consecutive sets (not including the initial set).

(*Appendices continue*)

In the late training phase (32 trials), 16 trials continued from the previous phase as fillers. On the remaining 16 trials, a known nonsocial cue, Cue $E_{(X)}$ or $C_{(X)}$, conflicted with a novel adviser's recommendation (the potentially highlighted information sources, Participant 5_Y or Participant 6_Y). On trials involving the known accurate nonsocial cue, Cue $E_{(X)}$, the novel advisor, Participant 5_Y, rather than the known cue, indicated the correct response. On trials involving the known inaccurate nonsocial cue, Cue $C_{(X)}$, the previously inaccurate cue rather than the novel adviser, Participant 6_Y, indicated the correct response. Thus, the presence of a novel nonsocial cue changed the accuracy of a learned adviser.

The testing phase (16 trials) included trials in which a potentially highlighted adviser, Participant 5_Y or Participant 6_Y, conflicted with a nonsocial cue that had been accurate more frequently, Cue $F_{(X)}$ or Cue $D_{(X)}$. Highlighting would be indicated if participants selected the highlighted adviser more often than would be expected by chance. Interspersed with these testing trials were 16 late phase training trials, four of each type.

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