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Cognitive changes from explanations

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When individuals detect that a description is inconsistent, theorists from William James onwards have argued that a cognitive change occurs: They modify the description in a minimal way to make it consistent. We present an alternative hypothesis: Reasoners create an explanation that resolves the inconsistency, and the explanation entails a revision or reinterpretation of the description. According to this *principle of resolution*, revision is consequent upon explanation. Hence, when individuals have such an explanation in mind, they should be faster than otherwise to modify assertions to make them consistent. Two experiments corroborated this prediction.

Keywords: Explanations; Inconsistency; Mental models; Minimalism; Reasoning.

Randall Dale Adams was convicted for murdering a police officer in 1977. The basis of the conviction came from eyewitness testimony that placed Adams at the scene of the crime. During the trial, Emily Miller, one of the key eyewitnesses, pointed to Adams and identified him as the killer: ''His hair is different, but that is the man.'' Miller also said that she had identified Adams in a police line-up, and Adams was sent to death row. When Errol Morris, a documentarian, examined the case years later, he discovered inconsistencies in Miller's testimony. One such point was that Adams's case file showed no record that Miller had identified him in a police line-up. Another was that, before she testified, she made a statement identifying the killer as Mexican or a light-skinned African American; but Adams was Caucasian. In 1989, after Adams had spent 12 years in prison, the Texas Court of Criminal Appeals overturned his conviction and released him, citing the key eyewitness's inconsistencies (Ex Parte Adams, 1989, p. 282–287).

Conflicts can change the way we think, and in so doing, they can save lives. New information can lead to explicit revisions of beliefs, and the most dramatic cases may be when an individual presumed to be guilty of murder is exonerated of the crime. The springboard for such changes is often an inconsistency between an existing set of propositions and a new and incontrovertible fact. Once individuals are aware of such an inconsistency, something normally has to change. But quite what happens is a fundamental mystery of higher cognition.

The resolution of inconsistencies is outside orthodox logic. Logic neither calls for inconsistent assertions to be abandoned, nor does it offer guidance on how to restore a set of propositions to consistency, i.e., the choice among several options for revision is arbitrary (see Jeffrey, 1981).

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In response to this limitation, researchers in artificial intelligence have proposed extensions of orthodox logic to handle inconsistencies (see Brewka, Dix, & Konolige, 1997, for a review). Psychological studies have approached the problem by observing how individuals revise propositions in order to restore consistency (e.g., Dieussaert, Schaeken, De Neys, & d'Ydewalle, 2000; Elio & Pelletier, 1997; Politzer & Carles, 2001; Rehder & Hastie, 1996; Revlis, Lipkin, & Hayes, 1971; Schlottmann & Anderson, 1995; see also Knauff, Bucher, Krumnack, & Nejasmic, 2013, who investigate how individuals modify beliefs about spatial positions of objects). But, no consensus exists about the underlying mental processes.

One of the earliest accounts of the resolution of inconsistencies is due to William James (1907, p. 59). He wrote: "[The new fact] preserves the older stock of truths with a minimum of modification, stretching them just enough to make them admit the novelty." Many theorists have echoed this view, emphasising minimal changes to sets of propositions (Gärdenfors, 1982, p. 136; Harman, 1986, p. 46; Levi, 1991; Quine, 1992, p. 14), and we refer to their collective view as *minimalism*. It implies that the primary goal in restoring consistency is change*:* individuals modify a set of propositions to make them consistent. To assess minimalist predictions, theorists have developed a measure of the amount of change, which in essence depends on counting all the propositions that change their truth values (Harman, 1986, p. 61). As Elio and Pelletier (1997, p. 426) wrote: "[O]ften this relies on counting the number of propositions whose truth values would change in one kind of revision versus another". One consequence, as these authors point out, is that a change to a categorical proposition is more minimal than a change to a generalisation. Once a generalisation is given up, inferences from it cannot occur, and so the overall number of changes is greater. We will come back to this point in the General Discussion.

Minimalism runs counter to the view that in everyday reasoning, the primary goal is usually not to reject information, but to understand why the inconsistency arose in the first place (Johnson-Laird, Girotto & Legrenzi, 2004; Khemlani & Johnson-Laird, 2011; Walsh & Johnson-Laird, 2009). The value of an explanation is that it can guide you to seek out new information or to act. For example, the Texas Court of Criminal Appeals determined that the explanation of Emily Miller's inconsistencies was that she was untrustworthy, and they found that the police had coached her to change her testimony.

The explanation of an inconsistency and the revision of the conflicting propositions are distinct mental processes in theory. Explanations call for new propositions about new entities, their interrelations, and their properties (Khemlani & Johnson-Laird, 2011). Revisions call for a choice of which of the conflicting propositions to change, and of how to modify them—the rejection of a proposition is, of course, equivalent to its negation. Explanations do not demand direct changes to inconsistent propositions. Indeed, recent studies show that individuals tend to not to notice an inconsistency when they have to explain what's going on (Khemlani & Johnson-Laird, 2012).

The mental model theory of reasoning posits that an explanation of a phenomenon is a causal model of the situation that gave rise to the phenomenon (Johnson-Laird, 2006). The *principle of resolution* postulates that when individuals detect an inconsistency among a set of propositions, their primary goal is to create an explanation of its origins. As a side effect, its implications may yield a reinterpretation of the propositions (Khemlani & Johnson-Laird, 2012). Revision is normally consequent upon explanation. The theory therefore predicts that when individuals have an explanation in mind, it should take less time for them to restore consistency to a set of inconsistent propositions. To test this prediction, participants in two experiments were asked to revise a set of inconsistent assertions before or after they had constructed an explanation for the inconsistency.

EXPERIMENT 1

When individuals have an explanation in mind, they should be faster than otherwise to revise assertions to make them consistent. Experiment 1 tested this prediction. Participants were presented with inconsistent descriptions such as:

> If graphite rods are inserted into a nuclear reactor, then its activity slows down.
>
> Graphite rods were inserted into this nuclear reactor but its activity did not slow down.

Their task was to revise the assertions by deciding which one was false, but they did so either before or after they had answered the question, "why not?", which elicited an explanation.

Method

Participants. Forty undergraduate students from Princeton University participated in exchange for partial course credit. None of the participants had received any training in logic.

Design. Participants were given six sets of inconsistent assertions (see the Appendix). All of the problems consisted of two assertions, a conditional generalisation (*If A then B*) that was inconsistent with a conjunction (*A, but not B*). Each set of assertions occurred twice in two separate blocks. Participants carried out an explanation task in one block, and a revision task in the other. Nineteen participants performed the revision task for the six problems followed by the explanation task of those same problems, and the remaining 21 participants carried out the two blocks in the opposite order. All of the trials had contents similar to the earlier example. The order of the problems was randomised within each block.

Procedure. The experiment was conducted in the laboratory using a computer interface written in C#. Participants interacted with the interface by typing on the keyboard and using a mouse to click buttons on the computer screen. To measure the time it took them to revise the assertions or to construct an explanation, they first read a scenario, and then pressed a button on the computer's keyboard as soon as they had finished reading it. This response started a timer, cleared the assertions from the screen, and made available a text box within which they typed their response. Latency was measured between their button click and their first keystroke, i.e., the time between when they stopped reading and started writing. This latency served as a proxy for the mental time it took to perform each task.

To cue whether the task was to generate an explanation or to revise the assertions, a coloured rectangular border appeared around the screen. In a training session of six trials, participants learned to associate the colour of the border with the experimental task: If the border was black, they provided an explanation, and if the border was red, they revised the assertions by typing out the assertion (the conditional or conjunction) that they judged to be false. During this training session, the experimenter answered the participants' questions and corrected their errors. The experimenter then left the room, and the participants carried out the experiment proper, which began (unbeknownst to the participants) with six practice trials that were omitted from the data analysis.

Results and discussion

Figure 1 presents the mean response latencies in seconds for the explanation task and the revision task. Overall, participants took longer to construct an explanation than to revise the assertions (14.97 s vs. 10.04 s), Wilcoxon test, $z = 3.98$, $p < .0001$, Cliff's $\delta = .45$. This effect was driven by the low latency of the revision task for the group that carried it out after they had created an explanation. There was no difference in latency between the group that carried out the revision task first and the group that carried out the explanation task first (11.9 s vs. 13.06 s), Mann-Whitney test, $z = 0.73$, $p = .46$, Cliff's $\delta = .14$. Participants' responses corroborated the principle of resolution, and the predicted interaction was significant. The group that initially constructed an explanation of the inconsistency was faster to revise the assertions than the group that initially carried out the revision task, Mann-Whitney test, $z = 2.42$, $p = .01$, Cliff's $\delta = .45$. The speed with which participants revised the inconsistent assertions in Experiment 1 therefore depended on whether or not they had already explained the

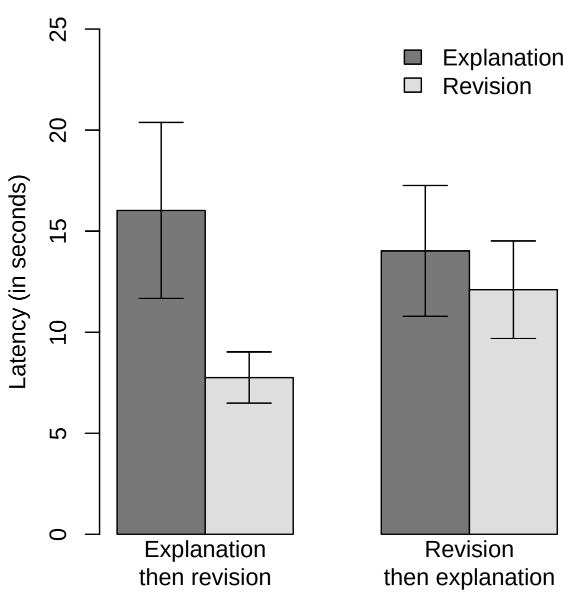

Figure 1. The mean response latency in seconds for the explanation task and the revision task in Experiment 1 depending on whether participants carried out the explanation task first or the revision task first.

inconsistency. This effect occurred despite the fact that the two tasks were in two separate blocks. In other words, for any given set of contents, several different trials intervened between the creation of an explanation of an inconsistency and the revision of the same contents. These intervening trials could have suppressed any residual effect of explanation on revision. Nevertheless, the effect occurred.

According to the principle of resolution, an explicit revision depends on the construction of an explanation. So, if reasoners have a putative explanation in mind after revising a set of assertions, then they should be faster to state the explanation than otherwise. As Figure 1 shows, the trend in the mean latencies was in accordance with the prediction, but the difference was not reliable (16.02 s vs. 14.02 s), Wilcoxon test, $z = 1.10$, $p = .27$, Cliff's $\delta = .20$. The participants may have construed their task as calling for novel explanations, i.e., one that they had no thought of before. In this case, the latencies should not differ reliably between the two conditions. The issue calls for further investigation.

The results support the prediction that explanations should make it easier to revise assertions. However, the results are open to two alternative explanations. First, participants could have been faster to revise the assertions after an explanation as a result of mere exposure to the assertions. In other words, the production of an explanation may have done nothing more than increase the activation of the concepts relevant to the revision, and this increase in activation may have sped up responses. Second, the explanation task could have demanded more cognitive resources than the revision task. Participants may have become aware of these task demands and therefore focused more resources on the interpretation of the assertions. Their subsequent faster revision could therefore have reflected, not the availability of an explanation, but this increase in cognitive resources. Experiment 2 accordingly tested both of these alternative explanations. It contrasted a different prior demanding task with the need to explain inconsistencies. It also presented the prior task on the same trial instead of in a separate block of trials.

EXPERIMENT 2

This experiment used the same set of inconsistencies as before, but the participants carried out three sorts of trial: (1) They created an explanation of an inconsistency and then revised the assertions, (2) they judged which of the two events was more surprising and then revised the assertions, and (3) they merely revised the assertions. We used judgements of surprise because they required the participants to think about both assertions, but without having to construct an explanation. A previous study showed that this task was of comparable difficulty to the creation of explanations (Khemlani & Johnson-Laird, 2012, Exp. 3).

Method

Participants. Nineteen undergraduates and residents of the Princeton University community participated in the experiment in exchange for course credit or monetary compensation. None of the participants had received any training in logic.

Design. Participants carried out 12 trials based on inconsistent assertions, such as:

> If someone is very kind then he or she is liked by others.
>
> Someone was very kind but was not liked by others.

As in the previous study, all the problems presented a conditional generalisation that was inconsistent with a conjunction (see the Appendix). For the four trials in which the participants judged surprise, they were told to decide which of two events in the assertions was more surprising and to type their response. Once they had responded, they carried out the revision task. For four trials in which they created an explanation, they typed their response to the question "Why not?" and then they carried out the revision task. For the four trials in which they carried out the revision task alone, as in the second part of the other trials, they typed whichever sentence they judged to be false. The three conditions were intermingled so that each participant received the problems in a different randomised order. Participants received each set of contents only once, and the contents were rotated over the three conditions so that each content occurred equally often in each condition in the experiment as a whole. The experiment was run face-to-face under computer control. The order of the problems was randomised within each block.

Procedure. The sequence of events in the three sorts of experimental trial is shown in Figure 2. As in the previous study, participants first read two inconsistent assertions on the screen and pressed a button to initiate the trial once they had read them. The screen contained a coloured border that acted as a nonverbal cue to the task participants needed to perform. When the border was red, participants revised the assertions by deciding which one of them was false; when it was black, they clicked a button to choose which of the two given events was more surprising, e.g., "someone was very kind" versus "someone was not liked by others"; and when it was blue, they typed out an explanation of the inconsistency. Once participants clicked the button to initiate the trial, a timer started, the assertions disappeared, and the screen changed to the appropriate task. The computer measured the latency between their first click and their first keystroke for the revision task only, i.e., the time between when they stopped reading and started writing out their decision about which assertion was false. This latency served as a proxy to the mental time it took to perform the revision task.

As in the previous study, participants received a training session in which they received six trials under the supervision of the experimenter. This procedure enabled the participants to learn the three tasks corresponding to the different coloured borders. During the training session, the experimenter answered questions and corrected any errors that the participants made. After the experimenter left the room, they received another six practice trials before the experiment proper.

Results and discussion

Figure 3 presents the mean response latencies in seconds for the revision task in each of the three conditions. Overall, participants were faster to revise assertions after they had constructed an explanation than after they had carried out a judgement of surprise (10.82 s vs. 14.52 s), Wilcoxon test, $z = 2.01$, $p = .044$, Cliff's $\delta = .27$. Likewise, they were faster to revise assertions after constructing explanations than in carrying out the revision task alone (10.82 s vs. 17.57 s), Wilcoxon test, $z = 3.20$, $p = .001$, Cliff's $\delta = .56$. These two analyses are not orthogonal; nevertheless, they provide a heuristic assessment of the latency data. The data are similar to the previous study in that a 7 s reduction in latency was observed when explanations were generated prior to the revision task relative to the control condition in each study. The reduction in latency was less than 4 s following the judgement of surprise.

The results corroborated the hypothesis that when individuals have an explanation in mind, they are faster to choose which assertions to revise. The results likewise ruled out the possibility that faster responses were a result of an increase in activation of the relevant concepts, because

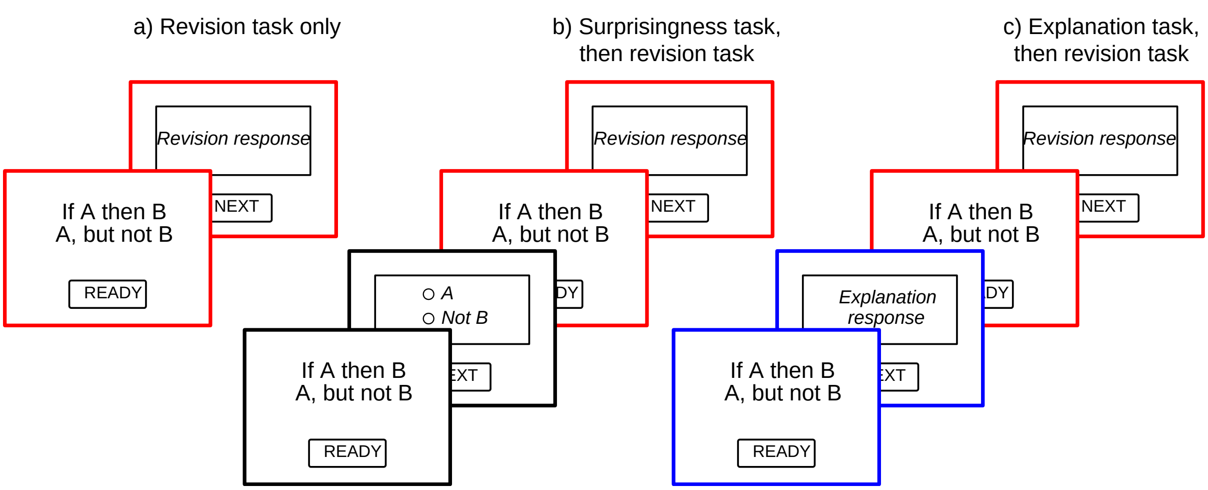

Figure 2. The sequence of events in Experiment 2. In each of the three different sorts of trial, participants saw two conflicting assertions, and clicked the button marked "Ready" once they had finished reading the assertions. In Condition (a), they typed a revision response in a box on the screen. In Condition (b), they chose which event was more surprising, and then revised the assertions. And in Condition (c), they explained the inconsistency and then revised the assertions.

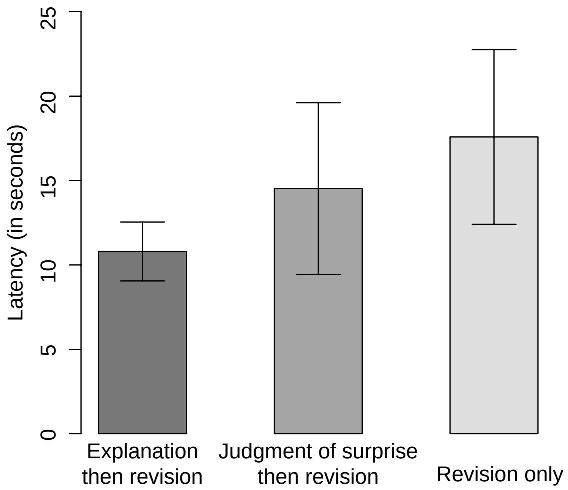

Figure 3. The mean response latency in seconds for the revision task in Experiment 2 depending on whether participants carried out the explanation task then the revision task, the judgement of surprise then the revision task, or only the revision task.

participants were faster to revise assertions after constructing an explanation than after making a judgement of surprise. However, the data do not rule out the possibility that tasks of comparable processing load can yield the same results, because a judgement of surprise led to a faster revision than in the control condition. In hindsight, this reduction in latency may have occurred because judgements of surprise cued participants to the assertion they should reject. Nevertheless, explanations yielded a reliably larger reduction in latency than judgements of surprise.

Could the participants have learned to anticipate the subsequent tasks on each trial? That is, they knew that the surprise task and the explanation task were going to be followed by the revision task, and so they developed anticipatory responses for the revision task. However, this account cannot explain why participants were faster to revise assertions after they constructed an explanation than after they made a judgement of surprise. Likewise, the account does not apply to the results of the previous study.

GENERAL DISCUSSION

The two experiments showed that when individuals have explained an inconsistency, they are faster to choose which assertion to abandon in order to restore consistency than when they have not made an explanation. Experiment 1 used separate blocks for the two sorts of trial in a counterbalanced order. Experiment 2 replicated the effect using randomly ordered trials and with the two tasks in the same trials. It contrasted explanation with a judgement of surprise and with a control trial. In both cases, the revision task called for the participants to decide which assertion in an inconsistent set was false. Hence, the results show that such decisions are not always independent of other processes. They can depend on an assessment of how surprising the events are, and to a greater degree on the creation of an explanation of the inconsistency.

Is there an alternative account of the phenomena? One possibility is that the creation of an explanation is bound to trigger a revision of the assertions, that is, revision is part of the process of explanation. Such a process is plausible in Experiment 2, because participants carried out both the explanation and the revision tasks on the same trials. But, this account cannot explain performance in Experiment 1: Participants had no knowledge of the order of the blocks, and they were unaware that they would see each set of contents twice in the study, so they could not anticipate that they would need to revise the inconsistency that they had explained.

Our results show that when you construct an explanation for an inconsistency, you are faster to revise the offending propositions. But, earlier results show that when you construct an explanation, you may have difficulty in detecting the inconsistency (Khemlani & Johnson-Laird, 2012). These two sets of results may themselves seem inconsistent. However, there is a simple resolution of the two sets of results. In the earlier experiments, the participants constructed explanations for both consistent and inconsistent sets of assertions, and then they responded to the question, "Can both of these statements be true at the same time?" The explanation can yield a reinterpretation of the assertions that makes it harder to detect an inconsistency. The present experiments also called for explanation, but it used only inconsistent sets of assertions, and the participants' task was to decide which one of them was false. It was therefore much harder for participants to lose track of the conflict.

In the past, theorists have argued that the way to cope with inconsistency is to revise the conflicting propositions, preferably as little as possible—a view that goes back to William James (1907). The principle of resolution controverts this hypothesis. The main psychological task is, not to restore consistency, but to make sense of the origins of the inconsistency. One reason for the importance of explanation is that it can help you to decide what to do. You believe that if you pick up the phone, then you'll hear the dial tone. You pick up the phone but the line is dead. You may know that the phone company's central system is plagued with problems. So, you explain the lack of a dial tone to such a problem, and so you decide to contact the phone company. Alternatively, you may know that there is a glitch in your home system, and that you can cure it by calling your home number on your mobile phone. So, you call home. A corollary is that causal explanations are more likely to be based on counterexamples to conditional generalisations, such as: "If you pick up the phone then you hear the dial tone", than on counterexamples to simple categorical assertions, such as: "Someone picked up the phone but did not hear the dial tone". The theory therefore predicts the same bias in the participants' actual choices of which assertion to abandon. In Experiment 1, the two tasks were in separate blocks, and so such residual effects did not occur. But, in Experiment 2, the percentages of revisions in which the participants rejected the conditional generalisation were as follows: 60% after they had carried out the surprise task, 70% for the revision task alone, and 83% after they had carried out the explanation task, Kendall's $W = .76$, $p < .002$ (see also Legrenzi & Johnson-Laird, 2005). These results are contrary to minimal revisions (see the introduction). They suggest that the evaluation of surprise leads individuals to think about other matters apart from the resolution of an inconsistency, whereas the creation of an explanation that resolves the inconsistency yields a causal alternative to the generalisation it contains.

Our studies are consistent with the hypothesis that when individuals create an explanation to resolve an inconsistency, they are likely to establish a model of the facts of the matter and of the original assertions (Khemlani & Johnson-Laird, 2011, 2012). They can then use the model to decide which of the assertions is false. In other words, when people have to revise inconsistent assertions, they are first likely to construct an explanation of the inconsistency. This explanation has the side effect of implying a change to the assertions. Without an explanation, however, individuals must generate one, which takes additional resources and time. This claim is, of course, the principle of resolution. Sometimes cognitive change is a by-product of a better understanding of the world.

REFERENCES

Brewka, G., Dix, J., & Konolige, K. (1997). *Nonmonotonic reasoning: An overview*. Stanford, CA: CLSI Publications, Stanford University.

Dieussaert, K., Schaeken, W., De Neys, W., & d'Ydewalle, G. (2000). Initial belief state as a predictor of belief revision. *Current Psychology of Cognition*, *19*, 277–288.

Elio, R., & Pelletier, F. J. (1997). Belief change as propositional update. *Cognitive Science*, *21*, 419–460.

Ex Parte Adams, 768 W.2d 281 (Tex. Cr. App. 1989).

Gärdenfors, P. (1982). Epistemic importance and minimal changes of belief. *Australasian Journal of Philosophy*, *62*, 136–157.

Harman, G. H. (1986). *Change in view: Principles of reasoning*. Bradford, MA: Bradford Books.

James, W. (1907). *Pragmatism—A new name for some old ways of thinking*. New York, NY: Longmans.

Jeffrey, R. (1981). *Formal logic: Its scope and limits*. New York, NY: McGraw Hill.

Johnson-Laird, P. N. (2006). *How we reason*. Oxford, UK: Oxford University Press.

Johnson-Laird, P. N., Girotto, V., & Legrenzi, P. (2004). Reasoning from inconsistency to consistency. *Psychological Review*, *111*, 640–661.

Khemlani, S., & Johnson-Laird, P. N. (2011). The need to explain. *Quarterly Journal of Experimental Psychology*, *64*, 2276–88.

Khemlani, S., & Johnson-Laird, P. N. (2012). Hidden conflicts: Explanations make inconsistencies harder to detect. *Acta Psychologica*, *139*, 486–491.

Knauff, M., Bucher, L., Krumnack, A., & Nejasmic, J. (2013). Spatial belief revision. *Journal of Cognitive Psychology*, Advance online publication. doi: 10.1080/20445911.2012.751910.

Legrenzi, P., & Johnson-Laird, P. N. (2005). The evaluation of diagnostic explanations for inconsistencies. *Psychologica Belgica*, *45*, 19–28.

Levi, I. (1991). *The fixation of belief and its undoing*. Cambridge, MA: Cambridge University Press.

Politzer, G., & Carles, L. (2001). Belief revision and uncertain reasoning. *Thinking and Reasoning*, *7*, 217–234.

Quine, W. V. O. (1992). *Pursuit of truth*. Cambridge, MA: Harvard University Press.

Rehder, B., & Hastie, R. (1996). The moderating influence and variability on belief revision. *Psychonomic Bulletin and Review*, *3*, 499–503.

Revlis, R., Lipkin, S. G., & Hayes, J. R. (1971). The importance of universal quantifiers in a hypothetical reasoning task. *Journal of Verbal Learning and Verbal Behavior*, *10*, 86–91.

Schlottmann, A., & Anderson, N. H. (1995). Belief revision in children: Serial judgment in social cognition and decision-making domains. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 1349–1364.

Walsh, C., & Johnson-Laird, P. N. (2009). Changing your mind. *Memory and Cognition*, *37*, 624–631.

APPENDIX

Materials in Experiments 1 and 2

Domain	*Conditional generalization*	*Inconsistent conjunction*
Biology/physiology	If a person is bitten by a viper then they die	Someone was bitten by a viper but did not die
Biology/physiology	If a person does regular aerobic exercises then that person strengthens his or her heart	Someone did regular aerobic exercises but did not strengthen his or her heart
Mechanical	If a car's engine is tuned in the special way then its fuel consumption goes down	This car's engine was tuned in the special way but its fuel consumption did not go down
Mechanical	If graphite rods are inserted into a nuclear reactor, then its activity slows down	Graphite rods were inserted into this nuclear reactor but its activity did not slow down
Mechanical	If the aperture on a camera is narrowed, then less light falls on the film	The aperture on this camera was narrowed but less light did not fall on the film
Mechanical	If a person pulls the trigger then the pistol fires	Someone pulled the trigger but the pistol did not fire
Natural	If a substance such as butter is heated then it melts	This piece of butter was heated but it did not melt
Natural	If these two substances come into contact with one another then there is an explosion	These two substances came into contact with one another but there was no explosion
Psychological	If someone is very kind then he or she is liked by others	Someone was very kind but was not liked by others
Psychological	If a person receives a heavy blow to the head then that person forgets some preceding events	Pat received a heavy blow to the head but did not forget any preceding events
Social/economical	If people make too much noise at a party then the neighbours complain	People made too much noise at a party but the neighbours did not complain
Social/economical	If the banks cut interest rates then the economy increases	The banks cut interest rates but the economy did not increase