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Neuroscience and You: A look into societal interaction with neuroscience both internally and online

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By

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Introduction

In the early 1990's Former President George H. W. Bush declared the "Decade of the Brain." As he put it, the purpose of such a declaration was to "enhance public awareness of the benefits to be derived from brain research" (Bush, 1990.) This declaration was brought about through the intense urging of a dedicated group of scientist who were passionate about the neurological discoveries of the 20th century and acutely aware of the benefits these discoveries could have for society at large (Goldstein, 1994). Spearheaded by the National Institute of Neurological Disorders and Stroke (NINDS) and the National Institute of Mental Health (NIMH) and backed by the Bush Administration, public funding and publish support for neuroscience research flourished.

This declaration left a lasting impact on the public that is still felt today. In 2010, a group of neurophilosphers conducted a content analysis on all of the news articles published between 1995 and 2004 from major U.S. and U.K. English-language news sources (Racine, Waldman, Rosenberg, & Illes, 2010). The time period corresponds to the height of the "Decade of the Brain." Racine (2010) were particularly interested in understanding public support for the neurosciences through media coverage of technologies in the field. They found that during the ten-year period, 1,256 articles reported on the brain and neuroscience technology in some capacity (Racine et al., 2010). The tone of these articles was overwhelmingly positive; however, even in articles that were considered "research reports" very little detail about these technologies and discoveries were provided (Racine et al., 2010). Racine's findings highlight a very important concern in the sensationalism of neuroscience findings and the lack of public understanding about these findings.

The primary objective of this work is to address how members of the public both consume and understand neuroscience information. This overarching question will be tackled in two distinct studies. The first questions the validity of sensationalizing neuroscience findings through investigating the effect of neuroscientific information on assessments of moral judgments. The second study proposes a manner by which we can correct the spread of misinformation in neuroscience utilizing social media platforms.

The Influence of Scientific Explanations on

Assessments of Moral Responsibility

Ciarra Smith and John Bickle

INTRODUCTION

As science advances, we become better at ascribing causal relationships between biochemical processes and behavior. Scientists are certain that mutations to BRCA1 and or BRCA2 genes increase the risk of developing cancer later in life (Miki et al., 1994). However, scientists are less certain how mutations in monoamine oxidase A (MAOA) are associated with violence and aggressive behavior (Buck, 2014). Even still, scientific information has been used in criminal proceedings as a means of reducing sentencing in some cases. In some instances sentences were reduced from first-degree murder to a lesser charge of second-degree murder (Bernet, Vnencak-Jones, Farahany, & Montgomery, 2007). The distinction between first- and second-degree hinges entirely on the perception of premeditation or in other words, impulsivity.

Furthermore, the precise influence of scientific data in courts has been difficult to determine. When presented with scientific explanations for behaviors, judges are likely to find the same data mitigating or aggravating in determining punishment (Feresin, 2009). In one study conducted on U.S. state trial judges, researchers found cases that included biochemical data were likely to be interpreted by the judges as mitigating factors but in those instances, the judges were also likely to point towards a larger number of other factors that they considered aggravating (Aspinwall, Brown, & Tabery, 2012). In a population of college students and suburban residents, another research team attempted to examine differences in perceived culpability when participants were presented with physiological explanations (chemical imbalance) or experiential explanations (abusive parents) (Monterosso, Royzman, & Schwartz, 2005). Monterosso et al, found physiological explanations to have a higher influence on the reduction of culpability. However, the research team only addressed instances in which the characters described in the vignettes performed actions deemed negative or immoral.

The present study goes a step further by assessing changes in perceived culpability when the actor performs both a generally positive or moral action and a generally negative or immoral action. Additionally, the present study subdivides the "physiological" explanation into two categories, neuroscience and genetics. The reason for division emphasizes the novel use of the magnetic resonance imaging as evidence for mitigating information in courts (Aspinwall et al., 2012). Consistent with previous studies, we believe physiological explanations will have more influence on participants in reducing culpability in both negative and positive actions. Furthermore, we posit neuroscience explanations as likely to have greater influence in assessments of blame and responsibility relative to genetic or experiential/psychological information due to its popularity in the public sphere.

METHOD

The research protocol was reviewed and approved by the Institutional Review Board at Mississippi State University. All participants viewed a consent form and agreed to participate.

Participant Characteristics

Four hundred Amazon Mechanical Turk (MTurk) participants ages 18 or older and located in the United States were invited to participate in the web-based survey. The participants were randomly assigned to one of eight conditions. Participants who failed the manipulation check were excluded from the survey (N = 12). The results of three hundred and eighty-eight participants are reported here (Table 1). The mean age of the participants was 34.8 (SD = 10.69) with 63% identifying as male. In regard to race and ethnicity, 76.3% of participants were white, 15.5 % were black or African American, 6.2% were Asian, and 14.7% were Hispanic or Latinx.

Participants were more well-educated than the U.S general public with 62.9% holding a bachelor's degree or higher (compared to 30.9% in the general population; United States Census Bureau, 2017). The political ideology of the participants skewed toward liberal with 12.9% identifying as very liberal, 32.3% as liberal, 8% as very conservative, and 20.1% as conservative. Participation in this study was voluntary and participants were compensated $0.75 for completion of the survey.

Measures

Participants viewed one of two short vignettes of an actor performing in an impulsive action. They also evaluated a series of five false science statements and six true science statements (statements were taken from Kahan, 2017, and Smith, Davern, Freese & Hout, 2018) to measure science literacy. Participants were asked to rate whether each statement was true or false. Additionally, participants were asked to indicate the level to which they agreed or disagreed with statements addressing deference to scientific authority (Brossard & Nisbet, 2007), science-efficacy (Fives, Huebner, Birnbaum, & Nicolich, 2014) and a free will inventory developed by Nadelhoffer, Shepard, Nahmias, Sripada, & Ross (2014). The free will inventory evaluated the participants belief in free will, determinism, and dualism. All statements are provided in the appendix.

Stimulus

The vignettes were taken from Knutson (2010) and were determined from Knustson's study to be relatively equal in terms of morality/immorality in which one vignette was deemed moral and the other immoral. The two were also relatively opposite equivalents in norm violation, social affect, and intentionality. Vignettes are provided in the appendix. Participants were asked to evaluate the action and actor on the morality of the action, moral responsibility of the actor, blameworthiness of the actor, likelihood of recidivism, and a self-evaluation (Monterosso et al., 2005).

Research Design

The experiment was embedded in a web-based Qualtrics survey that was administered to approximately 400 adults (aged 18 or older) in the U.S. through Amazon Mechanical Turk (MTurk) in February 2019. Participants were paid $0.75 for completing the survey. It utilized a 2 (Action: positive vs. negative) x 3 (Scientific Explanation: neuroscience, genetics, environmental) between-subjects experimental design with one "no explanation" control group. Participants were randomly assigned to one of eight conditions.

In the scientific explanation conditions, participants viewed a short vignette describing an action that was considered to be either moral or immoral. Then scientific information about the actor was presented to the participant. In the neuroscience condition, participants were informed that "[a]n fMRI scan of this individual's brain indicates increased activity in the VTA of the prefrontal cortex. This region of the brain is highly correlated with the regulation of impulsive behavior. Other individuals with this level of activity have been known to engage more often in impulsive behavior." In the genetic condition, participants were informed that "[a] sample analysis of this individual's blood indicates reduce expression of the gene coding for 5-HIAA. This molecule is highly correlated with the regulation of impulsive behavior. Other individuals with this level of expression have been known to engage more often in impulsive behavior." In the environmental condition, participants were informed that "[a]n inquiry into this individual's background indicates high rates of petty theft and violent crimes in their childhood neighborhood. These crime rates are highly correlated with individuals who display impulsive behaviors. Other individuals from these types of neighborhoods have been known to engage more often in impulsive behavior." After viewing one or none of these additional scientific explanations, participants were asked to evaluate the morality of the action, the moral responsibility of the actor, the blameworthiness of the actor, the likelihood the actor will commit the action again, and the degree to which the participant felt they would perform the action given the same scientific factors where true of them.

RESULTS

The hypothesis presents a variation in the type of scientific explanatory information on the assessment of five factors, moral responsibility, blameworthiness, likelihood of recidivism, beliefs about self, and the morality of the action. The hypothesis explicitly posits neuroscientific explanations has the most likely to move beliefs about all five factors relative to the no explanation control subjects. The present study utilizes multiple independent paired t-tests to evaluate the effectiveness of the scientific explanations to alter responses to the five factors when participants are confronted with both a positive and negative action.

The results for the free will assessment were combined into an index and are as follows. On a seven-point scale, participants had a higher belief in free will ($M = 5.1$, $SD = 1.2$, $\alpha = 0.856$) than determinism ($M = 3.7$, $SD = 1.51$, $\alpha = 0.892$) and dualism ($M = 2.4$, $SD = 1.36$, $\alpha = 0.67$). Out of a total of nine points, participants had an average science literacy of 6.9 ($SD = 1.67$). The science efficacy of the subjects was relatively high at 4.0 ($SD = 0.68$, $\alpha = 0.799$) on a five-point scale. The participant's deference to scientific authority was also relatively high 3.9

(SD = 0.80, α = 0.664) on a five-point scale. All questions can be found in the appendix. Lastly, we collected demographic items provided in the participant characteristics (Table 1).

Table 1

Demographics

Characteristic	M	(SD)
Age, mean	34.8	10.69
Science Literacy	6.9	1.67
Belief in Free Will	5.1	1.2
Belief in Determinism	3.7	1.51
Belief in Dualism	2.4	1.36
Deference to Scientific Authority	3.9	0.8
Science Efficacy	4.0	0.68

Characteristics	n	%
Education		
High School graduate or GED	48	12.4
Some college	59	15.2
Technical School	7	1.8
Associate Degree	30	7.7
Bachelor's Degree	185	47.7
Some postgraduate	6	1.5
Master's Degree	41	10.6
PhD, law, or medical degree	12	3.1
Gender		
Male	244	63.0
Female	141	36.4
Other	2	0.5
Ethnicity/Race		
White	296	76.3
Black or African American	60	15.5
Asian	24	6.2
Hispanic/Latino	57	14.7
American Indian/Alaska Native	11	2.8
Other	8	2.1
Political Leaning		
The Republican Party	44	43.6
The Democratic Party	57	56.4

Ideology		
Very Conservative	31	8.0
Conservative	78	20.1
Moderate	104	26.8
Liberal	125	32.2
Very Liberal	50	12.9
Religious Attendance		
More than once a week	15	3.9
Once a week	69	17.9
Once or twice a month	45	11.7
A few times a year	49	12.7
Seldom	54	14.0
Never	154	39.9

Table summarizes the participant demographics for study one. The top section of the table presents mean and standard deviations for the scales and indexes. The bottom section of the table contains the percentage of the tested population exhibiting the specified characteristic.

Positive Action

Overall, participants exposed to the scientific explanation containing an environmental explanation for behavior were the most likely to produce significant changes in belief relative to no explanation control subjects (refer to Table 2). In the question of moral responsibility, those exposed to the environmental explanation indicated a significant reduction in attributing moral responsibility of the actor to the performed action comparative to the control (M=5.01, SD = 1.64, $t_{73.558}$= 2.139, $p < 0.05$). This reduction is smaller but not significant when compared to the mean score from participants exposed to the neuroscientific explanation (M = 5.32, SD = 1.42, $t_{77.754}$ = 0.921, p = 0.360). While participants exposed to the genetic explanation for behavior did not significantly differ from control subjects (M = 5.84, SD = 1.03, $t_{95.619}$ = -0.615, p = 0.543) this reduction in assessment of moral responsibility was the only significant distinction across all measures comparatively to the neuroscientific explanation subjects ($t_{87.327}$ = -2.074, $p < 0.05$).

Concerning factor two, beliefs about blameworthiness interpreted here as an attribution of accountability, all experimental groups reported a greater attribution comparative to the no explanation control group (M = 5.69, SD = 1.32). The neuroscientific explanation (M = 4.82, SD = 1.64), the genetic explanation (M = 4.67, SD = 1.96), and the environmental explanation (M = 4.83, SD = 1.70) expressed no significant variation between the three factors in an one-way analysis of variance [$F(2, 135) = 0.236$, $p = 0.79$].

Factor three, an assessment of the actor's likelihood of recidivism based on the scientific explanation, found a significant reduction only with the presentation of the environmental explanation (M = 4.68, SD= 1.31, $t_{85.313} = 2.396$, $p < 0.05$). Again, this difference was significant comparatively to the mean value for participants who viewed a neuroscientific explanation (M = 5.47, SD = 1.17, $t_{78.800} = 2.984$, $p < 0.05$).

The fourth factor asked participants to rate their likelihood of committing the same action given the scientific explanations provided for the fictitious actor was true of them. Similar to factor two, all explanations provide a marginal increase in the belief that the participants would perform the action relative to the control (M = 4.37, SD = 1.75). However, in a one-way ANOVA neither of the explanations produced significant results [$F(2,135) = 0.405$, $p = 0.668$].

The final factor asked participants to assess the morality or immorality of the action. No explanation control subjects evaluated the action as highly moral (M = 6.13, SD = 1.19) on a seven-point Likert scale. This assessment is comparative to the mean value of morality determined from the original article (Knutson et al., 2010). Across all three experimental groups, the presentation of the scientific explanations for behavior reduced assessments of the actions. Again, the only experimental group that showed significance were the participants who viewed an environmental explanation for the actor's actions (M = 5.03, SD = 1. 39, $t_{76.793} = 4.045$, p <

0.001). Additionally, this value is significantly smaller than the means from participants who viewed neuroscientific explanations (M = 5.80, SD = 1.43, $t_{83.985} = 2.547$, $p < 0.05$). However, the variation between the genetic explanation group (M = 5.86, SD = 1.19) is non-significant comparative to the neuroscientific explanation group ($t_{91.311} = -0.245$, $p = 0.807$).

Table 2: Mean values for the Positive Action

	Control *N = 52*		Neuroscience *N = 49*		Genetics *N = 49*		Environmental *N = 40*	
Factor	M	SD	M	SD	M	SD	M	SD
Q1: This person is morally responsible for their actions	5.69	1.32	5.32	1.42	5.84†	1.03	5.01*	1.64
Q2: This person is blameworthy for their actions	3.48	2.10	4.82**	1.64	4.67*	1.96	4.83*	1.70
Q3: This person will commit this action again	5.35	1.36	5.47	1.17	5.26	1.35	4.68*†	1.31
Q4: Try to put yourself in this person's shoes. If all the same facts were true of you, do you think you would have behaved the same way?	4.37	1.75	4.61	1.67	4.86	1.81	4.56	1.55
Q5: This action is immoral - moral	6.13	1.19	5.80	1.43	5.86	1.19	5.03**†	1.39

**p<0.05 compared to control*
***p<0.001 compared to control*
†p<0.05 compared to neuroscience
††p<0.001 compared to neuroscience

Negative Action

In evaluating the variation in assessments for the same five factors, participants who read the vignette of an actor performing a negative action were much more likely to produce a change in belief relative to the control as a result of the genetic and neuroscientific explanations (refer to Table 3). In factor one, those exposed to genetic (M = 5.20, SD = 1.51) and neuroscientific (M = 5.65, SD = 1.29) explanations recorded a reduction in moral responsibility relative to the control groups (M = 5.88, SD = 1.34). Only the genetic explanation was significant comparatively to the control groups ($t_{97.027} = 2.402$, $p < 0.05$). The environmental explanation (M = 6.23, SD = 1.21) suggested an increase in moral responsibility comparatively to the neuroscientific explanation group ($t_{94.994} = -2.300$, $p < 0.05$).

Concerning factor two, a similar trend was determined. Attribution for accountability is reduced when participants viewed a neuroscientific explanation for behavior comparatively to no explanation control subjects (M = 5.50, SD = 1.57, $t_{73.894} = 3.631$, $p < 0.001$). The same can be said for participants who viewed genetic explanations for the actor's behavior (M = 5.24, SD = 1.55, $t_{74.695} = 4.734$, $p < 0.001$). The environmental explanation did not significantly differ from the control but did from groups that viewed either the neuroscience or genetic explanations (M = 6.17, SD = 1.43, $t_{72.604} = 1.014$, $p = 0.314$).

There was some variation in the assessment of factor three, a determination of the likelihood of recidivism. Participants who were exposed to neuroscientific explanations (M = 5.62, SD = 1.38) and those exposed to environmental explanations (M = 5.50, SD = 1.50) where slightly more likely to suggest the actor would commit the action again relative to the control (M = 5.49, SD = 1.101). Participants that viewed genetic information were slightly less likely to believe the actor would commit the action again relative to the control (M = 5.28, SD = 1.26).

On the fourth factor, all four factors increased the participants' beliefs that they might also perform the same action given the circumstances described in the explanations. Neuroscience and genetic explanations again play the largest role in influencing the participants' beliefs. An independent paired samples t-test showed the neuroscientific explanation to produce a significant effect on assessments of personal likelihood to commit the action (M = 4.00, SD = 1.87, $t_{97.629} = -2.743$, $p < 0.05$). Those exposed to genetic information also produced a significant increase (M = 3.92, SD = 1.83, $t_{97.098} = -2.568$, $p < 0.05$). Participants exposed to the environmental explanation produced a marginal increase in believing themselves likely to commit the same action comparative to the no explanation control group (M = 3.39, SD = 2.40).

In the final factor, participants were asked to assess the morality or immorality of the action. The no explanation control subjects rated the action at a 2.56 on a seven-point Likert scale in which 1 was immoral and 7 was moral. This value is about equivalent to the mean score determined in the original work by (Knutson et al., 2010) The presentation of the explanations only slightly increased the morality of the action. Those exposed to the neuroscientific information determined the action to be only marginally less immoral or marginally more moral (M = 3.10, SD = 1.59, $t_{95.689} = -1.557$, p = 0.123). Participants who viewed the genetic explanation also reduced determined the action to be slightly less immoral (M = 3.24, SD = 1.71, $t_{97.268} = -1.901$, p = 0.60). Again, those viewing environmental explanations reduced the immorality of the action (M= 2.87, SD = 1.72, $t_{94.982} = -0.856$, p = 0.394).

Table 3: Mean Values for Negative Action

	Control		Neuroscience		Genetics		Environmental	
	N = 51		*N = 50*		*N = 50*		*N = 47*	
Factor	M	SD	M	SD	M	SD	M	SD
Q1: This person is morally responsible for their actions	5.88	1.34	5.65	1.29	5.20*	1.51	6.23†	1.21
Q2: This person is blameworthy for their actions	6.41	0.83	5.50**	1.57	5.24**	1.55	6.17†	1.43
Q3: This person will commit this action again	5.49	1.01	5.62	1.38	5.28	1.26	5.50	1.50
Q4: Try to put yourself in this person's shoes. If all the same facts were true of you, do you think you would have behaved the same way?	2.90	2.15	4.00*	1.87	3.92*	1.83	3.39	2.40
Q5: This action is immoral - moral	2.56	1.86	3.10	1.59	3.24	1.71	2.87	1.72

**p<0.05 compared to control*

***p<0.001 compared to control*

†p<0.05 compared to neuroscience
††p<0.001 compared to neuroscience

DISCUSSION

It must first be made clear that none of the three types of explanations are currently known to be causal. Given the multitude of differing explanations to exonerate and absolve individuals of blame it is important to determine how differing types of scientific explanations influence popular perception of blame and accountability.

In the case of the positive or moral action, environmental explanations overwhelmingly influence beliefs about a fictitious actor comparatively to either neuroscience or genetic information when the action performed in generally considered positive or moral. In the case of the negative action, there was a tendency of physiological information to have greater influence on assessments, of blame, responsibility, and morality as expected. However, the expected greater influence of neuroscience explanations or neuroscience information was disproved. The data suggests that as of now, there is very little distinction between how types of physiological scientific information is internalized and analyzed among members of the public.

The findings of this study enhance the general body of knowledge on attribution theory given the context of science and morality. Kelley's (1973) work in attribution theory further divides the model into internal (personality) and external (situational) attribution. Furthermore, the phenomena of the correspondence bias explains peoples' tendency to apply greater importance to internal attributes rather than external attributes when assessing another's behavior. Additionally, previous studies indicate that belief in free will is positively correlated with the correspondence bias (Genschow, Rigoni, & Brass, 2017). Given the high evidence of belief in free will in the tested subjects it would be expected that all of the scientific explanations should move participants to evaluate blame and responsibility in similar direction for the positive and the negative actions; however, there was a clear distinction in which types of scientific explanation were likely to influence perceptions of culpability depending on the perceived morality of the action. The explanations address internal attributions it is plausible that the tested subjects perhaps perceived physiological explanations (neuroscience and genetics) as external attributes. Although this determination is outside the scope of this study, it does pose a question to be considered in further studies of the effect of science as a mitigating or aggravating factor in perceptions of moral responsibility.

Correction of Misinformation in Neuroscience Using Social Media

Ciarra Smith and Holli Seitz

INTRODUCTION

The scientific and healthcare communities must often contend with a misinformed public. In 2017, a measles outbreak hit a small Somli-American community in Minnesota (Hall, 2017). Of the 65 confirmed cases, 62 individuals where unvaccinated (Hall, 2017). The community decision to not vaccinate against the disease was directly linked to concerns raised in 2008 about the false association between the development of autism and receiving the MMR vaccine (Hall, 2017). This case, and others like it, go beyond a lack of understanding on the topic at hand, but include a deeply held belief in false information. Misinformation spread among a local or even national community can have deleterious consequences for local and national health. If not addressed, misinformation in public health can and will undermine evidence-based public health efforts (Tan, 2015; van der Meer, 2018).

Correcting misinformation is notoriously difficult. However, it is suggested that one of the best methods for correcting misinformation is the immediate presentation of corrective information following the misinformed belief (Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012). In line with this thread of reasoning, researchers attempted to address the peer-to-peer spread of misinformation via social media by means of Facebook's "related story" algorithm (Bode & Vraga, 2015). The research provides some promising results, among individuals who held misperceptions about the relationship between GMOs and illnesses, those exposed to debunking articles experienced a change in belief. Participants who viewed mixed message articles where not likely to change their beliefs (Vagra and Bode, 2015). The present study adopts the methodology of Vagra and Bode with a few additional modifications particularly by attempting to correct misconceptions in neuroscience (hereafter referred to as neuromyths)

Addressing misinformation in fields such as neuroscience where public interest in high polarized language is low can help us to generalize a unique method for misinformation correction in the health sciences. This study utilizes neuromyths established by OECD and Dekker and attempts to correct the misinformation using a modified version of the Varga and Bode strategy that take advantage of Facebook's "related article" feature. The primary study uses a 3 (Neuromyth: language acquisition vs. 10% brain vs. hemispheric dominance) x 5 (Related article position: confirm misinformation, correct misinformation, confirm then correct misinformation, correct then confirm misinformation, unrelated) between-subjects experimental design with one "no message" control group. We evaluate three separate myths with varying levels of public belief in order to test the ability of suggested news articles to sway belief in misinformation across a more generalized topic. We believe that among participants who believe neuromyths, belief change (as measured by changing from "True" to "False" and a decrease in certainty) will be greater among those exposed to correcting related articles than those exposed to confirming, mixed, or unrelated related articles

METHODS

This research protocol was reviewed and approved by the Institutional Review Board at Mississippi State University. All participants viewed a consent form at each phase or research and agreed to participate.

Participant characteristics

One thousand, three hundred and thirty-nine Amazon Mechanical Turk (MTurk) participants ages 18 or older and located in the Unites States were invited to participate in the pretest survey. The mean age of participants was 36.7 (SD = 11.6), and 48% identified as female. In regard to race and ethnicity, 84.2% identified as white, 8.8% identified as black or African American, 6.8% identified as Asian and 10.9% identified as Hispanic or Latinx (a full break down of participant characteristics can be found in Table 4). Pretest participants were slightly more well-educated than the general U.S. population with 53.8% having a bachelor's degree or higher (compared to 30.9% in the general population; (compared to 30.9% in the general population; U.S. Census Bureau, 2017). The pretest population was skewed slightly liberal. Forty-six-point-one percent of participants identify as Democrats, 25.8% identify as Republicans, and 26.4% identified as Independents. Participants were asked about their Facebook usage and over 50% indicated they use the social media platform several times a day.

All pretest participants were asked to participate in the main experiment. Seven hundred and forty-four participants completed the main experiment in addition to the pretest experiment. There were very few significant differences in the characteristics of the pretest participants comparatively to the main experiment participants. The main experiment subjects were slightly more literate in science (M = 8.83, SD = 1.73, t_{1336} = -2.84, p = 0.005). Additionally, main experiments were less religious than pretest participants ($\chi^2(1)$ = 12.30, p = < 0.001).

Demographics Table

Characteristic	M (SD)	
Age, mean (SD)	36.7 (11.6)	37.7 (12.0)
*Science Literacy	8.70 (1.80)	8.83 (1.73)
	Pretest % (n)	Experiment % (n)
Education		
Less than high school	0.6 (8)	0.4 (3)
Some high school	1 (13)	1.2 (9)
High School Graduate / GED	8.1 (109)	8.2 (62)

Some college	21.9 (293)	21.7 (163)
Associate degree (Occupational/vocational program)	7.1 (95)	8 (60)
Associate degree in college (Academic program)	7.6 (102)	7.7 (58)
Bachelor's degree	39.8 (533)	41.1 (309)
Master's degree	10.5 (140)	9.3 (70)
Professional School Degree	1.9 (25)	1.5 (11)
Doctorate degree (For example: PhD, EdD)	1.6 (21)	0.9 (7)
Gender		
Male	51.7 (692)	53.1 (399)
Female	48 (643)	46.5 (350)
Ethnicity/Race		
White	84.2 (1128)	83 (624)
Black	8.8 (118)	10.6 (80)
Asian	6.8 (91)	6.6 (50)
*Hispanic/Latino	10.9 (146)	8.5 (64)
American Indian /Alaska Native	1.9 (26)	1.3 (10)
Native Hawaiian / Pacific Islander	0.1 (1)	0 (0)
Other	1.6 (21)	1.9 (14)
Political Leaning		
Republican	25.8 (345)	23.8 (179)
Democrat	46.1 (617)	45.6 (343)
Independent	26.4 (353)	28.7 (216)
Other	1.8 (24)	1.9 (14)
Ideology		
Very conservative	7 (94)	5.7 (43)
Conservative	18.6 (249)	18.2 (137)
Moderate	27.7 (370)	28.2 (212)
Liberal	31.8 (426)	34 (256)
Very liberal	14.9 (199)	13.8 (104)
Religious attendance		
More than once a week	4.2 (56)	3.9 (29)
Once a week	15.6 (209)	13.3 (100)
Once or twice a month	8.7 (116)	7.7 (58)
A few times a year	12.2 (163)	11.6 (87)
Seldom	17.6 (236)	18.5 (139)
Never	41.7 (559)	45.1 (339)
Facebook Usage		
Several times a day	57.1 (716)	57.5 (408)
About once a day	20.7 (260)	21.2 (150)
A few days a week	13.2 (165)	12.8 (91)

Every few weeks	5.6 (60)	4.5 (32)
Less often	3.4 (43)	3.9 (28)
Children must acquire their native language before a second language is learned. If they do not, neither language will be fully acquired	69.4 (929)	71.9 (541)
We only use 10% of our brain	55 (736)	54.1 (407)
Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.	16.8 (225)	16.2 (122)

*religion $\chi^2(1) = 12.30, p = < 0.001$
*science literacy t(1336) = -2.84, p = 0.005

Measures

Pretest. In the pretest, participants were asked age and frequency of Facebook use. The participants were then asked to evaluate three neuromyths and three true statements about neuroscience (see Table 1) from Dekker, Lee, Howard-Jones, and Jolles (2012) and selected from a larger set of statements evaluated in a pilot test. Participants also evaluated a series of five false science statements and six true science statements to measure science literacy (Kahan, 2017 and Smith, Davern, Freese, & Hout, 2018). Neuroscience and general science statements were mixed together and presented in a random order for each participant. Participants were asked to decide wether each statement was true or false and then to rate their certainty regarding the correctness of each response. Participants then responded to demographic items.

Experiment. After viewing the experimental manipulation, participants reevaluated the six neuroscience statements from the pretest. If participants viewed related articles (see Research Design), they evaluated each related article as novel, useful, interesting, trustworthy, credible, and accurate. Participants then completed measure of science efficacy (Fives et al., 2014), deference to scientific authority (adapted from Brossard & Nisbet, 2007), and need for cognition (Cacioppo & Petty, 1982). The present paper will only address the evaluates of the neuroscience statements, other measures will be addressed in a future publication

Research Design

Pretest. A web-based Qualtrics survey was administered to approximately 1,334 adults (aged 18 and older) in the U.S. through Amazon Mechanical Turk (MTurk) in October 2018. Pretest participants completed the measures noted above and were paid $0.25 for completing the survey. Approximately two weeks after completing the pretest, participants were invited to participate in the experiment.

Experiment. The experiment was embedded in a web-based Qualtrics survey. It utilized a 3 (Neuromyths: language acquisition vs. 10% brain vs. hemispheric dominance) x 5 (Related article position: confirm misconception, correct misinformation, confirm then correct misinformation, correct then confirm misinformation, unrelated) between-subjects experimental design with one "no message" control group. Participants were randomly assigned to one of 16 conditions.

In message conditions, participants viewed a simulated Facebook post sharing one of three particular neuromyths (varying by condition; see Experimental Manipulations below). The post included a statement from the Facebook user and a newspaper article that included of the three neuromyths. The post was followed by two related articles that varied by condition. All participants were paid $0.50 for completing the survey.

Experimental Manipulations

Participants in message conditions saw a simulated Facebook page that features a news article posted by a user whose name and image had been covered (See Figure 1). The simulated news article was introduced by the anonymous user with a simple exclamation (e.g., "See, we only use 10% of our brains!) that corresponded to the news article. The news article shown varied according to condition (Neuromyths: language acquisition vs. 10% brain vs. hemispheric dominance). Each news article included the sample simple image of a brain, a headline, and a brief summary, and appeared to come from *The WashingtonPost.* (*The Washington Post* was chosen to follow the methodology used by Bode and Vraga, 2015). On the simulated Facebook page, the statement and article were followed by two related articles that varied according to condition (Related article position: confirm misinformation, correct misinformation, confirm then correct misinformation, correct then confirm misinformation, unrelated). These articles consisted of an image of the source's logo (the first article was always attributed to Snopes.com and the second to the American Medical Association, sources used by Bode and Vraga, 2015), a headline, and a brief article summary. User introductions, article headlines, and article summaries were crafted to be as similar as possible across conditions (See Figure 1 for examples).

Data Analysis

Experiment participants were divided into one of 16 conditions in which they viewed one of three neuromyths (language acquisition vs. 10% brain vs. hemispheric dominance). Participants were asked to evaluate six neuroscience equations as true or false and indicate their level of certainty in their answer, on a 7-point Likert scale during both the pretest and the experiment. The participants correctness score was determined as follows. If participants correctly identified their neuromyth (based on condition) as false, it was coded as +1 for correct. If participants incorrectly identified their neuromyth (based on condition) as true, it was coded as -1 for incorrect. This score was then multiplied by their level of certainty for a new score that ranged from -7 (very certain and incorrect) to 7 (very certain and correct). The correctness score was calculated from both the participant's pretest data and experimental data. We considered this variable interval or analysis purposes.

A neuromyth change score was calculated and utilized as the dependent variable for this study. The change score was determined by subtracting the participants pretest correctness score from their experimental correctness score. This variable ranged from -14 (incorrect) to 14 (correct). To test our belief that those who initially believed the neuromyths and were presented with correcting messages, change in belief would be greater we conducted a two-way analysis of variance (ANOVA) of neuromyth change by neuromyth, related stories, and the interaction between those two factors.

RESULTS

In order to address the hypothesis, we conducted a two-way analysis of variance (ANOVA) with the participants' change score as the dependent variable. The ANOVA tested our two factors, neuromyth by related article condition. The neuromyths were selected based on the results of a pilot study in which participants were asked to evaluate whether a set of general science and neuroscience questions were true or false. Neuromyth 1, the belief that children needed to acquire a first language before a second, was widely believed to be false with 71.9% of experimental participants correctly identifying the myth as untrue. Neuromyth 2 suggested that the average human only uses 10% of their brain. This myth was identified correctly as false by 54.1% of experimental participants. Lastly, neuromyth 3 was the most widely believed myth in the tested population with only 16.2% correctly identifying the myth as untrue (Table 4). The two-way ANOVA yielded a main effect of neuromyth, $F(2, 685) = 7.796$, $p<0.001$ such that the greatest positive change in belief occurred in neuromyth 3 (Figure 1). The mean change of neuromyth 1 was -1.26 (SD = 5.34), the mean of neuromyth 2 was -0.402 (SD = 5.47), and the mean of neuromyth 3 was 0.614 (SD = 4.69). Neuromyth 1 saw the greatest reduction in the change dependent variable (Table 5).

Table 5. Estimated marginal means by neuromyth condition

Neuromyth	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Language acquisition	-1.26	0.333	-1.914	-0.606
10% brain	-0.402	0.344	-1.078	0.274
Hemispheric dominance	0.614*	0.339	-0.05	1.279

The table presents the mean values by neuromyth combining all related article conditions. The greatest positive change occurs in neuromyth 3 (hemispheric dominance) while no significant difference detected between neuromyth 1 (language acquisition) and neuromyth 2 (10% brain).
*significance of $p < 0.05$.

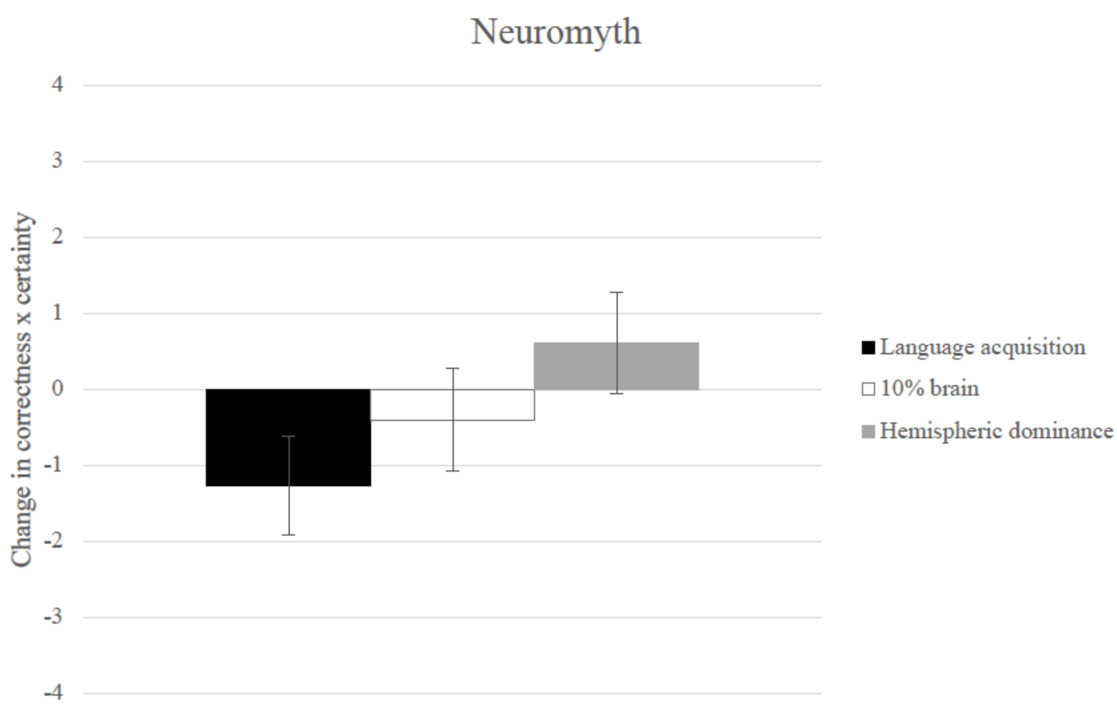

Figure 1: Change in correctness x certainty by neuromyth condition
Figure indicates the change in corrected x certain by neuromyth combing all related article conditions. Error bars indicate the 95% confidence level of each mean.

The additional to neuromyth, the primary factor in the present study was the related article condition. A two-way ANOVA yielded a significant main effect by related article, $F(4, 685) = 4.446$, $p = 0.001$ (Table 6, Figure 2). The greatest positive change for participants occurred within subjects who were presented with two correcting articles (M = 0.573, SD = 5.48). The greatest negative change for participants occurred with subjects who were presented with two confirming articles (M = -1.444, SD = 480) and with subjects who were presented with unrelated articles (M = -1.204, SD = 4.70). The mixed conditions in which one article was confirming and one article was corrected produced relatively similar results with a slight advantage to the conditions in which the corrective article was attributed to the American Medical Association (M = 0.202, SD = 5.11). The mixed condition in which the corrective article was attributed to Snopes.com produced similar results with a mean of 0.127 (SD = 5.71). The two-way ANOVA did not produce a significant interaction effect [$F(4, 685) = 0.716$, $p = 0.677$] among the two factors.

Table 6. Estimated marginal means by related article condition

Related article position	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Confirm misinformation	-1.444	0.414	-2.258	-0.63
Correct misinformation	0.573*	0.443	-0.297	1.443
Confirm/Correct misinformation	0.127*	0.459	-0.773	1.028
Correct/Confirm misinformation	0.202*	0.428	-0.638	1.042
Unrelated	-1.204	0.442	-2.071	-0.337

Table presents the mean change scores by related article condition and across all three neuromyths. The greatest positive change occurs in the two correcting related articles position (correct misinformation). Additionally, significant positive change occurred in the two mixed conditions. There was not significant difference between the confirm misinformation and the unrelated article conditions.

*significance of $p < 0.05$ comparatively from confirming misinformation related article condition

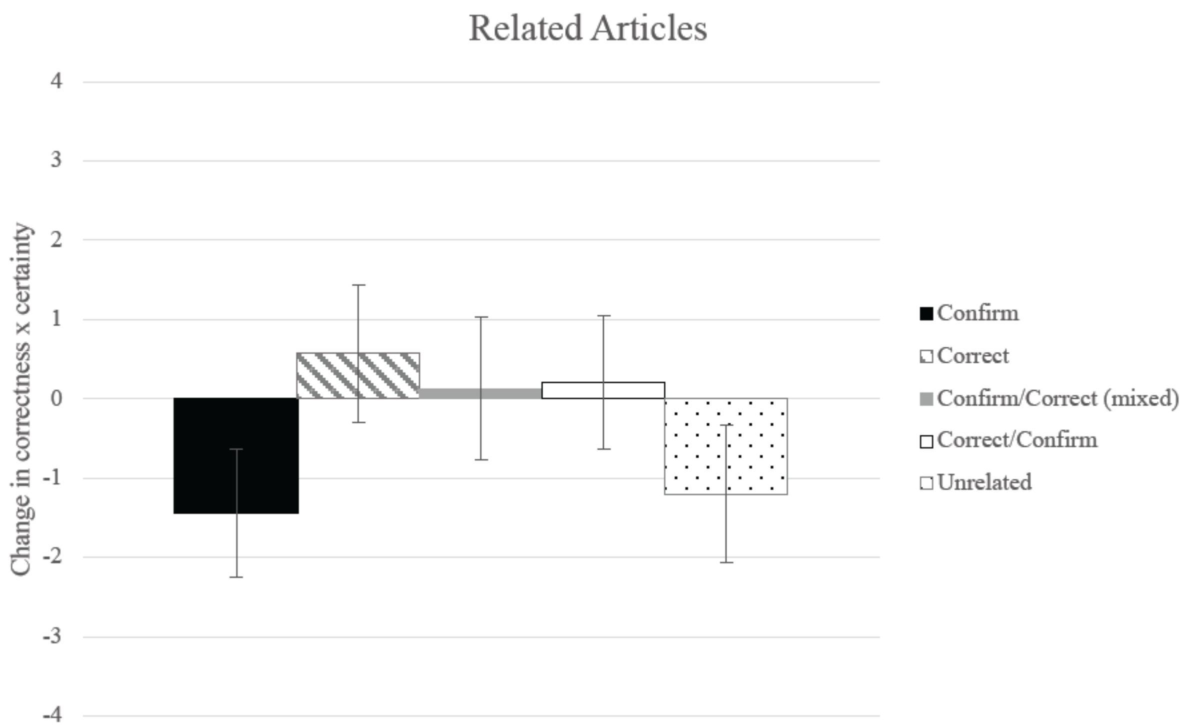

Figure 2. Change in correctness x certainty by related article condition
Figure indicates the change in corrected x certain by related article conditions across all three neuromyths. Error bars indicate the 95% confidence level of each mean

DISCUSSION

Utilizing a modified protocol from Bode and Vagra (2015), we are were able to expand on the body of research addressing the correction of misinformation through social media networks. Specifically, we found that individuals who originally believed in the neuromyth had a larger change in belief when exposed to correcting related news articles as opposed to mixed messages or confirming related articles. This finding confirms the hypothesis. Furthermore, the work presents a procedure that social media companies to utilize to begin the correction of misinformation on their platforms. There is undoubtedly a long way to go in the fight against misinformation with many ethical considerations, but this research provides a step in the right direction.

Concluding Remarks

The field of neuroscience is rapidly changing, and the public is deeply interested in its progression. Neuroscience information has crossed over into a number of different other field including but not limited to ethics, marketing, and education (Illes et al., 2010). The combination of neuroscience and various other field highlights the natural influence neuroscience can and does have on society. For this reason, this thesis explores just a few of the interactions between neuroscience and other aspects of culture.

The first study addresses the impact of neuroscience on our perceptions of other people. The seductive allure of neuroscience explanations (SANE) effect describes the ability of neuroscience information to cloud our judgments (Weisberg, Keil, Goodstein, Rawson, & Gray, 2008). It is the idea that neuroscience is so enchanting, it causes us to belie things we would not ordinarily believe were neuroscience information not present. The SANE effect can mislead us into believing that this effect is specific to neuroscience while that may not be the case. Neuroscience information is intriguing to the public but many members of the public are not yet distinguishing neuroscience from other physiological sciences. The finding begs a more careful understanding of what neuroscience data can and cannot be used as evidence and courts and highlights a greater need for more research on public interpretation of neuroscience data.

The second study presents and interesting method for social media companies to utilize in the fight against "fake news" and misinformation. As mentioned, there is much work left to do on how best to implement such an algorithm such that it protects our natural rights and freedoms of expression but also tampers down the spread of inaccurate data. Both studies provide a framework by which we can begin to assess how members of the public are responding to laboratory science. Research in this field is critical and this work is only the tip of the iceberg.

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Appendix

Study 1: Influence of Scientific Explanations on Assessments of Moral Responsibility

1.1 Vignettes

1.1.1 Positive Vignette: During my commute through downtown, I see a lot of homeless people. One day I was driving and saw a homeless woman walking her dog. I pulled over and gave her some money.

1.1.2 I was staying with a friend who lived in a house of a very famous man. There were many autographed books in the house. I stole one of the books, which was autographed by a very famous celebrity.

1.2 Scientific Explanations

1.2.1 Neuroscience: An fMRI scan of this individual's brain indicates increased activity in the VTA of the prefrontal cortex. This region of the brain is highly correlated with the regulation of impulsive behavior. Other individuals with this level of activity have been known to engage more often in impulsive behavior.

1.2.2 Genetics: A sample analysis of this individual's blood indicates reduce expression of the gene coding for 5-HIAA. This molecule is highly correlated with the regulation of impulsive behavior. Other individuals with this level of expression have been known to engage more often in impulsive behavior.

1.2.3 Environmental: An inquiry into this individual's background indicates high rates of petty theft and violent crimes in their childhood neighborhood. These crime rates are highly correlated with individuals who display impulsive behaviors. Other individuals from these types of neighborhoods have been known to engage more often in impulsive behavior.

1.3 Deference to Scientific Authority (Brossard & Nisbet, 2007)

1.3.1 Scientist know best what is good for the public

1.3.2 It is important for scientist to get research done even if they displease people by doing it.

1.3.3 Scientist should do what they think is best, even if they displease people by doing it.

1.4 Science Efficacy Questions (Nadelhoffer et al., 2014)

1.4.1 I know when to use science to answer questions.

1.4.2 I can use science to make decisions about my daily life.

1.4.3 I know how to use the scientific method to solve problems.

1.4.4 It is easy for me to tell the difference between scientific findings and advertisements.

1.4.5 I can tell the difference between observations and conclusions in a story.

1.5 Free Will Inventory

1.5.1 Free Will Subscale

1.5.1.1 People always have the ability to do otherwise.

1.5.1.2 People always have free will.

1.5.1.3 How people's lives unfold is completely up to them.

1.5.1.4 People ultimately have control over their decisions and their actions.

1.5.1.5 People have free will even when their choices are completely limited by external circumstances

1.5.2 Determinism Subscale

1.5.2.1 Everything that has ever happened had to happen precisely as it did, give what happened before.

1.5.2.2 Every event that has ever occurred, including human decisions and actions, was completely determined by prior events.

1.5.2.3 People's choices and actions must happen precisely the way they do because of the laws of nature and the way things were in the distant past.

1.5.2.4 A supercomputer that could know everything about the way the universe is now could know everything about the way the universe will be in the future.

1.5.2.5 Given the way things were at the Big Bang, there is only one way for everything to happen in the universe after that.

1.5.3 Dualism/Anti-Reductionism Subscale

1.5.3.1 The fact that we have souls that are distinct from our material bodies is what makes humans unique.

1.5.3.2 Each person has a non-physical essence that makes that person unique.

1.5.3.3 The human mind cannot simply be reduced to the brain.

1.5.3.4 The human mind is more than just a complicated biological machine.

1.5.3.5 Human action can only be understood in terms of our souls and minds and not just in terms of our brains.

Study 1: Correction of Misinformation in Neuroscience Using Social Media

1.1 Neuromtyhs (Dekker et al., 2012)

1.1.1 Children must acquire their native language before a second language is learned. If they do not, neither language will be fully acquired.

1.1.2 We only use 10% of our brain.

1.1.3 Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.

1.2 Need for Cognition (Cacioppo & Petty, 1982)

1.2.1 I prefer complex to simple problems.

1.2.2 I like to have the responsibility of handling a situation that requires a lot of thinking.

1.2.3 Thinking is not my idea of fun. [Reverse coded]

1.2.4 I would rather do something that requires little thought than something that is sure to challenge my thinking abilities. [Reverse coded]

1.2.5 I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something. [Reverse coded]

1.2.6 I find satisfaction in deliberating hard and for long hours.

1.2.7 I only think as hard as I have to. [Reverse coded]

1.2.8 I prefer to think about small daily projects to long term ones. [Reverse coded]

1.2.9 I like tasks that require little thought once I've learned them. [Reverse coded]

1.2.10 The idea of relying on thought to make my way to the top appeals to me.

1.2.11 I really enjoy a task that involves coming up with new solutions to problems.

1.2.12 Learning new ways to think doesn't excite me very much. [Reverse coded]

1.2.13 I prefer my life to be filled with puzzles I must solve.

1.2.14 The notion of thinking abstractly is appealing to me.

1.2.15 I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.

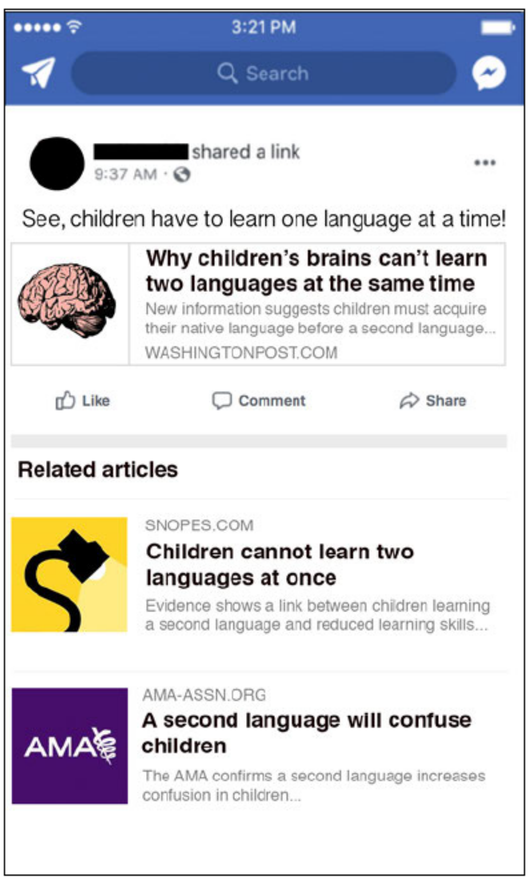
1.2.16 I feel relief rather than satisfaction after completing a task that requires a lot of mental effort. [Reverse coded]

1.2.17 It's enough for me that something gets the job done; I don't care how or why it works. [Reverse coded]

1.2.18 I usually end up deliberating about issues even when they do not affect me personally.

1.3 Example Stimuli

1.3.1 Two Confirmation Related Article Condition



1.3.2 Two Correcting Related Article Condition