Superfluous Neuroscience Information Makes Explanations of Psychological Phenomena More Appealing

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Abstract

■ Does the presence of irrelevant neuroscience information make explanations of psychological phenomena more appealing? Do fMRI pictures further increase that allure? To help answer these questions, 385 college students in four experiments read brief descriptions of psychological phenomena, each one accompanied by an explanation of varying quality (good vs. circular) and followed by superfluous information of various types. Ancillary measures assessed participants' analytical thinking, beliefs on dualism and free will, and admiration for different sciences. In Experiment 1, superfluous neuroscience information increased the judged quality of the argument for both good and bad explanations, whereas accompanying fMRI pictures had no impact above and beyond the neuroscience text, suggesting a bias that is conceptual rather than pictorial. Superfluous neuroscience information was more alluring than social science information (Experiment 2) and more alluring than information from prestigious "hard sciences" (Experiments 3 and 4). Analytical thinking did not protect against the neuroscience bias, nor did a belief in dualism or free will. We conclude that the "allure of neuroscience" bias is conceptual, specific to neuroscience, and not easily accounted for by the prestige of the discipline. It may stem from the lay belief that the brain is the best explanans for mental phenomena. ■

In 1995, a group of graduate students had just completed the 8th Cognitive Neuroscience Summer Institute at University of California, Davis, and thus, it was time to get one of the commemorative t-shirts. They read "Image is Everything," a double entendre linking a hot new methodology to an older adage about the importance of strategic self-presentation. Nonetheless, we suspect that in a broader sense the attendants to that Summer Institute wore the motto in all earnestness, awed at possibilities of the nascent field of neuroimaging. Twenty years later, it seems uncontroversial that neuroimaging has led to a redescription of mental processes in ways that have often enriched our understanding of the psychology. When done well, cognitive neuroscience provides additional explanatory power to the mechanisms that underlie psychological processes. Alas, cognitive neuroscience—like any science—is not always reported well. Sometimes, superfluous information is added that does not provide additional insight. In this study, we ask whether such superfluous neuroscience information increases the perceived quality of psychological explanations and begin to explore the possible mechanisms underlying this effect.

One possible reason why some neuroscience information may bias judgments is perceptual: The ease of processing of brain pictures might make the argument seem more compelling (*perceptual processing* hypothesis). Consistent with this view, perceptual qualities of brain pictures, such as their three dimensionality, tend to increase the perceived scientific quality of the accompanying text (Keehner, Mayberry, & Fischer, 2011; Reber & Schwarz, 1999). Another possible reason for the neuroscience bias is the prestige of the "hard" sciences (*prestige of science* hypothesis). People believe that biological explanations are more complex and more scientific than psychological explanations. This bias toward the natural sciences emerges as early as kindergarten, and vestiges of it can be observed in adulthood (Keil, Lockhart, & Schlegel, 2010). Thus, explanations that invoke neuroscience may be viewed as reflecting greater expertise. In a related vein, the use of jargon in describing neuroscience information might also cue expertise. For example, the mere presence of a nonsense math equation increases the perceived quality of a scientific abstract (Eriksson, 2012). Finally and most intriguingly, superfluous neuroscience information might increase the perceived scientific quality of explanations if people's lay theories of the mind embrace the idea that the brain is the best explanans of mental phenomena (i.e., a *brain-as-engine-of-mind* hypothesis). If so, superfluous explanations should fool participants into seeing the explanations as informative, but giving the superfluous information a "neuro" flavor would be essential; this hypothesis predicts that other jargon or scientific cues would not work as effectively.

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Past research has explored whether the presence of a brain picture increases the perceived quality of a neuroscience explanation. Although initial findings supported the hypothesis, more recent studies have failed to replicate those findings (Hook & Farah, 2013; Michael, Newman, Vuorre, Cumming, & Garry, 2013; Schweitzer, Baker, & Risko, 2013; Gruber & Dickerson, 2012). In 2008, McCabe and Castel gave their participants a one-page summary of a cognitive neuroscience finding written for the popular press. This baseline condition was compared with experimental conditions in which the same neuroscience information was accompanied by either an fMRI or a bar chart. Participants in this study rated the scientific reasoning most highly when the neuroscience explanation was paired with the fMRI, leading the authors to conclude that brain images conferred credibility to the neuroscience explanations. However, more recent studies using a similar methodology have failed to replicate these findings. In 2013, Hook and Farah showed their participants short descriptions of fictional neuroscientific research (e.g., "when viewing images of food, obese participants had reduced activation in brain areas related to self-control"). These vignettes were paired with either a brain picture or a bar chart; the presence of a brain picture did little to modify the perceived quality of a neuroscientific explanation. That same year, a comprehensive study by Michael and collaborators, comprising 10 experiments and almost 2000 participants, reached the same conclusion.

As these recent studies clearly show, the addition of a brain picture does little to increase the perceived quality of a neuroscientific explanation (Hook & Farah, 2013; Michael et al., 2013; Schweitzer et al., 2013; Gruber & Dickerson, 2012). However, none of those studies have tested whether superfluous neuroscience information (either pictorial or textual) has an influence on an otherwise non-neuroscientific explanation. This omission leaves open the possibility that neuroscience may exert an undue influence in judgments of research quality. Furthermore, this omission is theoretically important because it raises the possibility that the effect would be driven not by the perceptual properties of brain images but rather by conceptual properties of neuroscience, such as its status as a hard science and/or its role as the "engine of the mind" in current lay theories of the mind. In other words, it remains a possibility that neuroscience would influence people's judgment in profound ways.

Does the glow of neuroscience seem to illuminate the explanation of psychological phenomena? Addressing this question requires a design comparing the impact of superfluous neuroscience explanations to the impact of non-neuroscience explanations. To our knowledge, there is only one study that addresses this question. In 2008, Weisberg and collaborators asked participants to read vignettes about well-established psychological phenomena and their possible explanations (Weisberg, Keil, Goodstein, Rawson, & Gray, 2008). One vignette, for example, described the "curse of knowledge," the phenomenon in which participants who do know a fact report that an inaccurately large percentage of others would know it too. Although the description of the phenomena was always accurate, the quality of the explanation was variable: sometimes the arguments were good, and other times they were circular. For the curse of knowledge, the circular statement was "The researchers claim that this 'curse' happens because subjects make more mistakes when they have to judge the knowledge of others."[1] A second factor provided the critical manipulation: Half of the vignettes included superfluous neuroscience sentences, whereas the other half did not. For the curse of knowledge, the superfluous information made the circular explanation read as follows: "Brain scans indicate that this 'curse' happens because of the frontal lobe brain circuitry known to be involved in self-knowledge. Subjects make more mistakes when they have to judge the knowledge of others." Superfluous sentences proved effective, increasing the perceived quality of circular explanations.

Weisberg et al.'s work was novel and insightful, but the findings raised a number of new questions. Conceptually, the study did not address whether the effect was specific to the addition of neuroscience information or if the addition of any science information would work. The *neuroscience* condition did not display any brain images (it was solely words) and thus did not address whether pictorial information, such as brain images, had an effect above and beyond that of written explanations. In addition, there were some methodological limitations to the study. Because the neuroscience information condition was compared with a condition devoid of any explanation, length of explanation was a possible confounding reason why the neuroscience information condition boosted ratings (i.e., a *length of explanation* account). To further complicate matters, the neuroscience information was inserted in the middle of the vignette, interrupting the flow of reading. Irrespective of content, such an interruption could have obscured the circularity of the argument. Furthermore, the superfluous information modified the sentence structure, possibly masking its circularity. In the absence of superfluous information, the circularity of the argument was obvious: "This curse happens because subjects make more mistakes when they have to judge the knowledge of others." In other words, the subordinate clause was a restatement of the phenomenon, making it very easy to detect the circularity. When superfluous neuroscience information was included, it read "this curse happens because of the frontal lobe brain circuitry known to be involved in self-knowledge. Subjects make more mistakes when they have to judge the knowledge of others." In this condition, the restatement of the phenomenon appeared not as a subordinate clause but as a separate sentence. As a consequence, the circularity might not have been so easy to detect. This could explain the "beneficial" effect of superfluous information without the need for a rich interpretation based on neuroscience. Consistent with this account, superfluous information was beneficial only for circular explanations and not for good explanations. These limitations notwithstanding, Weisberg et al.'s work has often been cited along McCabe and Castel (2008) as evidence supporting the distorting influence of neuroscience, and after failures to replicate McCabe and Castel's initial findings, it currently stands as the single piece of evidence in support of the allure of neuroscience.

In four experiments, we addressed the methodological limitations of Weisberg et al.'s work and began to investigate the possible mechanisms by which the allure of neuroscience may operate. To facilitate comprehension and the flow of reading, we used streamlined vignettes and placed the superfluous explanation at the very end. To assess the *perceptual fluency* hypothesis, we added a condition in which brain images supplemented the neuroscience information (Experiment 1). To rule out a *length of explanation* hypothesis, we included a condition with superfluous social science information (Experiment 2); this also allowed us to test whether the bias was limited to neuroscience or instead extended to the social sciences. Finally, we added a condition in which the information was devoid of any neural references but still contained information coming from the "hard" sciences (Experiment 3). This allowed us to contrast the *prestige of science* hypothesis, which predicted that the effect would generalize to any natural science pseudo explanation, against the *brain-as-engine-of-mind* hypothesis, which predicted that the effectiveness of superfluous information would be specific to neuroscience information.

We also used a variety of ancillary measures to test several additional hypotheses. To assess whether general reasoning skills protect against the neuroscience bias, we included three measures of analytical thinking (the Cognitive Reflection Task [CRT], a set of Concrete Syllogisms, and a set of Abstract Syllogisms). To assess possible modulations of the effect by lay theories of mind, we included surveys on dualism, free will, determinism, and religious beliefs. Finally, to assess the possible role of scientific prestige in the neuroscience bias, we collected information about participants' attitudes toward neuroscience and other natural sciences and toward psychology and other social sciences.

EXPERIMENT 1: NEUROSCIENCE VERSUS NEUROSCIENCE WITH BRAIN IMAGES

In Experiment 1, we aimed to replicate the original findings of Weisberg et al.'s work, showing that superfluous neuroscience information increases the perceived quality of psychological explanations. More importantly, we also tested whether including brain pictures had an influence above and beyond that of written text referencing neuroscience (i.e., *perceptual fluency* hypothesis). Finally, we explored whether participants' analytical skills were negatively correlated with the bias, consistent with a processing limitation rather than a conceptual limitation.

Methods

Disclosure of Research Conduct

We report all measures collected, all data exclusions (if any), and all manipulations, in all the studies conducted for this project.

Participants

A total of 91 Villanova undergraduates participated in the task. Sixty-four of them were students in an introductory psychology course and participated for course credit (32 women, 27 men, and 5 who did not report gender). Another 27 participants were students in a physiological psychology course who participated as part of a classroom activity (82% of students in the class were women). The introductory psychology course serves students who have diverse academic interests and majors, including business (approximately 25%), science (25%), nursing (15%), social studies (8%), and psychology (6%). The physiological psychology course serves mostly students majoring in psychology (>90%).

Stimuli

General instructions. The following instructions were presented at the beginning of a paper questionnaire distributed to participants:

> You will read descriptions of various scientific findings. All the findings come from solid, replicable research; they are the kind of material you would encounter in an introductory psychology textbook. You will also read an explanation of each finding. Unlike the findings themselves, the *explanations* of the findings range in quality: Some explanations are better than others, they are more logically sound. Your job is to judge the quality of such *explanations*, which could range from a very poor explanation (−3) to a very good explanation (+3).

Vignettes. There were 18 vignettes adapted from Weisberg et al.'s work. Each vignette described a unique research topic and was displayed on a separate page with the topic title at the top (e.g., "1. Curse of Knowledge") and the instruction reminder at the bottom. The relevant information was broken down into "method," "findings," and "explanation." The explanations presented arguments of varying quality. The good quality argument was, in most cases, the genuine explanation that researchers typically give for each phenomenon. For the curse of knowledge, it stated that it "happens because subjects have trouble switching their point of view to consider what someone else might know, mistakenly projecting their own knowledge onto others." The bad quality argument was a circular restatement of the phenomenon, and therefore, it was nonexplanatory. For the curse of knowledge, it stated that it "happens because subjects make more mistakes when they have to judge the knowledge of others. People are much better at judging what they themselves know."

Following the argument, superfluous neuroscience information was added for the *neuroscience* condition. For the curse of knowledge vignette, it stated that "studies indicate that self-knowledge engages a neural circuitry in the frontal lobes of the brain." The superfluous information always appeared after the argument. The information was similar to the information used by Weisberg et al., albeit slightly modified so that the information could be presented as a stand-alone sentence at the end of the argument. In the *neuroscience + brain image* condition, a brain image and a figure caption were displayed in addition to, and just below, the explanation. (For a complete example, see Appendix A; for a complete list of superfluous neuroscience information, see Appendix B.)

Images. Brain images were selected by the first author from cognitive neuroscience journal articles. The information depicted in the image was always consistent with the information offered in the superfluous neuroscience explanation; for example, if the superfluous information referred to activation in the right pFC, the selected brain image similarly depicted activation in the right pFC. Selection was limited to high-quality, high-contrast images. These images included a variety of formats and orientations. Six images depicted the lateral view of an "inflated" brain (i.e., with visible sulci pushed outward), a seventh image depicted a lateral view of a "standard" brain (i.e., not inflated), and an eighth image depicted a ventral view. Nine other images were 2-D cross-sections of the brain (two showed a coronal cut, two showed a sagittal cut, and five others showed more than one cut). Finally, one vignette was paired up with a 3-D rendition of a head with a horizontal and a sagittal plane exposed. The image sizes ranged from 4.3 × 4.1 cm to 6.6 × 9.1 cm and were printed on white paper by a high-definition color printer. Areas of brain activation were always clearly visible; in some cases, they were further highlighted by a cross hair or an arrow.

Image captions. For each brain image, we included a caption that accurately described the image but provided no additional information. For example, for the vignette with the neuroscience explanation "As we get older, the memory centers in the medial-temporal lobe change in specific ways (see Figure below)," the image caption was "Age-related brain changes, including medial-temporal lobe (circled)."

Design

Two factors were crossed in a 2 × 3 within-subject factorial design: Quality of argument (good; circular) and Type of superfluous information (no information; neuroscience; neuroscience + brain image). Crossing these two factors created six within-subject conditions. Every vignette was doctored so that it could fit in any of the six conditions. Participants read three vignettes in each of the six conditions, for a total of 18 vignettes. Participants saw one of six different forms of the 18 vignettes, with each form created by changing subsets of three vignettes from one condition to another. That is, vignettes moved in groups of three, such that three vignettes that were in the same condition on one form (e.g., Vignettes 2, 8, 18) would be in a different condition on one of the other forms (still in Positions 2, 8, 18). For example, if a participant receiving the first form saw a group of vignettes in the "good quality, neuroscience information" condition, then a participant receiving the second form would see that same group of vignettes in the "bad quality, no information" condition. Across the six forms, each vignette appeared in each condition once. The vignettes were shown in fixed order, with condition order varying across forms.

Ancillary Measures

We asked participants to complete three individual difference measures of analytical thinking: the CRT, a set of Concrete Syllogisms, and a set of Abstract Syllogisms. These measures could be used to see whether susceptibility to being biased by neuroscience information is more likely in those who are less able to analyze quality of arguments and thus may rely more heavily on superficial argument cues.

All but one participant completed the CRT, a three-item task that measures one's tendency to respond with deliberate responses rather than intuitive ones (Frederick, 2005). An example of one of the items from this task is: "A bat and a ball cost $1.10. The bat costs $1.00 more than the ball. How much does the ball cost?" The intuitive response (10 cents) is incorrect, and arriving at the correct answer (5 cents) requires deliberate thought. The total number of correct answers for the three items (0, 1, 2, or 3) serves as the score for this task.

Most participants were also asked to assess the logic of 16 syllogistic arguments adapted from a study by Markovits and Nantel (1989). Each syllogistic argument took the form of three statements, and participants were asked to answer whether or not the third statement could be concluded based on the information in the first two statements. Participants first assessed eight concrete syllogistic arguments—that is, the arguments used familiar categories of items, such as:

Premise 1: All things that are smoked are good for the health.
Premise 2: Cigarettes are smoked.
Conclusion: Cigarettes are good for the health.

Participants then completed eight abstract syllogistic arguments, which were made abstract by using made-up words for categories, such as:

Premise 1: All animals love water.
Premise 2: Selacians do not like water.
Conclusion: Selacians are not animals.

The concrete and abstract syllogistic arguments were identical in structure, differing only in terms of the content words. However, for all of the concrete syllogisms, when the syllogistic arguments were valid, the logical conclusion was inconsistent with common knowledge (e.g., smoking example). When the syllogistic arguments were invalid, the (illogical) conclusion was consistent with common knowledge (e.g., Premise 1: All unemployed people are poor; Premise 2: Bill Gates is not unemployed; Conclusion: Bill Gates is not poor). The syllogisms were distributed as a single packet. A total of 66 participants completed both versions of the tasks. Because of a researcher's mistake, the other 25 participants completed only one version of the task (13 completed the concrete version, and 12 answered the abstract version).

Results

The approach to the data analysis was similar in all four experiments. Data for argument quality ratings were recoded to go from 1 (*very poor*) to 7 (*very good*). Next, for each participant, responses to the three vignettes per condition were averaged to obtain mean scores in each of the six conditions. Those mean scores were entered in a preliminary analysis to assess whether the course in which participants were enrolled (introductory or physiological psychology) interacted with the factors of interest. Because there were no interactions between course and our variables of interest (in Study 1 or any of the other experiments), course was not included as a factor in reported analyses.

Data were submitted to a 2 × 3 within-subject ANOVA with Quality of argument (circular; good) and Type of superfluous information (no information; neuroscience; neuroscience + brain image) as factors. Significant main effects were followed up by simple contrasts.

Figure 1 depicts the main findings of Experiment 1. Not surprisingly, good arguments were deemed more compelling than circular arguments, increasing the quality judgment by 0.70 of a point, $F(1, 90) = 43.80$, $p < .001$, $\eta_p^2 = .33$. More importantly, there was a main effect of Information type, $F(2, 180) = 37.67$, $p < .001$, $\eta_p^2 = .30$. Information type and Argument quality did not interact, $F(2, 180) = 0.69$, $p = .5$. A simple contrast showed that superfluous neuroscience information made the argument more compelling than no information, increasing the quality judgment by 0.88 of a point, $F(1, 90) = 58.69$, $p < .001$, $\eta_p^2 = .395$. The inclusion of brain pictures did not provide any additional benefit, increasing the quality judgment of the neuroscience explanation by a negligible amount (.05 of a point), $F(1, 90) = 0.21$, $p = .64$.

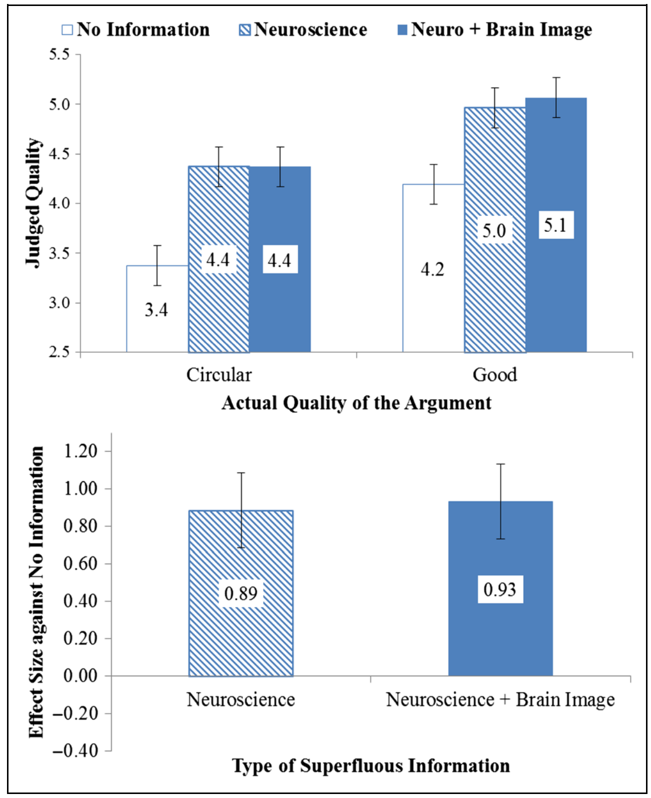

Figure 1. *Top:* Judged quality of arguments for Experiment 1, plotted with 95% within-subject confidence interval (Masson & Loftus, 2003). *Bottom*: Effect sizes of the neuroscience information against no information contrast and neuroscience + brain image against no information contrast.

Ancillary Measures

Table 1 shows that, as expected, all three measures of analytical thinking (CRT, Concrete Syllogisms, and Abstract Syllogisms) were positively correlated. The influence of neuroscience information was calculated as the difference score between the *neuroscience* condition and the *no information* condition. The influence of brain images was calculated as the difference score between the *neuroscience + brain image* conditions and the *neuroscience* condition. Neither of these two scores showed a negative correlation with any of the measures of analytical thinking. Thus, we found no evidence that increased analytical mindset protected participants from the neuroscience bias. This null effect should be interpreted cautiously, as we also failed to find a correlation between the ability to discriminate between good and circular arguments and any of the measures of analytical thinking.

Discussion

Superfluous neuroscience information increased the judged quality of the scientific argument, thus replicating

Table 1. Correlations between Measures of Analytical Thinking and the Allure of Neuroscience Bias in Experiment 1

Measure	*1*	*2*	*3*	*4*	*5*	*6*	*M*	*SD*
1. CRT	–	**.48**	**.48**	.10	.12	.05	1.24	1.09
2. Syllogisms (concrete)		–	**.78**	.09	.08	.02	6.07	1.82
3. Syllogisms (abstract)			–	−.08	.11	.11	6.19	1.74
4. Neuroscience vs. No Info				–	−.20	−.01	–	–
5. Neuro + Image vs. Neuroscience					–	−.14	–	–
6. Good vs. Circular						–	–	–

$p < .05$ in **bold** font.

the main finding of Weisberg et al. (2008) with a more rigorous methodology in which the superfluous information did not interrupt the flow of the argument. The only substantial difference was that Weisberg et al. found the effect only for circular explanations, although we found it for good explanations, too. This finding suggests that the addition of neuroscience information does not just make bad explanations better; even if a good explanation—one that is not lacking in explanatory power—is provided, the effect still persists.

Importantly, brain images did not have an impact above and beyond the written text that mentioned neuroscience. These results suggest that the effect of neuroscience on judgments of argument quality cannot be attributed to superficial properties of the stimulus, such as the perceptual quality of the picture. Furthermore, we did not find any evidence that more analytical aptitude protected participants from the bias. Thus, it seems more likely that the effect of neuroscience is conceptual, driven by lay theories on the role of neuroscience, or possibly, by a reverence for the natural sciences in general. Alternatively, it is possible that the effect is simply an artifact of neuroscience explanation being longer than explanations with no superfluous information. We address these possibilities in the experiments described below.

EXPERIMENT 2: NEUROSCIENCE VERSUS SOCIAL SCIENCES

In Experiment 2, we replaced the *brain image* condition of Experiment 1 with a condition that contained superfluous *social science* information. This allowed an assessment of the *length of explanation* hypothesis, which predicts that the effect would be absent when comparing the *neuroscience* condition to a condition of similar length. The comparison against the *social science* condition also allowed us to test the specificity of the effect: Is the benefit of superfluous information specific to neuroscience, or would it generalize to social science information? We predicted that the effect would be stronger for neuroscience, possibly because of the higher perceived status of the natural sciences. To explore this interpretation, we also collected information on participants' attitudes toward the natural and social sciences.

Methods

Participants

A total of 90 Villanova undergraduates participated in the study as to match the number of participants in Experiment 1. Sixty-four of them were students (both psychology majors and non-majors) in an introductory psychology course and participated for course credit (33 women, 31 men). Another 26 participants (22 women) were students in a physiological psychology course required for psychology majors—they participated as part of a classroom activity.

Stimuli

In Experiment 2, participants were exposed to three different types of superfluous information (neuroscience; social science; and none). For example, for the vignette describing mental rotation, the neuroscience information read: "Brain scans of these subjects show activation of a neural circuit in parietal and occipital lobes." The social information for that same vignette read: "Cross-cultural research shows that perception of complex objects is influenced by the amount of industrialization in the society." The neuroscience information was largely the same as in Experiment 1, although we did introduce some slight changes in the wording, to ensure that no sentence would carry any explanatory power. For example, the *attentional blink* sentence was shortened to "areas in the frontal lobe were active in response to the stimuli" instead of "areas in the frontal lobe previously shown to mediate attention functioned in response to the stimuli." Other changes included the choice of more obvious anatomical correlates (e.g., right parietal lobe instead of premotor cortex for the vignette on spatial reasoning), the elimination of jargon (e.g., deleting "CA3" from the sentence "CA3 brain cells of the hippocampus"), and some additional streamlining (see Appendix B). Finally, the formatting of Experiment 2 was different from Experiment 1 in that the information for all three parts of each vignette (method, findings, explanation) was further broken down into bullet points to facilitate their reading and comprehension.

Design

As in Experiment 1, two factors were crossed in a 2 × 3 within-subject factorial design: Quality of argument (good; circular) and Type of superfluous information (no information; neuroscience; social science). We excluded the data from one question from one form from analysis because by mistake that question in that form had both the circular and the good explanations. We also recoded, in one form, two questions in which the quality of the explanation was flipped from the intended design. Other aspects of the design remained the same as in Experiment 1.

Ancillary Measures

We included the same measures of analytic thinking that were used in Experiment 1. In addition to these measures, we included an assessment of attitudes toward science and questionnaires regarding beliefs in dualism, free will, genetic determinism, and religion. These ancillary measures were presented in fixed order following the main task.

Attitudes toward science. Participants were asked to use a 10-point scale to rate nine different disciplines in terms of their scientific rigor, their societal prestige, and the knowledge gap between an expert in the field and a layperson. Besides Neuroscience, Psychology, and Social Psychology, we included three natural sciences (Biology, Chemistry, Genetics) and three social sciences (Sociology, Cultural Anthropology, Political Science). (For exact wording, see Appendix C.) Next, participants read contrasting definitions of Behavioral Neuroscience (the study of the *brain* and its contributions to thinking and behavior) and Cultural Psychology (the study of *culture* and its contribution to thinking and behavior) and then matched different personality traits to the practitioners the trait best described, either behavioral neuroscientists or cultural psychologists. There were eight *competence* traits (determined, persistent, scientific, serious, skillful, intelligent; creative, imaginative) and four *warmth* traits (sincere, social, tolerant, warm) adapted from the work of Fiske et al. (Fiske, Cuddy, & Glick, 2007; Rosenberg, Nelson, & Vivekananthan, 1968).

Questionnaires on determinism, free will, dualism, and religious beliefs. A 24-item questionnaire probed participants' beliefs about genetic determinism, scientific determinism, free will, mind/brain dualism, and religion (for exact wording, see Appendix D).[2] We found no correlations between these measures and neuroscience allure, which we operationalized for these analyses as the increase in argument quality brought about by superfluous neuroscience information (vs. superfluous social information). The same was true for the subsequent experiments. We do not discuss these questionnaires any further.

Results

The data were submitted to a 2 × 3 ANOVA with Quality of argument (circular; good) and Type of superfluous information (no information; neuroscience; social science) as within-subject factors. Significant main effects were followed up by simple contrasts.

Figure 2 depicts the main findings of Experiment 2. Once again and not surprisingly, good arguments were deemed more compelling than circular ones, in this study by 0.80 of a point, $F(1, 89) = 45.47$, $MSE = 1.91$, $p < .001$, $\eta_p^2 = .34$. Consistent with our hypothesis, there was a main effect of Information type, $F(2, 178) = 8.08$, $p < .001$, $MSE = 1.23$, $\eta_p^2 = .09$. Information type and Argument quality did not interact, $F(2, 178) = 0.32$, $p = .73$.

A simple contrast analysis showed that superfluous neuroscience information made the arguments more compelling than no information, increasing the quality of arguments by 0.48 of a point, $F(1, 89) = 13.54$, $MSE = 2.8$, $p < .001$, $\eta_p^2 = .13$. This result replicates the finding of Experiment 1.

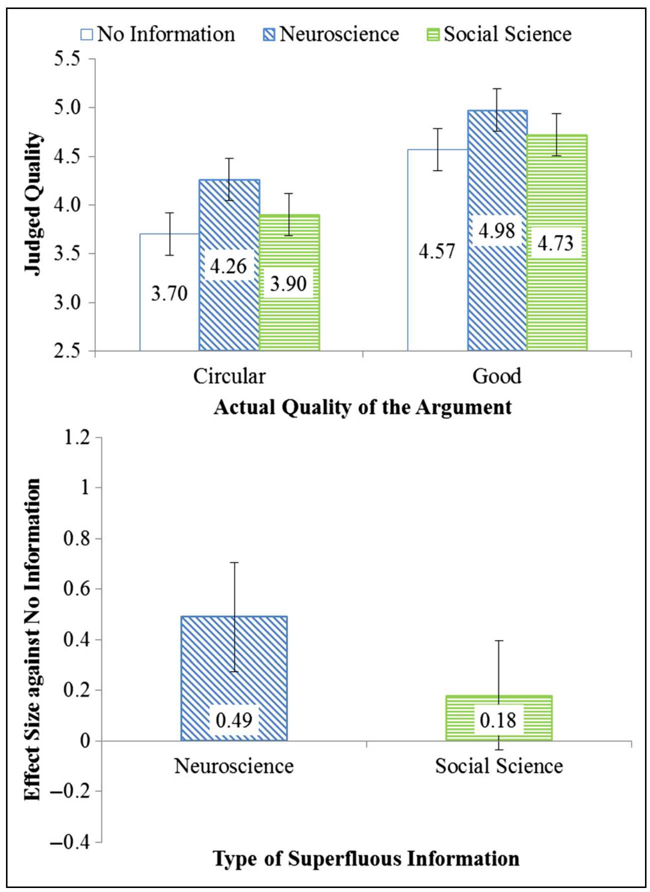

Figure 2. *Top:* Judged quality of arguments for Experiment 2, plotted with 95% within-subject confidence interval. *Bottom:* Effect sizes of the neuroscience information against no information contrast and social science against no information contrast.

Table 2. Correlations between Measures of Analytical Thinking and the Allure of Neuroscience Bias in Experiment 2

Measure	*1*	*2*	*3*	*4*	*5*	*6*	*M*	*SD*
1. CRT	–	**.32**	**.27**	.04	−.04	**.23**	1.31	1.05
2. Syllogisms (concrete)		–	**.83**	−.11	−.14	**.27**	6.17	1.81
3. Syllogisms (abstract)			–	**−.24**	−.17	**.29**	6.37	1.68
4. Neuroscience vs. No Info				–	**.57**	−.02	–	–
5. Neuroscience vs. Social					–	−.12	–	–
6. Good vs. Circular						–	–	–

p < .05 in **bold** font.

More importantly, superfluous neuroscience information was also more compelling than social science information, increasing the quality of arguments by 0.31 of a point, $F(1, 89) = 8.6, MSE = 1.1, p < .004, \eta_p^2 = .08$. Finally, arguments adorned with superfluous social science information were deemed only slightly better than those devoid of it, increasing the quality of arguments by 0.18 of a point, an effect that failed to reach statistical significance, $F(1, 89) = 2.5, MSE = 1.14, p = .11, \eta_p^2 = .027$.

Ancillary Measures

Analytical thinking. Table 2 shows that all three measures of analytical thinking (CRT, Concrete Syllogisms, and Abstract Syllogisms) were positively correlated, as in Experiment 1. Table 2 also shows that all three measures of analytical thinking were positively correlated with the ability to discriminate between good and circular explanations (rs > .23, ps < .01). The influence of neuroscience information was computed in two different ways. One was the difference score between the *neuroscience* condition and the *no information* condition, and the other was the difference score between the *neuroscience* condition and the *social science* condition. Crossing the three measures of analytical thinking with the two measures of neuroscience influence allowed us to test six possible correlations; only one of them was statistically significant and even then it was a weak correlation at $r = -.24$. Thus, we found little evidence to support the hypothesis that increased analytical mindset protected participants from the neuroscience bias.

Attitudes toward science. For each of the nine disciplines, participants used a 10-point scale (1–10) to make three related judgments: one on scientific rigor, another on the knowledge gap between experts and laypeople, and a third one on the societal prestige of the discipline. The three judgments were averaged to compute an Admiration Score (see Figure 3). Admiration scores for Biology, Chemistry, and Genetics were averaged into a Natural Sciences mean score, and admiration scores for Sociology, Anthropology, and Political Science were averaged into a Social Sciences score. Admiration scores for neuroscience, psychology, and social psychology were kept separate. Pairwise comparisons with Bonferroni adjusted alpha levels of .0025 per test (.05/20) showed significant differences in all the contrasts. Neuroscience was the most admired discipline, the natural sciences were more admired than the social sciences, and psychology and social psychology lay in the middle.

Trait ratings for the sciences. Participants rated the sciences on eight traits that have been linked to *competence* in previous work (determined, persistent, scientific, serious, skillful, intelligent; creative, imaginative) and four traits that have been linked to *warmth* (sincere, social, tolerant, warm). Each trait was attributed in a two-alternative forced-choice to either Behavioral Neuroscientists or Cultural Psychologists. Behavioral Neuroscientists were deemed more competent than Cultural Psychologists, receiving endorsements of competence traits 69.7% of the time (95% CI [66.5, 72.9]), one-sample t test against chance, $t(89) = 12.39, p < .001$. The percentage rose to 78.6% when the least prototypical items (creative, imaginative) were filtered out. Cultural Psychologists were deemed higher in warmth than Behavioral Neuroscientists (82.7%), 95% CI [77.9, 87.5], $t(89) = 13.47, p < .001$.

Discussion

Experiment 2 showed that there was an effect of superfluous information that was specific to neuroscience, above and beyond any bias caused by the social sciences.

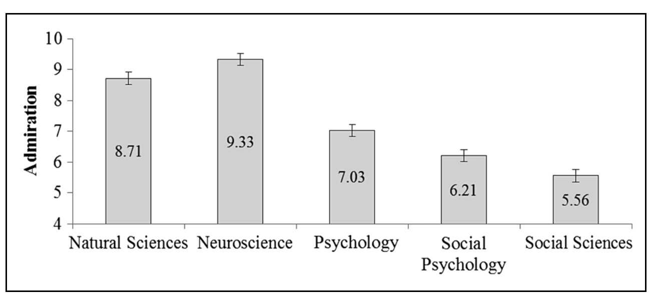

Figure 3. Participants' attitudes toward different sciences in Experiment 2, plotted with 95% within-subject confidence interval.

Thus, the neuroscience effect is not just because of longer explanations, as the neuroscience and the social science information were comparable in length. As in Experiment 1, the neuroscience effect was present for both circular and good explanations. Although, as predicted, analytical thinking helped participants to distinguish between good and bad explanations, analytical thinking did little to help participants to avoid the neuroscience bias. Thus, as in Experiment 1, we found no support for a performance explanation of the neuroscience bias. Instead, the bias seems more likely to be conceptual, driven by lay theories about the role of neuroscience, or possibly, by a reverence for the natural sciences in general. Consistent with the *prestige of science* hypothesis, neuroscience and the other natural sciences were held in higher regard than the social sciences, and neuroscience was slightly more admired than the other natural sciences. However, it is also possible that scientific prestige was a coincidental feature, rather than the driving force behind the effect, a possibility we test in Experiment 3.

EXPERIMENT 3: NEUROSCIENCE VERSUS HARD SCIENCES

If the effect of superfluous neuroscience information depends on the scientific prestige of neuroscience, the effect should generalize to other "hard" sciences. In contrast, a failure to generalize to other "hard" sciences would be consistent with a *brain-as-engine-of-mind* hypothesis. According to the *brain-as-engine-of-mind* hypothesis, the brain is assigned a privileged role in folk theory of mind. Such a privileged role would make neuroscience—but not other natural sciences—the most alluring explanation of psychological phenomena. Thus, in Experiment 3, we tested the competing predictions of the *prestige of science* hypothesis and the *brain-as-engine-of-mind* hypothesis by adding a condition with superfluous information from the hard sciences that was devoid of neuroscience information. Those non-neuroscience explanations used jargon from a variety of fields, including genetics, math, computer science, physics, biology, and biochemistry.

Methods

Participants

A total of 96 Villanova undergraduates participated in the task as to approximately match the number of participants in Experiments 1 and 2. Sixty-nine of these participants were students in an introduction to psychology course and participated for course credit (47 women, 22 men). Another 27 participants (22 women, 5 men) were students in a physiological psychology course required for psychology majors. They participated as part of a classroom activity. The average age was 19.8 years (SD = 1.9, range = 18–32).

Stimuli

In Study 3, the *no information* condition of Study 2 was replaced with a *hard science* condition that provided superfluous information from the natural sciences. We drafted explanations that included information from a diverse set of disciplines, including genetics (n = 6); biology and biochemistry (n = 6); and math, physics, and computer science (n = 6). Thus, there were three different types of superfluous information (hard science; neuroscience; and social science). For example, in a vignette explaining the phenomenon of "confirmatory bias," the hard science explanation read: "The response to emotional messages is modulated by the gene expression of the glucocorticoid receptor involved in the physiology of stress." For the same vignette, the neuroscience explanation read, "A brain structure called the amygdala known to be involved in emotional processing is activated by this task." For the social explanation, the vignette read, "Social factors, such as the number of people present in the room have an influence in the magnitude of the effect." (See Appendix B for complete list of explanations.) Finally, as in Experiment 2, participants completed assessments of analytical thinking (CRT, syllogisms) and attitudes toward science, as well as a 24-item questionnaire on determinism, free will, dualism, and religious beliefs.

Results

The data were submitted to a 2 × 3 ANOVA with Quality of argument (circular; good) and Type of superfluous information (hard science; neuroscience; social science) as within-subject factors. Significant main effects were followed up by simple contrasts.

Figure 4 depicts the main findings of Experiment 3. As in the two previous experiments, good arguments were deemed more compelling than circular ones, increasing the quality of arguments by 0.79 of a point, $F(1, 95) = 82.81$, $MSE = 1.09$, $p < .001$, $\eta_p^2 = .47$. Also as in the previous experiments, there was a main effect of Information type, $F(2, 190)$ 12.47, $p < .001$, $MSE = 1.09$, $\eta_p^2 = .12$. Once again, Information type and Argument quality did not interact, $F(2, 190) = 0.03$, $p = .97$.

A simple contrast analysis showed that superfluous neuroscience information made the arguments more compelling than hard science information, increasing the quality of arguments by 0.33 of a point, $F(1, 95) = 8.80$, $MSE = 1.15$, $p = .004$, $\eta_p^2 = .08$. Superfluous neuroscience information was also more compelling than social science information, increasing the quality of arguments by 0.53 of a point, $F(1, 95) = 20.77$, $MSE = 1.3$, $p = .001$, $\eta_p^2 = .18$. Arguments adorned with hard science information were deemed somewhat better than those adorned with social science information, with hard science information increasing the quality of arguments by 0.20 of a point, $F(1, 89) = 4.75$, $MSE = 0.83$, $p = .03$, $\eta_p^2 = .05$.

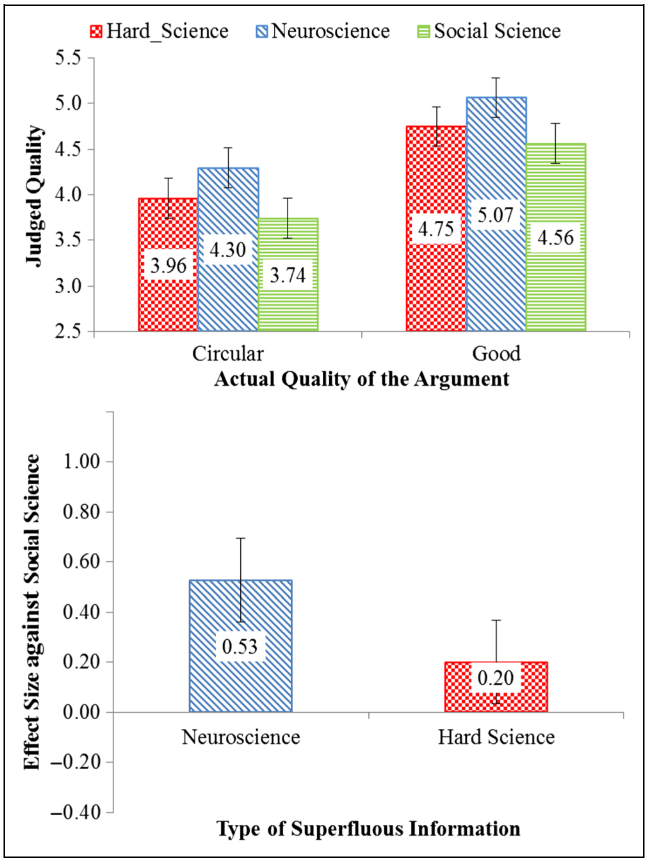

Figure 4. *Top:* Judged quality of arguments for Experiment 3, plotted with 95% within-subject confidence interval. *Bottom:* Effect sizes of the contrast of neuroscience information against social science information and the contrast of hard science against social science.

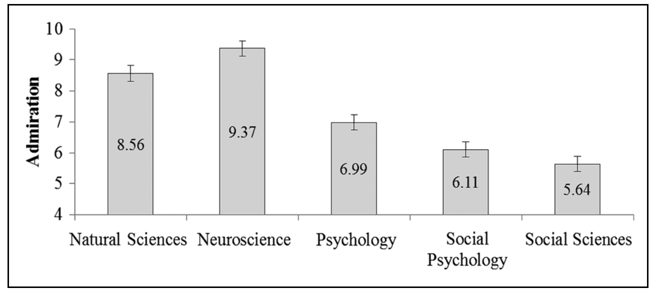

Figure 5. Participants' attitudes toward different sciences in Experiment 3, plotted with 95% within-subject confidence interval.

Ancillary Measures

Analytical thinking. Table 3 shows that all three measures of analytical thinking (CRT, Concrete Syllogisms, and Abstract Syllogisms) were positively intercorrelated, as in Experiments 1 and 2. Furthermore, two of the three measures of analytical thinking were positively correlated with the ability to discriminate between good and circular explanations. The influence of neuroscience information was computed in two different ways. One was the difference score between the *neuroscience* condition and the *hard science* condition, and the other was the difference score between the *neuroscience* condition and the *social science* condition. Crossing the three measures of analytical thinking with the two measures of neuroscience influence allowed us to test six possible correlations: They were all uncorrelated (rs between $-.045$ and $.086$). In other words, we found no support for the hypothesis that increased analytical mindset protected participants from the neuroscience bias.

Attitudes toward science and trait ratings for the sciences. As in Experiment 2, neuroscience was the most admired discipline, the natural sciences were admired more than the social sciences, with psychology and social psychology lying in the middle (see Figure 5); pairwise comparisons with Bonferroni-adjusted alpha levels of .0025 per test (.05/20) showed significant differences in all the contrasts. Behavioral Neuroscientists were deemed more competent than Cultural Psychologists, receiving endorsements of competence traits 70.0% of the time (95% CI [68%, 72%]), one-sample t test against chance, $t(95) = 19.95$, $p < .001$. The percentage rose to 81.3% (95% CI [77.3%, 85.3%]) when the least prototypical competence traits (creative, imaginative) were filtered out. Cultural Psychologists were deemed higher in warmth, being attributed warmth traits 85.9% of the time (95% CI [82.1%, 89.7%]), $t(95) = 18.74$, $p < .001$.

Table 3. Correlations between Measures of Analytical Thinking and the Allure of Neuroscience Bias in Experiment 3

Measure	*1*	*2*	*3*	*4*	*5*	*6*	*M*	*SD*
1. CRT	–	**.36**	**.34**	.09	−.01	**.22**	1.44	1.04
2. Syllogisms (concrete)		–	**.80**	−.002	.05	**.20**	6.32	1.74
3. Syllogisms (abstract)			–	−.05	.06	.14	6.36	1.61
4. Neuroscience vs. Hard Science				–	**.66**	−.04	–	–
5. Neuroscience vs. Social					–	−.08	–	–
6. Good vs. Circular						–	–	–

$p < .05$ in **bold** font.

Discussion

Superfluous neuroscience information more effectively raised perceived explanation quality than superfluous information from the other hard sciences. This was the case for both circular and good explanations and occurred despite the relative similarity in these disciplines in terms of their perceived rigor and prestige. Indeed, in the absence of neuroscience jargon, there was only a modest effect of hard sciences information relative to social sciences information. This pattern of results argues against the *prestige of science* hypothesis and favors instead the *brain-as-engine-of-mind* hypothesis.

EXPERIMENT 4: A REPLICATION OF NEUROSCIENCE VERSUS HARD SCIENCES

In Experiment 4, we aimed to replicate the findings of Experiment 3 using a different site (a large public university on the west coast, as opposed to a smaller private university in the northeast) and a different method of data collection (online and remotely accessed instead of paper-and-pencil completed on site). On the basis of the results of Experiment 3, we predicted that superfluous information would be most beneficial in the neuroscience condition. Less importantly, we also predicted that participants' attitudes would be more positive toward neuroscience and the other natural sciences than toward the social sciences.

Methods

Participants

A total of 141 university student participants signed up to participate in an online study in exchange for partial fulfillment of a psychology class requirement. Four participants withdrew without providing data. Another 29 participants were excluded because they failed an Instructional Manipulation Check twice in a row. This check was included to ensure that participants were reading the instructions thoroughly (Oppenheimer, Meyvis, & Davidenko, 2009). Thus, we were left with 108 participants (75 women and 31 men). When participants were asked their major, answers clustered around natural sciences (23%), psychology (23%), business (17%), and other majors, such as social studies and journalism (26%).

Stimuli and Procedure

Participants who signed up to do the study were presented with a series of questions via Qualtrics survey software. After consenting to participation and passing the Instructional Manipulation Check, participants completed the main task.[3] The stimulus materials were the same as in Experiment 3, with the information broken down into "method," "findings," and "explanation," with information displayed in bullet-points, as in Experiments 2 and 3. Unique to Experiment 4, each of the sections and bullet points was displayed sequentially at a self-paced rate, with the preceding information remaining in display until the vignette was complete and a response was made. Also, the main findings in each vignette were initially displayed in bold font. After each vignette, a message appeared reminding participants of the task instructions. All of these modifications were aimed at facilitating comprehension and encouraging careful reading of the vignettes. At the end of the main task, participants completed the same questionnaires as in Experiment 3 (except for the religiosity questions for which we did not have human participants compliance approval at this site). Two participants did not provide data on trait ratings for the sciences.

Results and Discussion

Figure 6 depicts the main findings of Experiment 4. Once again, good arguments were deemed more compelling than circular ones, increasing the quality of arguments by 0.54 of a point, $F(1, 107) = 37.83$, $MSE = 0.85$, $p < .001$, $\eta_p^2 = .26$. As in all previous experiments, there was

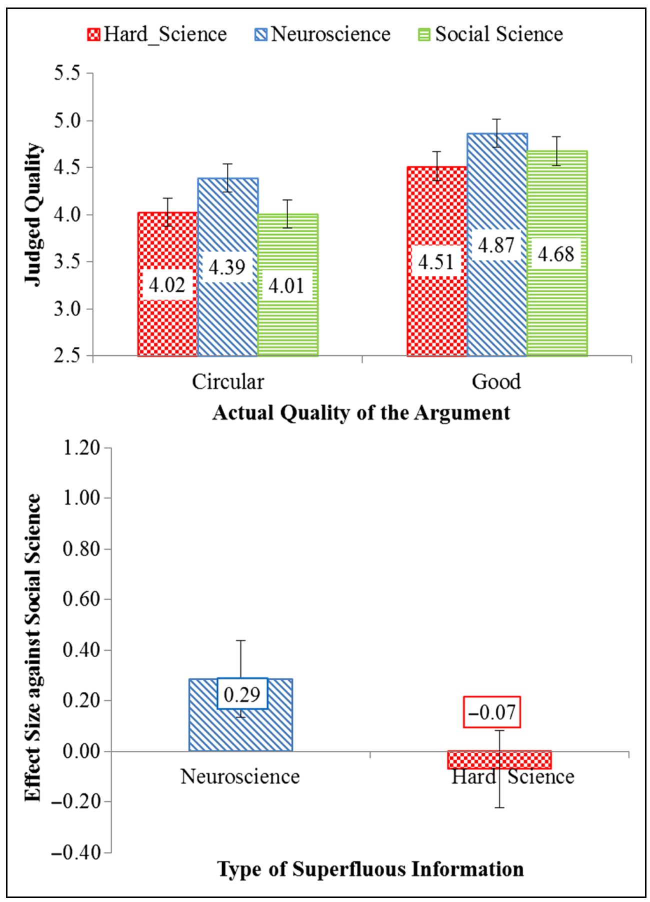

Figure 6. *Top:* Judged quality of arguments for Experiment 4, plotted with 95% within-subject confidence interval. *Bottom:* Effect sizes of the contrast of neuroscience information against social science information and the contrast of hard science information against social science information.

Table 4. Correlations between Measures of Analytical Thinking and the Allure of Neuroscience Bias in Experiment 4

Measure	*1*	*2*	*3*	*4*	*5*	*6*	*M*	*SD*
1. CRT	–	**.48**	**.45**	.06	.10	.01	.79	1.04
2. Syllogisms (concrete)		–	**.80**	−.05	.03	**.20**	4.06	2.09
3. Syllogisms (abstract)			–	−.07	.04	.16	4.51	1.70
4. Neuroscience vs. Hard Science				–	**.50**	.18	–	–
5. Neuroscience vs. Social					–	.03	–	–
6. Good vs. Circular						–	–	–

$p < .05$ in **bold** font.

a main effect of Information type, $F(2, 214) = 4.48$, $MSE = 0.92$, $p < .001$, $\eta_p^2 = .07$. Once again, the two factors did not interact, $F(2, 214) = 0.69$, $p = .50$.

As in Experiment 3, superfluous neuroscience information made the arguments more compelling than hard science information, increasing the quality of arguments by 0.36 of a point, $F(1, 107) = 14.75$, $MSE = 0.94$, $p < .001$, $\eta_p^2 = .12$.[4] Superfluous neuroscience information was also more compelling than social information, increasing the quality of arguments by 0.29 of a point, $F(1, 107) = 9.90$, $MSE = 0.90$, $p = .002$, $\eta_p^2 = .085$. The slight benefit of hard science over social science finding observed in Experiment 3 was not replicated in Experiment 4. If anything, hard science information decreased the quality of arguments by a negligible amount of 0.07 of a point, in favor of the social science information, $F(1, 107) = 0.61$, $p = .43$, $\eta_p^2 = .006$.

Ancillary Measures

Analytical thinking. Table 4 shows that the analytical thinking measures (CRT, Concrete Syllogisms, and Abstract Syllogisms) were positively correlated among themselves. Furthermore, performance in concrete syllogisms, a measure of analytical thinking, was correlated with the ability to distinguish between good and circular arguments. In contrast and consistent with Experiments 1–3, there were no significant negative correlations between analytical thinking and the allure of neuroscience bias (*r*s between −.05 and .10).

Attitudes toward science and trait ratings for the sciences. The data on participants' attitudes toward different disciplines replicated the pattern obtained in Experiments 2 and 3, with the only exception being that the difference between Social Psychology and the other Social Sciences failed to reach statistical significance. As in previous experiments, Behavioral Neuroscientists were deemed more competent than Cultural Psychologists, receiving endorsements of competence traits 63.4% of the time, one-way *t* test against chance, $t(105) = 7.4$, $p < .001$. The percentage rose to 73.0% when the least prototypical items (creative, imaginative) were filtered out. Cultural Psychologists were deemed higher in warmth than Behavioral Neuroscientists (78%), $t(104) = 12.2$, $p < .001$ (Figure 7).

A possible alternative explanation in Study 4 is that explanation quality was affected by sentences providing the superfluous information in the different domains. In other words, the hard science explanations might have been less effective than the neuroscience explanations simply because the sentences detailing the hard science superfluous information were viewed as inferior to the sentences detailing the neuroscience superfluous information. To explore this, we asked a new group of students in a physiological psychology course to judge the perceived quality of the superfluous information sentences. Participants were randomly assigned to judge hard science ($n = 12$), neuroscience ($n = 13$), or social science ($n = 14$) superfluous sentences, which were displayed in isolation. They were told that for each sentence they had to "judge its quality; that is, decide whether it is the kind of sentence that may be published in an academic publication or college textbook." The sentences were printed in a fixed order, without the titles or the other parts of the vignettes. Participants answered on a 7-point scale (1 = *not at all*, 7 = *absolutely*). A one-way ANOVA showed a main effect of Domain, $F(2, 36) = 3.55$, $p = .04$, with Tukey post hoc tests showing that the hard science sentences were deemed of better quality than the social science sentences ($M_{\text{hard}} = 5.03$; $M_{\text{social}} = 4.36$). Most importantly, the comparison between hard science sentences and the

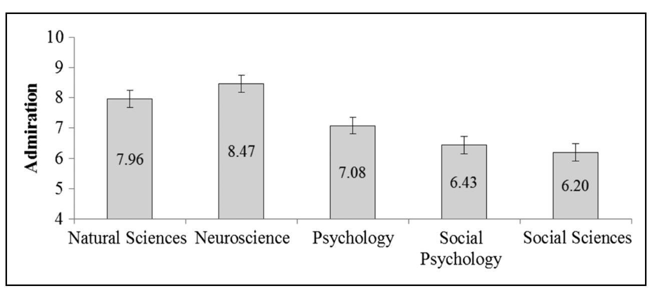

Figure 7. Participants' attitudes toward different sciences in Experiment 4, plotted with 95% within-subject confidence interval.

neuroscience sentences failed to reach statistical significance, and to the extent that there was a difference, it was in the direction opposite to the one supporting a quality confound artifact ($M_{\text{hard}} = 5.03$; $M_{\text{neuro}} = 4.57$). Thus, we found no evidence to support the contention that the neuroscience bias was driven by differences in quality of the superfluous information provided.

GENERAL DISCUSSION

Across four experiments, the presence of irrelevant neuroscience information made arguments more compelling. Experiment 1 documented the main finding for circular explanations as well as for good explanations and showed that brain images did not have an impact above and beyond written text. Experiment 2 ruled out *length of explanation* as a possible artifact and showed that the effect was specific to neuroscience, as it did not generalize to social science information. Experiments 3 and 4 further documented the specificity of the neuroscience effect, above and beyond the effect of other "hard" sciences.

The absence of a neuroimage effect, above and beyond written neuroscience information (Experiment 1), is consistent with recent findings from the literature (Hook & Farah, 2013; Michael et al., 2013; Schweitzer et al., 2013). This absence suggests that the allure of neuroscience information does not stem from processing differences related to the stimulus's perceptual quality (*perceptual processing* hypothesis) but rather from a deeper embrace of neuroscience as an explanatory mechanism. Consistent with this interpretation, we found little evidence that analytical thinking aptitude protected against the neuroscience effect, despite evidence that analytical thinking sometimes helped participants to distinguish between good and bad explanations.

Nonetheless, our conclusion that the allure of neuroscience is conceptual rather than pictorial should be further explored in future studies. A promising approach would be to directly compare a neuroscience image to a non-neuroscience image. Assuming that perceptual features of the stimuli are well matched across conditions, this comparison could show more conclusively that brain images have an effect because of the conceptual information they provide and not because of their perceptual properties. Future studies should also explore whether the effect of the neuroscience text is fully redundant with the effect of the neuroscience image. If so, a brain image without accompanying text should be sufficient to cause a maximum effect. In the absence of a contribution from perceptual fluency (an absence we documented in Experiment 1), we predict that an isolated brain image will be less effective than neuroscience text. On the other hand, studies on moral judgment have sometimes shown that the presence of a brain image is effective even when the image is not explicitly related to the case with textual elaboration. For example, in one such a study, the inclusion of a brain image nudged participants to endorse deterministic explanations of criminal behavior and minimize moral condemnation (Beall et al., 2013). A potential limitation of the current study stems from the stimuli differences across domains. In developing the materials, we aimed for sentences that were of the same quality in the non-neuroscience domains as in the neuroscience domain. We succeeded in that aim for the hard science disciplines: Participants judged the additional information provided in the hard science explanations as equally likely to appear in an academic journal as the additional information provided in the neuroscience explanations. Nonetheless, participants attributed more explanatory power to the neuroscience explanations than to hard science explanations. Thus, it appears to be something specific to neuroscience, not mere information quality, that drove the effect. It does remain a possibility (despite what is indicated by our follow-up data) that the additional information provided differed in some other way across domain. However, the fact that neuroscience information was favored over information from a diverse group of hard science disciplines, as well as favored over information from the social sciences, suggests that there is a unique advantage when using neuroscience as an explanation for psychological phenomena. If people conceptualize the brain as the engine of the mind, as our study suggests, then invariably they will see the neuroscience information as more relevant than hard science counterparts. With our follow-up data, we did our best to disentangle this relevance effect from one based on more overall argument quality by asking participants to evaluate the domain-specific information separately from the phenomena being explained. However, relevance could be rightly viewed as an element of argument quality—just one that is contextually dependent.

Our study was limited to American college students—and college students taking psychology courses at that. Although that narrows our sample, it is worth noting that we found the same effects among students taking Introductory Psychology (many of whom were not psychology majors) and students in an upper level physiological psychology course (almost all of whom were psychology majors). This diversity makes it unlikely that our findings stemmed from any unique peculiarity of students majoring in psychology. Nor did we find differences between students attending a northeastern private university and those attending a public institution in the northwest. Nonetheless, clearly future studies would benefit by investigating whether our results generalize to a broader range of educational levels and backgrounds and also to cultures that hold different lay theories about the relationship between mind and brain than the participants in our experiments.

Our findings were mostly consistent with the current literature. First, we found no effect of brain images above and beyond the effect of neuroscience, a result that replicates the work of Michael and others (Hook & Farah, 2013; Michael et al., 2013; Schweitzer et al., 2013; Gruber & Dickerson, 2012). Also, we found no correlation between the "allure of neuroscience" and beliefs in dualism, a result consistent with the work of Hook and Farah (2013). Most importantly, we found that people's reasoning about psychological phenomena was biased by the presence of irrelevant neuroscience information, a finding that replicates the work of Weisberg and collaborators (2008). One difference, however, is that in Weisberg's study the effect of neuroscience was limited to circular explanations, whereas in our study it also extended to good explanations. An explanation of this inconsistency awaits future studies.

Our results raise the question of why people (or at least our participants) thought that neuroscience explanations were good explanations, even when they were not (i.e., even when the explanations were circular). One possibility that we entertained was that neuroscience carried an aura of real science that was lacking in the social sciences (Knobe, Prasada, & Newman, 2013). Experiment 2 showed that indeed our participants had a high regard for neuroscience and that superfluous social science information was ineffective in affecting the perceived quality of the arguments. Nevertheless, Experiments 3 and 4 made clear that the scientific prestige alone was not the driving force behind the effect, but rather a coincidental feature, as neuroscience information was more compelling than other highly respected disciplines, such as chemistry, biology, genetics, physics, and math. Furthermore, the natural sciences weren't any more compelling than the social sciences despite their much higher prestige. Thus, the most plausible mechanism for the allure of neuroscience may be the *brain-as-engine-of-mind* hypothesis. According to this view, people assign to neuroscience a privileged role in explaining psychological phenomena not just because neuroscience is a "real" science but because it is the most pertinent science for explaining the mind. Absent of a neuroscience link, "hard science" explanations may be too detached from the psychological phenomenon to effectively count as explanations (Yopchick & Kim, 2009). It remains an open question as to whether the inclusion of superfluous psychological material would be as effective as neuroscience material. Psychology is an interesting domain because it is less prestigious than neuroscience but equally pertinent—if not more—to explanations of the mind. As such, it could help to test the relative contributions of scientific prestige and proximity in determining the explanatory power of various explanations of mental phenomena.

The domain of psychology may also help explain the lack of correlation between holding dualist beliefs and being swayed by the allure of neuroscience. This null result runs counter to the *brain-as-engine-of-mind* hypothesis but is consistent with the results of Hook and Farah's (2013) study, which was explicitly designed to test such a correlation. Future studies should assess whether superfluous information from psychological science would be particularly compelling to those who endorse dualist beliefs.

Part of neuroscience's allure may be that it allows the neat, tidy attribution to one causal source: the brain. Future research should examine how neuroscience explanations stand up to other powerful "single source" explanations, such as genetic explanations. Thus, for example, Huntington's disease can be traced to a mutation on the HD gene (Bates, 2005)—as such, a genetic explanation provides a very high level of explanatory power for this disorder. A strong test of the allure of neuroscience bias would be to contrast the genetic explanations of diseases with neuroscientific explanations. However, a host of mental phenomena, including symptoms of mental disorders (Ahn, Proctor, & Flanagan, 2009), affective states (Lunt, 1991), and moral transgressions (Monterosso, Royzman, & Schwartz, 2005) are multiply determined—in fact, single causes are probably the exception rather than the rule for the phenomena we care about most. As such, infatuation with any single source explanation—whether it is the brain or something else—may impede humans' progress to find and accept more complete explanations.

APPENDIX A. SAMPLE STIMULUS USED IN EXPERIMENT 1

Face Recognition

The Method

Participants sat in front of a computer screen and watched a rapidly presented series of pictures, half of which were faces and half of which were places. Half of the participants had to press a button each time they saw a face, and the other half of the participants pressed a button for places.

The Findings

Researchers analyzed the response times and discovered that the patterns of response times were different for faces than for places.

The Explanation

This happens because the participants' responses were contingent on whether they saw a face or a place on the screen. An examination of the activation patterns in participants' brains shows that the extrastriate cortex (known to be involved in processing complex visual stimuli) is activated by pictures of faces and places (see Figure below).

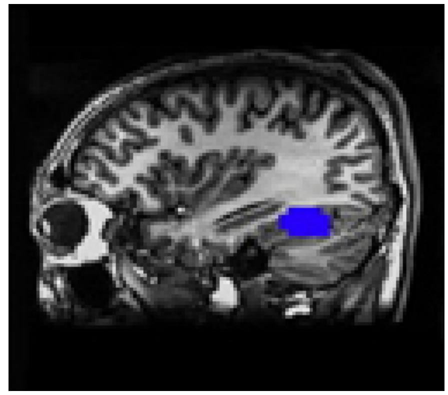

Figure. fMRI of brain, showing in blue the activation of extrastriate cortex in response to visual stimulus.

This explanation is:

−3	−2	−1	0	+1	+2	+3
VERY POOR						VERY GOOD

APPENDIX B. Superfluous Information—Neuroscience Information Used in Experiments 1–4, Social Science Information Used in Experiments 2 and 3, and Hard Science Information Used in Experiments 3 and 4

Topic	*Neuroscience*	*Social Science*	*Hard Science*
Curse of knowledge	Studies indicate that self-knowledge engages a neural circuitry in the frontal lobes of the brain.	Studies indicate that self-knowledge develops jointly for individuals raised in interdependent societies.	Studies indicate that self-knowledge is linked to epigenetic changes in the structure of DNA.
Accessibility Heuristic	Information about animals is stored by brain cells of the hippocampus, which have been shown to contribute to memory.	Information about animals is stored best in hunter–gatherer societies, which depend on such knowledge for survival.	Information about animals is regulated by the expression of genes important for long-term memory.
Infant math	Scans of babies' brains show activation in parietal lobe, an area important for the integration of information across sensory modalities.	The size of the family that babies are raised in determines the babies' expectations about the stimulus on this task.	Scans of the babies' eye movements show a pattern consistent with Fitts' law, $T = a + b \log2 (1 + D/S)$, so that the time required to reach a target (T) is a function of the target's distance (D) and size (S).
Goal-directed actions	Brain areas of the visual system known to process visual motion become activated in this task.	The level of involvement in cultural games and pastimes, such as "Cops and Robbers," "Hide and Seek," and "Tag," influences people's descriptions in this task.	The random motion video was implemented as a continuous time stochastic process.

APPENDIX B. (*continued*)

Topic	*Neuroscience*	*Social Science*	*Hard Science*
Face recognition	Neuroscientists have shown that the extrastriate cortex—an area of the brain known to be involved in processing complex visual stimuli—is activated by pictures of faces and places.	Sociologists have shown that faces and places are among the most important stimulus for social interactions.	Computational scientists have used spectrograms to show that pictures of faces and places convey a range of spatial frequencies.
Object labeling	The brain's language areas in the left temporal lobe are activated by object labeling tasks such as this.	This pattern of development is found across cultures throughout the world.	This pattern of language development is disrupted in children with specific language impairment due to a mutation in gene forkhead box P2 (FOXP2) on chromosome 7q.
Mental rotation	Brain scans of these participants show activation of a neural circuit in parietal and occipital lobes.	Cross-cultural research shows that perception of complex objects is influenced by the amount of industrialization in the society.	Genetic studies show that polymorphism in the ApoE gene correlates with performance in this task.
Confirmatory bias	A brain structure called the amygdala known to be involved in emotional processing is activated by this task.	Social factors, such as the number of people present in the room have an influence in the magnitude of the effect.	The response to emotional messages is modulated by the gene expression of the glucocorticoid receptor involved in the physiology of stress.
Spatial memory	As we get older, the memory centers in the medial-temporal lobe change in specific ways.	As we get older, the ability to remember cultural information remains intact whereas the ability to remember visuospatial information begins to deteriorate.	As we get older, the expression of the APOE4 gene becomes more pronounced, leading to memory effects.
Other-race effect	Scans of the participants' brains show that the fusiform gyrus in the brain responds to faces.	Sociological studies show that race plays an important role in people's perceptions of each other.	Facial recognition relies on algorithms based on PCA, a mathematical procedure that converts a set of observations into values of linearly uncorrelated variables.
Attentional blink	Areas in the frontal lobe were active in response to the stimuli.	The effect was reduced in countries where multitasking is more common.	Biologists have found the same pattern in other primates.
Religious beliefs	The right pFC, a brain area that contributes to abstract thinking, is important for this task.	Symbols, an aspect of culture that contributes to abstract thinking, are important for this task.	Quantum mechanics, an area of theoretical physics sometimes used for describing abstract thinking, provides a unique framework for interpreting findings in this area.
Word associations	Broca's area, a part of the brain's language system, is of importance to this task.	The ability to verbally communicate meaningful information is a basic human function that is found in every society and is of importance to this task.	Allelic variations in FOXP2, a gene important for the language system, have been associated with performance in this task.

APPENDIX B. (*continued*)

Topic	*Neuroscience*	*Social Science*	*Hard Science*
Spatial abilities	In this type of spatial reasoning task, the right parietal lobe of the brain, an area important for spatial processing and mental rotation, is often activated.	In this type of spatial reasoning task, performance differences are observed between cultures that speak a language in which the spatial frame of reference is egocentrically defined (left–right) and those in which the frame is geocentrically defined (north, south).	In this type of spatial reasoning task, testosterone levels are aligned with group differences in performance (high in men, low in women).
Emotional states	Parts of the brain involved in emotion processing, such as the amygdala, become active when children experience distress.	The attachment relation between mother and child, which varies across countries, influences the amount of distress children experience.	Biochemical assays show that cortisol levels rise when children experience distress.
Mental imagery	The task led to activation of large regions the visual cortex in the lateral occipital lobe.	This pattern of results occurs even in cultures that discourage fantasy and make-believe.	Mathematical models show that response time is best fit as a linear function of distance [$T = a + b\,D$].
Binocular rivalry	In this task, there is activation of V1, the primary visual area of the brain.	It is a phenomenon that occurs across cultures throughout the world.	Biologists have found the same pattern of results in New World primates.
Memory for vocal patterns	Information is stored in and retrieved from the hippocampus, the primary brain area involved in memory.	Information is stored in and retrieved from a network of personal knowledge embedded within a wider knowledge of one's community and history.	Biochemical studies have shown that an increase in blood levels of adrenaline facilitates memorization during the studying phase.

APPENDIX C. ATTITUDE TOWARD SCIENCES

1. Each of the three questions was presented in a separate page, in fixed order, with the nine disciplines listed in a column in the following fixed order (Biology, Psychology, Sociology, Chemistry, Cultural Anthropology, Political Science, Neuroscience, Genetics, Social Psychology). Participants responded by writing a number (1–10) next to each item
   a) Rate the scientific rigor of each of these disciplines (that is, how close its practitioners adhere to the scientific method)? (Use a 10 point scale: 1 = *not at all*, 10 = *absolutely*.)
   b) How big is the knowledge gap between what an expert in this field knows about it and what the average person knows about it? (1 = *no gap*, 10 = *enormous gap*)
   c) As viewed by society, how prestigious is this discipline? (Now, we are not interested in your personal beliefs but rather in how society sees it). (1 = *not at all*, 10 = *extremely*)
2. BEHAVIORAL NEUROSCIENCE (BN) is the study of the brain and its contributions to thinking and behavior. CULTURAL PSYCHOLOGY (CP) is the study of culture and its contribution to thinking and behavior. Match each trait below to the discipline practitioners that it best describes (BN = behavioral neuroscience, CP = cultural psychology). For each trait you should select one and only one of the two disciplines. BN or CP? Which group is more Creative, Determined, Sociable, Tolerant, Scientific, Persistent, Sincere, Skillful, Intelligent, Serious, Warm, Imaginative?

APPENDIX D. DETERMINISM, FREE WILL, DUALISM, RELIGION

INSTRUCTIONS. This is a questionnaire in which we are trying to assess how people think about mind, brain, and behavior. There are no right or wrong answers. Answer in a 7-point scale from *strongly disagree* (1) to *strongly agree* (7).

1. I think the chief reason why parents and children are so alike in behavior and character is that they possess a shared genetic inheritance. _____
2. I believe that many talents that individuals possess can be attributed to genetic causes. _____

3. I think that genetic predispositions have little influence on a person's personality characteristics ____
4. I am of the opinion that intelligence is a trait that is strongly determined by genetic predispositions____
5. I think that the upbringing by parents and the social environment have far greater significance for the development of abilities and personal traits than genetic predispositions. ____
6. Your genes determine your future. ____
7. Bad behavior is caused by bad life circumstances. ____
8. People's biological makeup influences their talents and personality. ____
9. People have complete control over the decisions they make. ____
10. People must take full responsibility for any bad choices they make. ____
11. People can overcome obstacles if they truly want to. ____
12. The mind is fundamentally physical. ____
13. Some spiritual part of us survives after death. ____
14. Each of us has a soul that is separate from the body. ____
15. All mental processes are the result of activity in the nervous system. ____
16. The mind is a nonmaterial substance that interacts with the brain to determine behavior. ____
17. Minds are inside brains but not the same as brains. ____
18. Some nonmaterial part of me (my mind, soul, or spirit) determines my behavior. ____
19. My mind (consciousness, memory, will) is an emergent property of my brain and cannot be separated from it. ____
20. The mind and the brain are the same thing. When I use the word "mind," it is just a shorthand term for the things my brain does. ____
21. Minds are in principle independent of bodies, to which they are only temporarily attached. ____
22. For each thought that I have, there exists a certain state that my brain is. ____

Religion

23. What are your religious beliefs? (0 = *not religious*, 7 = *deeply religious*) ____
24. Please indicate the extent to which you believe in the existence of a Supreme Being or God (or supreme beings/Gods). (0 = *not at all*, 7 = *completely*) _____

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Notes

1. The good explanation said that "The researchers claim that this 'curse' happens because subjects have trouble switching their point of view to consider what someone else might know, mistakenly projecting their own knowledge onto others."

2. For genetic determinism, five items were taken from Keller's (2005) work (e.g., "I think the chief reason why parents and children are so alike in behavior and character is that they possess a shared genetic inheritance."). For scientific determinism, three items were taken from Paulhus and Carey's (2011) work (e.g., "People's biological makeup influences their talents and personality."). For free will, another three items were taken from Paulhus and Carey's (2011) work (e.g., "Bad behavior is caused by bad life circumstances."). For dualism, 11 items were taken from work conducted by Hook and Farah (2013; e.g., "Some nonmaterial part of me (my mind, soul, or spirit) determines my behavior") and Stanovich (1989; e.g., "Minds are inside brains but not the same as brains."). Finally, for religion, we used two items inquiring about religiosity and belief in a supreme being (e.g., "What are your religious beliefs (not religious versus deeply religious)?").

3. Of the participants who passed the Instructional Manipulation Check, 25 passed it in the first try. Another 83 participants failed the Instructional Manipulation Check the first time but passed it after receiving a warning. Another 29 failed even that second time and, therefore, were excluded from the data analysis.

4. Analyses are averaged across items. As an exploratory analysis, we also looked to see if type of superfluous information exerted a bias at the level of individual items. For most items (16 of 18 for the good explanations; 12 of 18 for the circular explanations), the neuroscience information was rated higher than the hard science information. Thus, the effect did not appear to be driven by a few outliers. Next, we assessed possible differences within the hard sciences information, given that the superfluous information drew from a diverse set of disciplines, including genetics (n = 6); biology and biochemistry (n = 6); and math, physics, and computer science (n = 6). We entered the data from the item analysis into a 2 × 2 × 3 mixed ANOVA, with Quality of argument (circular, good) and Domain (neuro, hard science) as within-item factors and "Item set" as a between-item factor. Each set had six items grouped according to the nature of the information provided in the hard science condition. For example, "curse of knowledge" was in Set 1 because the hard science information provided for it was about DNA and epigenetics, whereas "binocular rivalry" was in Set 2 because the hard science information about it drew on biology and "mental imagery" was in a Set 3 because the hard science information about it was a mathematical formula. This analysis showed the expected main effects of Argument quality, $F(1, 15) = 13.7$, $p = .002$, and Domain, $F(1, 15) = 9.1$, $p = .008$. Most importantly, it showed no interaction between Set and Domain ($p = .32$). For all three disciplines, the bias was in the expected direction (neuro > hard) [genetics: 4.76 vs. 4.53; bio: 4.81 vs. 4.1; non-bio: 4.4 vs. 4.1]. In summary, the effect of neuroscience was not limited to a comparison with a single hard science discipline, but rather it generalized across all three.

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