

**RELATIONSHIP OF BDNF SNP TYPE AND GENDER DISPARITIES IN THE  
STEM WORKFORCE**

by

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fulfillment of the requirements for the degree of Master of Science in Neuroscience

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## ABSTRACT

The brain derived neurotrophic factor (BDNF) gene encodes for the BDNF protein that is essential for the development of the central nervous system. The BDNF gene consists of a common single nucleotide polymorphism (SNP) that produces an amino acid substitution (valine/Val to methionine/Met) which has been shown to have significant morphological effects, with the Met genotype SNP showing lower hippocampal volume and enhanced encoding of negative word feedback, consequently affecting negative emotional memory regulation. Stereotype threat (ST), defined as being at risk of confirming a negative stereotype about one's group, has been shown to negatively affect performance on math tasks in women. Women in a stressful stereotype threatening condition (i.e., under the impression that men are better than women at math) performed worse on a math task than participants overall. These findings suggest a link between genetic predispositions and environmental factors that engender stress among stigmatized individuals.- Given that Met allele carriers encode negative feedback more regularly than Val allele carriers, Met carriers may be more affected by stressful stereotype threatening contexts. STEM-identifying women in the traditionally male dominated STEM environment may already be susceptible to identity threat. This identity threat effect may be exacerbated by the Met allele SNP. The hypothesis of this study was to examine the modulatory effects of BDNF SNP on the gender distribution in the STEM field. Specifically, women with the Met SNP may experience more negative encoding of stereotype threatening situations in the STEM field. Over time, this may be a contributing factor to the amount of women holding positions in the STEM field.

This hypothesis was tested via three levels of analyses; regional, national, and global, that used BDNF data and STEM occupation data to probe for a possible effect from SNP differences. The regional study from our lab did not reveal an effect; however, national and global analyses revealed that as the Val/Val SNP increases in a population, the number of individuals in STEM fields increases. This interaction was stronger specifically for women in the global study.

The results of these analyses point to a relationship between the Val/Val SNP type and an increasing number of individuals in the STEM workforce, with the relationship being the strongest for women in our global study. This observed relationship highlights the gender differences within STEM. Mitigating the stereotype threat in the STEM workforce in areas where there is less of a Val/Val distribution may contribute to equal gender representation in the STEM workforce.

## **Chapter 1**

### **INTRODUCTION**

#### **1.1 Stereotype Threat**

Although there has been great improvement over the past 50 years, women are still vastly underrepresented in the STEM domain. For example, women make up 47% of jobs in the US, yet they only fill 24% of STEM jobs (Noonan, 2017). A well-studied phenomenon offering an explanation for women's avoidance of STEM is stereotype threat. Stereotype threat (ST) is defined as being at risk of confirming, as self-characteristic, a negative stereotype about one's group. This phenomenon was first proposed by Steele and Aronson in 1995. In their seminal study, Steele and Aronson (1995) tested whether emphasizing African American college students' race prior to taking an exam of academic ability would impact performance (Steele & Aronson, 1995). Steele and Aronson's results confirmed their hypotheses: when the role of race was emphasized before a test that was supposedly diagnostic of their intelligence, African American students performed worse than white students. However, when the role of race was not emphasized on a test that supposedly was not diagnostic of intelligence, African Americans and Caucasian students performed equally well.

In a 1999 study (Spencer et al., 1999), the concept of ST was applied to the gender/math stereotype (i.e. men are better than women at math). Although men and women often perform equally well on math tasks, women perform worse than men when their gender is primed, the math task is complex (Lindberg et al., 2010) and

when the task is framed as diagnostic of mathematical ability. Spencer and colleagues (1999) used men and women from an introductory psychology course pool at the University of Michigan, ensuring that the participants were equally qualified in their math ability. Additionally, participants needed to strongly agree with statements “I am good at math” and “it is important to me that I am good at math”, demonstrating that they identify with math to a large extent (Spencer et al., 1999). The students were given a series of difficult questions from the GRE exam.

Participants were randomly assigned to two conditions: one condition told the participants that there were gender differences in math ability, and the second condition told the participants that there were not gender differences in math ability. Women who were told that there were gender differences in math ability showed a significant decrease in performance on the test. By making the women consciously aware of a negative group stereotype, their performance was negatively affected.

Importantly, later studies revealed that ST contexts may be inherently stressful and that this stress alters memory encoding processes specifically (which possibly mediates the ST effect itself; Schmader, Johns, Forbes, 2008; Forbes et al., 2015; Forbes et. al, 2018). For example, a 2018 EEG study gave moderately math-identified men and women multiple choice multiplication and division problems to solve. The participants were assigned to one of two conditions; they were told that their score on the math test was diagnostic of their mathematical ability (DMT/threat) or they were told that it was a problem-solving task (PST/control). In both conditions, participants had 16 seconds to solve problems and were given immediate, veridical feedback on their answers. Participants saw either the word “correct” or “wrong” in novel fonts that stayed on the screen for 2 seconds. After this task, participants were given a

surprise memory test which assessed how well they remembered the various font/feedback combinations they saw.

Results showed that women in the DMT condition performed worse on the math task compared to everyone else overall, replicating the traditional ST effect. Interestingly, the memory test results showed that all participants on average encoded negative feedback more accurately than positive feedback. Using the EEG data collected during the task, however, Forbes et al. found evidence that only women in the DMT condition encoded negative feedback through an emotional memory neural network. Among DMT women, an indirect relationship was found between amygdala activity (operationalized as a startle response and the harbinger of emotional memory processes) and more accurately encoded negative feedback that was mediated by higher connectivity (i.e., greater communication) in an a priori defined emotional memory network of the brain. This relationship also predicted women's decreased perceptions of ability in relation to their math peers, and importance of the math domain. Thus, to the extent ST contexts are stressful, these findings suggest that memories for these experiences may be altered at a fundamental level to alter perceptions of competency and relevance in the math domain.

These findings also dovetail nicely with basic research on stress and memory encoding as it pertains to the brain. When an individual is placed in a stressful situation, the body and brain physiologically react in a very stereotypic manner. Amygdala activity increases, cardiac output increases (Mendes et. al, 2002), and cortisol levels rise in synchrony via the hypothalamic-pituitary-adrenal (HPA) axis. This stress response has been shown to negatively affect working memory performance (Elzinga & Roelofs, 2005), and it also appears crucial in facilitating

encoding of more negative, emotionally arousing and enduring memories of the stressful experience (McEwan, 1998). Though this can be an adaptive response in the short-term, to the extent women in ST contexts experience this stress response in the aggregate and over time, it suggests these women may develop more negative perceptions and associations with math domains that are mediated by the accrual of more negatively arousing, enduring math-based memories in threatening math contexts (e.g., in situations where they are simply outnumbered by men; Inzlicht & Ben-Zeev, 2000).

Based on these studies, amygdala-based affect and arousal appear to play an important role in how memories and subsequent domain perceptions are forged in stressful contexts like ST contexts. This suggests that differences in the ability to regulate amygdala activity and thus stress may actually modulate the extent to which stressed individuals forge more negative emotional memories in stressful contexts. One such difference may arise via a neurotrophic protein known as brain derived neurotrophic factor, a topic we turn to next.

## **1.2 BDNF Genotype and its Effects on Memory**

Brain derived neurotrophic factor (BDNF), a part of the neurotrophic protein family, is a protein that is essential for the development of the central nervous system, having a particularly large role in neuronal plasticity. BDNF acts by strengthening excitatory synapses and weakening inhibitory synapses (Binder & Scharfman, 2004). The BDNF gene consists of a common single nucleotide polymorphism (SNP) located at nucleotide 196, which produces an amino acid substitution from valine to methionine at codon 66 (Val66Met; Egan et al. 2003). This small substitution in the BDNF gene has been shown to have significant morphological effects, including

lower hippocampal volume in the Met genotype (Molendijk et. al, 2012). BDNF SNPs appear to have a significant role in hippocampal memory encoding. For instance, one fMRI study found that the interaction between the BDNF genotype and the hippocampal response during encoding accounted for 25% of the total variation in recognition memory performance (Hariri et. al, 2003). Importantly, compared to individuals with the Val/Val SNP, individuals with the Met allele exhibited diminished hippocampal engagement during the encoding and retrieval process. Given their reduced ability to regulate emotion, this suggests that Met carriers may be particularly prone to being influenced by emotional memories.

Particularly relevant to women encoding negative feedback in stressful STEM contexts, different BDNF SNPs have been shown to predict encoding of negative feedback specifically. One study using structural and fMRI presented participants with neutral, positive, and negative words. They found that subjects with the Met allele showed increased hippocampal encoding activation of negative words relative to neutral words and compared to subjects with the Val/Val homozygous allele (Molendijk et. al, 2012).

Importantly, individuals with Met/Met and Met/Val genotypes have also been shown to have impaired extinction learning, the mechanism by which one learns to decrease the fear response to an aversive conditioned stimulus. A study observing the effect of BDNF polymorphism type on extinction learning found significant differences for polymorphism type in both mouse models and humans (Soliman et. al 2010). They found that, in both mice and humans, extinction learning was impaired in Met allele carriers relative to non-Met allele carriers. In humans, this meant that Met allele carriers took longer to perceive a neutral cue as a non-aversive threat.

In addition, Soliman and colleagues used MRI to observe the neuroanatomical activity during fear conditioning and extinction. They found that the ventromedial prefrontal cortex (vmPFC) was less active in Met allele carriers than Val- allele carriers. In classic extinction learning, the expected response is to have decreased amygdala responses to the learned fear stimuli over time. However, the amygdala was hyperresponsive in Met allele carriers compared to non-Met allele carriers. These findings are consistent with the fact that the vmPFC is important in mediating previously learned associations and extinction (Milad & Quirk, 2002) and that the amygdala is important in fear conditioning (Phelps et. al, 2004). Furthermore, diffusion tensor imaging analyses revealed that Met allele carriers had reduced connectivity (white matter tracts) between vmPFC and amygdala, suggesting that the inability to extinguish learned fear responses was possibly due to an inability for vmPFC to efficaciously regulate amygdala activity during fear extinction trials. Overall, these findings suggest that BDNF broadly regulates the stress response, and met allele carriers are prone to irregular emotion regulation processes and may encode more negative, emotionally evocative information better as a result. Such findings would be consistent with recent work indicating a direct link between met allele carriers and emotional memory/stress-based disorders like PTSD (e.g., Zhang et al., 2014).

### **1.3 Current Study**

Together, findings from these seemingly disparate literatures suggest a provocative link between genetic predispositions and environmental factors that engender stress among stigmatized individuals. To the extent women in ST contexts (e.g., STEM contexts where they are outnumbered by men) experience stress and

subsequent encoding of more negative, enduring emotional memories in these contexts over time, and BDNF SNPs may modulate the experience of stress and subsequent emotional memory encoding, women may vary in the extent to which they underperform and encode negative emotional memories in STEM contexts if they possess BDNF SNPs known to exacerbate (or attenuate) stress and subsequent memories for these experiences. Given that downstream consequences of the biased encoding processes evoked by ST contexts consist of decreased conscious perceptions of ability and importance of the math domain, these variations in the experience of stress and encoding may even have ramifications for women's decision to leave math intensive domains (i.e., their career choices). That is, critically, women may opt out of stigmatized STEM fields at disproportionate rates compared to men in part because they foster more negative emotional memories and subsequent perceptions of math ability and importance over time. This would be consistent with Steele's argument for why individuals eventually leave stigmatized domains, which is that they do so ultimately to "escape the threat" they otherwise experience on a daily basis (Steele, 1997).

This study thus had three main objectives. First, this study aimed to compare scores on a multiple-choice math task between participants with the Met/Val and Met/Met SNP and the Val/Val SNP randomly assigned to either an ST condition (Diagnostic Math Task or DMT) or a control condition (Problem Solving Task or PST condition). We predicted that individuals with the Met/Val (or Met/Met) SNP would have lower scores compared to individuals with the Val/Val SNP given that ST contexts are known to be stressful, stress has a clear deleterious impact on performance, and individuals with Met/Val SNPs may ultimately have difficulty

regulating stress (via degraded connectivity between the amygdala and vmPFC). Second, this study compared scores on a surprise memory task given after the math task. Given that the Met/Val SNP has been linked to degraded episodic memory but also enhanced encoding of negative feedback specifically (Egan et. al, 2003; Molendijk et. al, 2012) we hypothesized that Met/Val carriers in ST contexts (i.e., stressful contexts) would exhibit higher (more accurate) memory scores for negative feedback received on the math task compared to Val/Val carriers.

Furthermore, this study proposed that the effect of BDNF SNP type on stress coping and memory could ultimately help explain why some women opt out of STEM fields, which may be inherently threatening, in the aggregate. Specifically, women with the Met/Val genotype may be more genetically susceptible to ST (stress) and subsequently may be less likely to remain in STEM careers given the likely exposure to stress in these domains and the accumulation of more negative associations with the domain over time (via encoding of more negative emotional situations). To provide a more veridical, direct test of these hypotheses with the appropriate power required by genetic studies, this was tested by performing a large-scale analysis leveraging BDNF SNP frequency databases with a database outlining the distribution of women and men in given STEM fields at the national and global levels. We expected to find that women with the Met/Val SNP would hold fewer STEM positions than women with the Val/Val SNP.

## Chapter 2

### STUDY 1: REGIONAL LEVEL

#### 2.1 Methods

##### 2.1.1 Participants

Students from the University of Delaware (Male=130, Female=174) were recruited to participate in two studies (Forbes et. al, 2018). Between the two studies, out of the participants that had BDNF SNP data, 182 had the Val/Val SNP, 76 had the Met/Val SNP and 8 had the Met/Met SNP. Participants who did not have experimental data due to not fully completing the study were excluded. This left 180 Val/Val, 74 Met/Val, and 8 Met/Met SNP participants (Male=115, Female=147).

##### 2.1.2 Procedure

Participants were brought into the lab and seated in front of a computer screen. They were randomly assigned to one of two conditions: the control/non-threat condition described the task as a problem-solving math task (PST), while the ST/threat condition framed the task as diagnostic of mathematical (DMT) ability. To prime ST (stereotype threat) in the DMT condition, participants were prompted to answer demographic questions, such as marking their gender (Spencer et. al, 1999). Furthermore, all DMT sessions included at least one male experimenter and had prerecorded instructions read in a male voice to them through headphones. In contrast, participants in the PST condition were not asked to mark their gender prior to the task, and sessions always contained all female experimenters with the instructions read aloud by a female experimenter. After the instructions, participants completed a math feedback task for 34 minutes (described below) and a traditional performance measure

consisting of standard filler math task. Next, participants were presented with a surprise memory test to assess the extent to which they encoded font types associated with negative or positive feedback during the font math task (described below). Participants then answered a series of questions, were debriefed and compensated for their participation.

### **2.1.3 Font Math Task**

The math problems consisted of 100 standard multiplication and division problems (e.g.,  $15 \times 36$ ) with 3 answer choices (a, b, or c) presented below the problem. Participants were instructed to select their answer, and immediately upon selection they were presented with feedback. The words “wrong” or “correct” were presented for 2 seconds in a novel font each time. Participants were given 16 seconds to solve each problem, and if they did not select an answer within the allotted time, they were given automatic wrong feedback. The font math task was adaptive, such that if a participant answered a question correctly, the difficulty of the problem increased. Likewise, when the participants answered a question incorrectly, the difficulty decreased. This allowed all participants to see equal amounts of correct and wrong feedback.

### **2.1.4 Standard Filler Math Task**

To provide a filler task and to also serve as an ST manipulation check, the following task was presented. This task contained 15 difficult math word problems taken from the GRE. Participants were provided with scratch paper and given 5 minutes to solve as many problems as they can. No feedback was provided. Scores

were calculated by dividing the number of correctly answered problems by the number of problems attempted, then the number was multiplied by 100.

### **2.1.5 Memory Task**

Following the math task, participants were presented with the words “wrong” or “correct” in novel fonts, 50 of them being combinations they saw during the font math task and some of them had not been shown (defined as ‘lures’). Participants were instructed to choose a number from 1-6, 1 being “I know I didn’t see it” and 6 being “I know I saw it.” Hits (defined as responses within the range of 4-6 to seen fonts), misses (defined as responses within 1-3 to seen fonts), false alarms (defined as responses within the range of 4-6 to ‘lures’), and correct rejections (defined as responses within the range of 1-3 to ‘lures’). Participants’ ability to accurately discriminate seen from unseen fonts were assessed by calculating  $d'$  (D Prime). The  $d'$  value has been argued to be a more sensitive assessment of memory effects that can account for potential guessing (Wickens, 2002). This was done by subtracting z scores for false alarm rates from z scores for hit rates. A larger  $d'$  value indicated better ability to accurately discriminate seen from unseen fonts, meaning that a higher score reflected a higher chance of the participant choosing a font they were confident they saw and was actually presented to them. A score of zero was exactly at chance level.

### **2.1.6 Exploratory Measures: Dot-Probe Task**

To assess more specific STEM aversion levels, a dot-probe task was conducted following the memory task. For a baseline assessment of aversion, participants were given an initial task where they were presented with a series of threatening and neutral pictures taken from the International Affective Picture System (IAPS, Lang et al.,

2008). For the STEM specific dot-probe task, previously normed threatening pictures related to STEM fields (e.g., pictures of men in lab coats in classrooms, male professors, classrooms full of men, etc) and non-threatening pictures in an academic setting (e.g., women teaching an English class, women in discussion groups, etc) were presented. Participants in front of a computer screen were instructed to fixate at a crosshair in the middle of the screen. One neutral and one threatening stimulus then appeared on the screen for 500 milliseconds. The pictures then disappeared, and a dot appeared in the place of one of those images. Participants had to indicate where the dot was placed as fast as possible. If STEM-oriented stimuli elicit an aversive response, then participants should locate the dot under the threatening stimuli faster than the non-threatening stimuli, as their attention was oriented towards the threat.

## **2.2 Results**

### **2.2.1 Font Math Task**

To assess the effect of Val/Val distribution among regional participants in the lab, a univariate 2 (Gender: Male/Female) x2(BDNF: Val/Val and Met Carriers) x2(Condition: Threat/Control) test was conducted. There was no significant 3-way interaction between gender, BDNF and condition ( $F(1,167)=0.425, p>0.05$ ). No other significant 2-way interactions were observed.

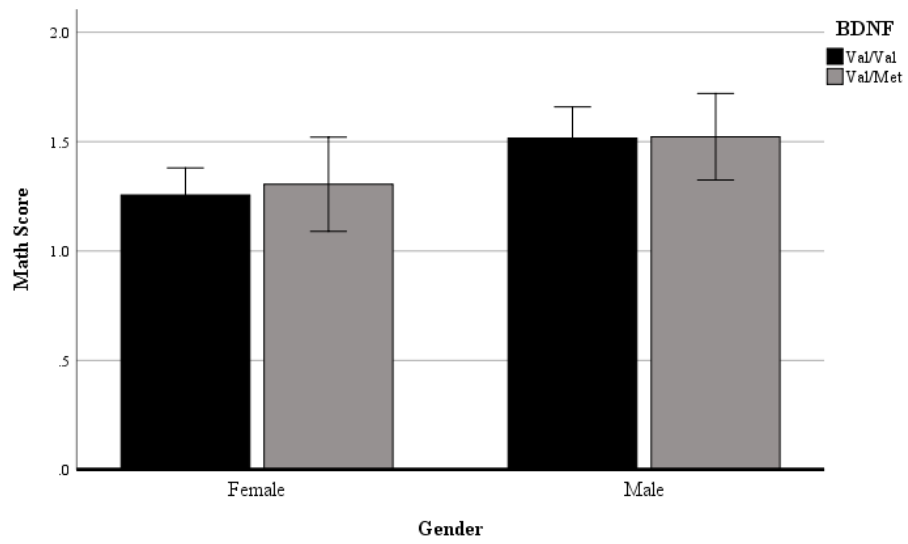


Figure 1. Scores on the font math task for Met carriers and Val/Val carriers by gender in the control condition.

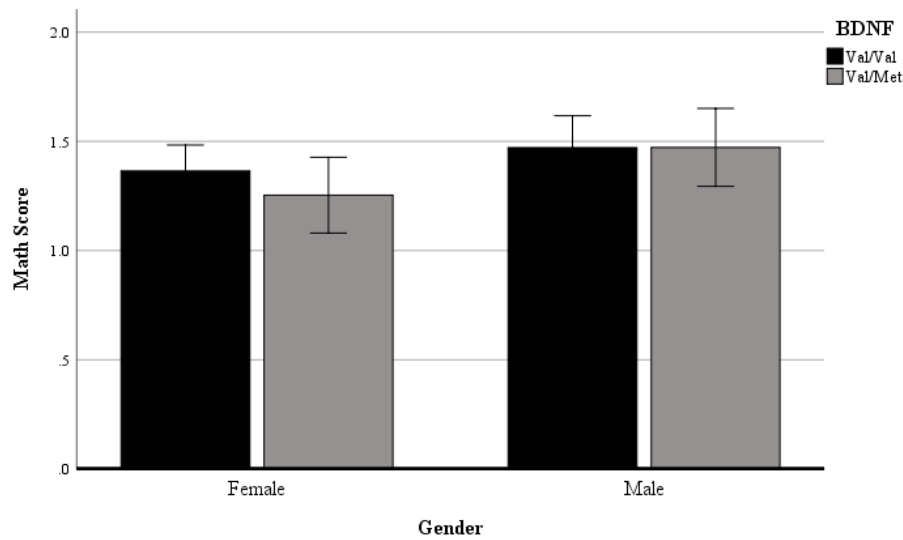


Figure 2. Scores on the font math task for Met carriers and Val/Val carriers by gender in the threat condition.

### 2.2.2 Simulation

Given the small sample size in our data, an exploratory simulation was conducted to simulate a proper genetic analyses. Genetic analyses require large sample sizes to achieve satisfactory statistical power (Hong & Park, 2012). Additionally, the SNP of the participants was unevenly distributed (Val/Val=68.7%, Val/Met=29.8%, Met/Met=1.5%). The data were skewed toward the Val/Val SNP, which may contribute to biased results. A simulation was conducted based off our participants' data.

The simulation was performed by inputting the variables in each condition into SPSS software. The number of participants was increased in the simulation, and the same analysis was run on this simulated data. The simulation yielded equally

distributed men (N=4000) and women (N=4000) in the DMT (N=4000) and PST (N=4000) condition, with an also equally distributed SNP type (Val/Val=4000, Val/Met;Met/Met=4000).

### **2.2.3 Simulation Results**

Results revealed three significant 2-way interactions. There was a significant interaction between BDNF and gender ( $F(1,7992)=37.74, p<0.001$ ). Women with the Val/Val SNP performed significantly better than Met carrier women ( $M_{\text{val/val}}=1.366; M_{\text{Met Carrier}}=1.309, p<0.001$ ). Men with the Val/Val SNP also performed significantly better than men who were Met carriers ( $M_{\text{val/val}}=1.583; M_{\text{Met Carrier}}=1.659, p<0.001$ ). There was a significant interaction between BDNF and condition ( $F(1,7992)=75.71, p<0.001$ ) and between gender and condition ( $F(1,7992)=3.93, p<0.001$ ).

Results also revealed a meaningful three-way interaction between gender, SNP type, and condition ( $F(1,7992)=124.61, p<0.001$ ). DMT women with the Val/Val SNP type performed better than those with the Val/Met;Met/Met SNP type ( $p<0.001$ ). PST women demonstrated the opposite pattern. PST women who had the Val/Val SNP type underperformed in comparison to those who had the Val/Met;Met/Met SNP type ( $p<0.001$ ). Men in the DMT and PST conditions followed similar pattern. Men with the Val/Val SNP type underperformed in comparison to those with the Val/Met;Met/Met SNP type ( $p<0.001$ ).

Further contrasts revealed that women with the Val/Val SNP type in the DMT condition outperformed those in the PST condition ( $p<0.001$ ).

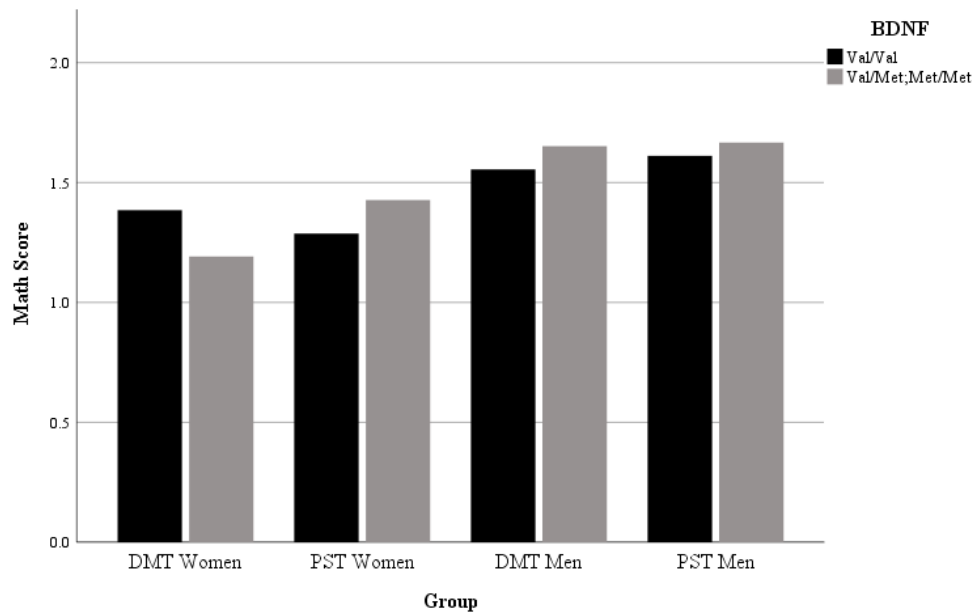


Figure 3. Simulated results of math scores for men and women with the Val/Val and Met carrier SNP in the DMT and PST conditions.

#### 2.2.4 Memory Task

The second univariate 2(Gender: Male/Female) x 2(BDNF: Val/Val and Met Carriers) x 2 (Condition: Threat/Control) analysis used participants' scores on the font memory task. There was no significant interaction between BDNF, gender and condition. There were also no significant 2-way interactions. However, there was a within condition interaction with participants in the control condition ( $M=0.014$ ,  $SD=0.111$ ) performing significantly better than participants in the threat condition ( $M=0.43$ ,  $SD=0.113$ ).

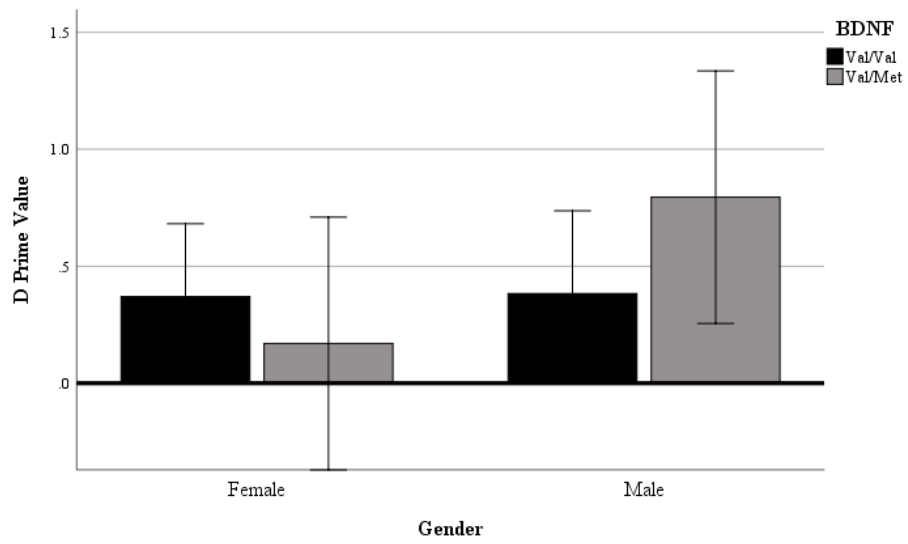


Figure 4. Scores on the memory task when presented with negative feedback for Met carriers and Val/Val carriers by gender in the control condition.

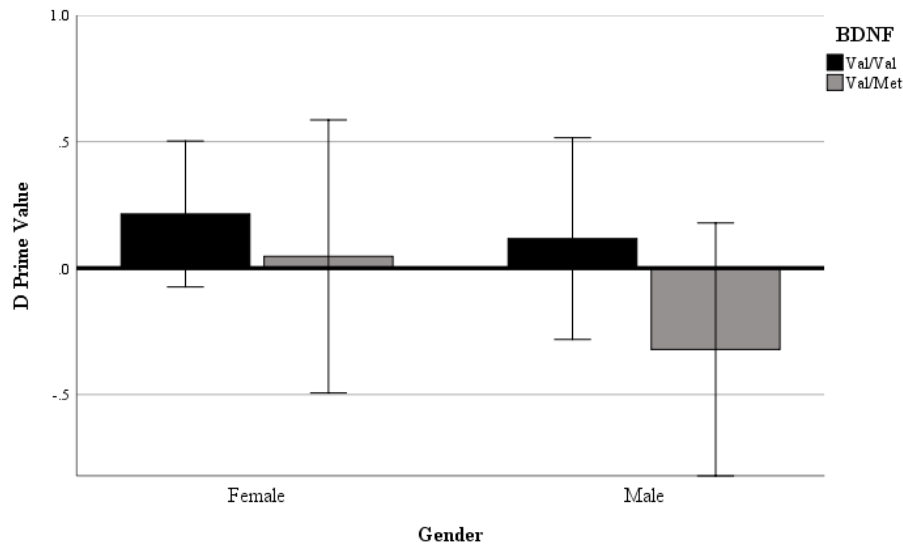


Figure 5. Scores on the memory task when presented with correct feedback for Met carriers and Val/Val carriers by gender in the threat condition.

### 2.2.5 Exploratory Dot-Probe Task Measure

Scores on the dot-probe task were included in the analysis to check for a potential impact on memory task scores. The analysis did not reveal a significant effect on gender ( $F(1,81)=1.68, p>0.05$ ), Val/Val ( $F(1,81)=1.26, p>0.05$ ) or a Val/Val and gender interaction ( $F(1,81)=0.55, p>0.05$ ).

### 2.2.6 Simulation

Like the math task, a simulation was conducted for the memory task scores. The simulation yielded equally distributed men ( $N=4000$ ) and women ( $N=4000$ ) in the DMT ( $N=4000$ ) and PST ( $N=4000$ ) condition, with an also equally distributed SNP type (Val/Val=4000, Val/Met;Met/Met=4000).

There were also two significant 2-way interactions. BDNF and condition were significant ( $F(1,7992)=34.05, p<0.001$ ), and gender and condition were significant ( $F(1,7992)=114.94, p<0.001$ ).

There was a significant 3-way interaction between gender, SNP type, and condition ( $F(1,7992)=66.44, p<0.001$ ). DMT women with the Val/Val SNP type performed significantly better than those with the Val/Met;Met/Met SNP ( $p<0.001$ ). Women in the PST condition followed a similar pattern. Women with the Val/Val SNP outperformed women with the Val/Met;Met/Met SNP ( $p<0.001$ ).

DMT men with the Val/Val SNP performed significantly better than those with the Val/Met;Met/Met SNP type ( $p<0.001$ ). However, men in the PST condition with the Val/Val SNP performed worse than men with the Val/Met;Met/Met SNP type.

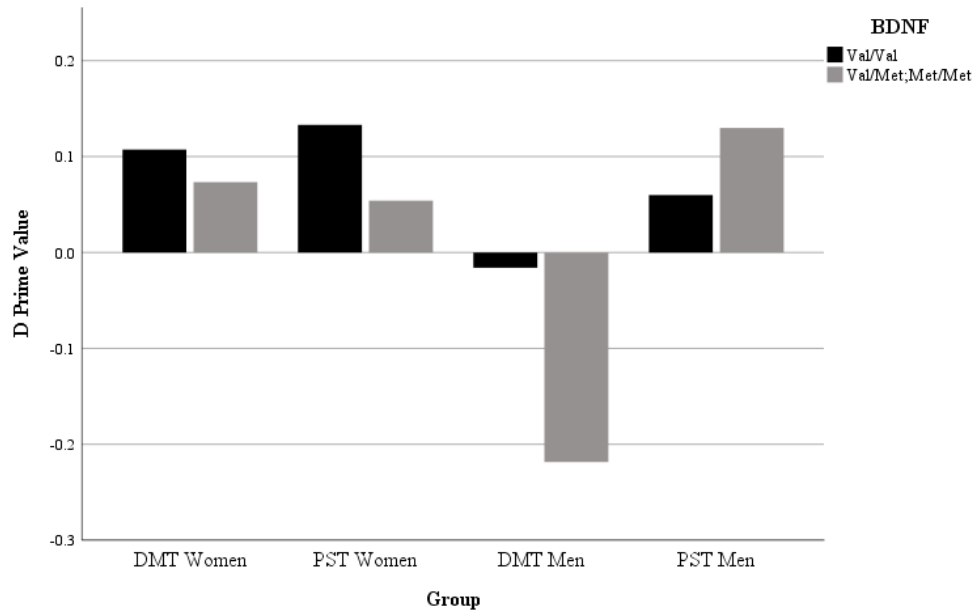


Figure 6. Simulated results of scores on the memory task when presented with negative feedback for men and women with the Val/Val and Met carrier SNP in the DMT and PST conditions.

### 2.3 Discussion

The results of this study using only our participants' data did not support the prediction that Met SNP carriers under stereotype threat may have lower scores on a math and memory task. Some factors contributing to this may be that the distribution of the Val/Val polymorphism was skewed towards Val/Val for the population, which was unable to be randomized due to the fact that BDNF samples were collected after the participants were given the math and memory tasks. Additionally, the small sample size did not allow us to have the appropriate statistical power a genetic study requires.

After conducting a simulation based off our data, there were significant interactions between SNP type, gender, and condition. In the math task, women in the DMT condition with the Val/Val SNP significantly outperformed women who were Met carriers. The opposite is seen in the PST condition: women with the Val/Val SNP underperformed compared to women who were Met carriers. This trend is seen in the memory task as well. DMT women with the Val/Val SNP performed significantly better than those who were Met carriers. These results provide support for our hypothesis, and additionally highlight the importance of an evenly distributed and sufficiently large sample.

## Chapter 2

### STUDY 2: NATIONAL LEVEL

Following Study 1, Study 2 observed BDNF and gender data while expanding the analysis by collecting data on a national level. To directly test the hypothesis regarding STEM careers, national occupation data was collected. Additionally, national assessment test scores, reported college major, and household income data were included to as covariates detailed in the methods below.

#### 2.4 Method

BDNF polymorphism data was compiled from an extensive literature search. Search terms included “BDNF, Val66Met, rs6265, Val/Val, Val/Met,” and “Met/Met.” In addition, the terms “USA, America,” and “United States” were included to specify studies conducted in the United States. Due to limited availability of state-specific studies, states were grouped into the four regions of the United States: Northeast ([n=1,053](#)), Midwest ([n=796](#)), South ([n=1,036](#)), and West ([n=1,539](#)) (United States, & Bureau of the Census, 1993).

To control for inherent mathematical and science abilities, scores from the most recent National Assessment of Educational Progress (NAEP; Salganik L.H., Dogan E., 2014) were collected from each state by gender. The NAEP is a congressionally mandated project conducted by the National Center for Education Statistics (NCES) which administers the same test in every state, allowing cross-comparison of state-wide results. Three specific test scores were gathered: Overall Science score, Physical Science score, and Mathematics score. Available data for the years 2014-2019 varied. The Overall Science score and Physical Science score had only the year 2015 available, and Mathematics score had the years 2015, 2017, and

2019 available. Furthermore, select states' Overall Science Score and Physical Science score were unavailable (Alaska, Colorado, Louisiana, and Pennsylvania.)

Reported college major was taken from the US Census (United States, & Bureau of the Census, 1993). College major was included as a covariate to provide a second point in time where the gender gap in science interest may occur. The college major categories used were Science and Engineering, and Science and Engineering Related Fields. These were broken down into subcategories by gender (male and female) and age (ages 25 to 39 and ages 40 to 64). The reported college major was also gathered from years 2014-2019.

Occupation data were taken from the US Census (United States, & Bureau of the Census, 1993)- in two categories: computer and mathematical occupations, and life, physical, and social science occupations. These occupations are further defined by the 2018 Standard Occupational Classification System (SOC) from the Bureau of Labor Statistics (2018 SOC System. (n.d.)). A list of the classifications pertaining to this study can be found in Appendix C). The total number of individuals in each category were divided by the total population in each state for each year to create a proportion of individuals in STEM careers relative to the total population. These covariates were collected for both males and females in each state. Additionally, personal income and percent of the population over the poverty level were also collected through the census to account for variability in state resources.

Lastly, the gender and science Implicit Association Test (IAT; Greenwald et. al, 1998) questionnaire was included in the data set to control for gender bias attitudes pertaining to science across different states. The specific variables included were

overall IAT score, overall attitudes on scientific interest and gender, and gender differences in mathematical ability.

BDNF data, personal income data, percent of the population over the poverty level, and IAT scores were all standardized prior to analysis. The remaining predictors were consistent across years and did not need to be standardized. An unstructured covariance matrix was used.

## **2.5 Results**

### **2.5.1 Computer and Mathematical Occupations**

A linear mixed model examined the effects of BDNF polymorphism on men and women in computer and mathematical occupations. To account for states differences, states were treated as having random intercepts. BDNF was used to predict the outcome of variation in the number of individuals in the computer and mathematical occupation. The model revealed a gender by Val/Val interaction ( $F(1,202)=5.879, p<0.05$ ); as the amount of individuals with the Val/Val SNP type increased the number of individuals in the computer and mathematical field increased. While the relationship between Val/Val and occupation differed for men and women, neither of these relationships were statistically different from chance. Simple slopes for men ( $\beta=0.94, t(149)= 0.015, p>0.05$ ) and women ( $\beta=-0.94, t(149)= -0.0002, p>0.05$ ) revealed that the slopes were not statistically significant. There was also a significant gender difference independent of Val/Val ( $\beta= -0.012, t(198)= -33.55, p<0.001, CI=[-0.013, -0.011]$ ), fewer women held occupations in this field than males.

Exploratory analysis for a possible interaction between gender and IAT score was also conducted. A higher IAT value indicated a stronger implicit belief of

perceived gender roles (i.e., men and women differ in their mathematical ability). Introduction of this gender by IAT interaction did not alter the significance levels of any of the primary predictors. When using IAT value as a dependent variable with gender, There were fewer males in computer and mathematical occupations ( $\beta = -0.001$ ,  $t(258) = -3.14$ ,  $p < 0.05$ ,  $CI = [-.001, 0.002]$ ). While there was a relationship between IAT and occupation for men, this relationship was not statistically different for women. As a region endorses more implicit gender roles, there were fewer males holding occupations in the computer and mathematical field.

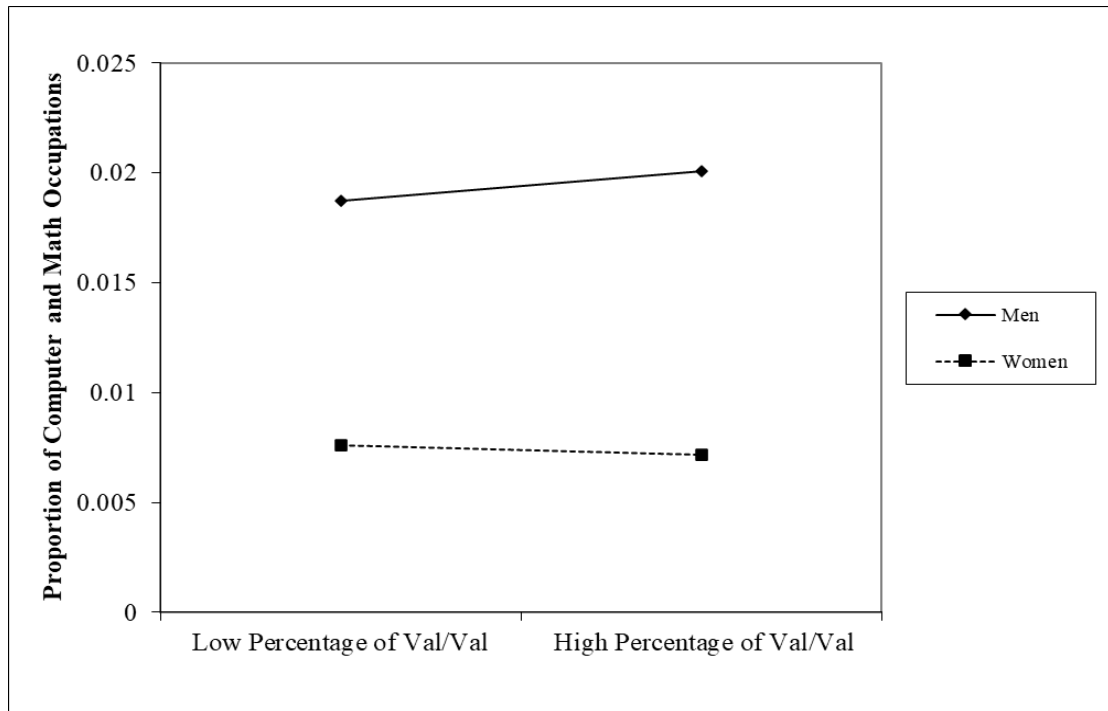


Figure 7. Low percentage of Val/Val and high percentage of Val/Val of men and women in computer and mathematical occupations.

### **2.5.2 Life, Physical and Social Science Occupations**

Next, life, physical and social science occupations were analyzed using the linear mixed model. There was a significant Val/Val by gender interaction ( $F(1,213)=8.96, p<0.05$ ); as Val/Val increased, occupations in the life, physical and social science field increased. Simple slopes analysis revealed that this relationship was significantly stronger for males than females ( $\beta=0.004, t(397)=4.25, p<0.001$ ).

Independent of Val/Val, there was a gender difference. There were significantly less females in this field than males ( $\beta= -0.0009, t(213)= -11.15, p<0.001, CI=[-0.001,-0.007]$ ).

Exploratory analysis of a potential gender and IAT interaction was also conducted for these occupations. This analysis also did not alter the significance of any of the primary predictors. A significant interaction was found for females, with females in the field decreasing as IAT scores increase ( $\beta= -0.0003, t(200)= -3.66, p<0.001, CI=[-0.0005, -0.0001]$ ).

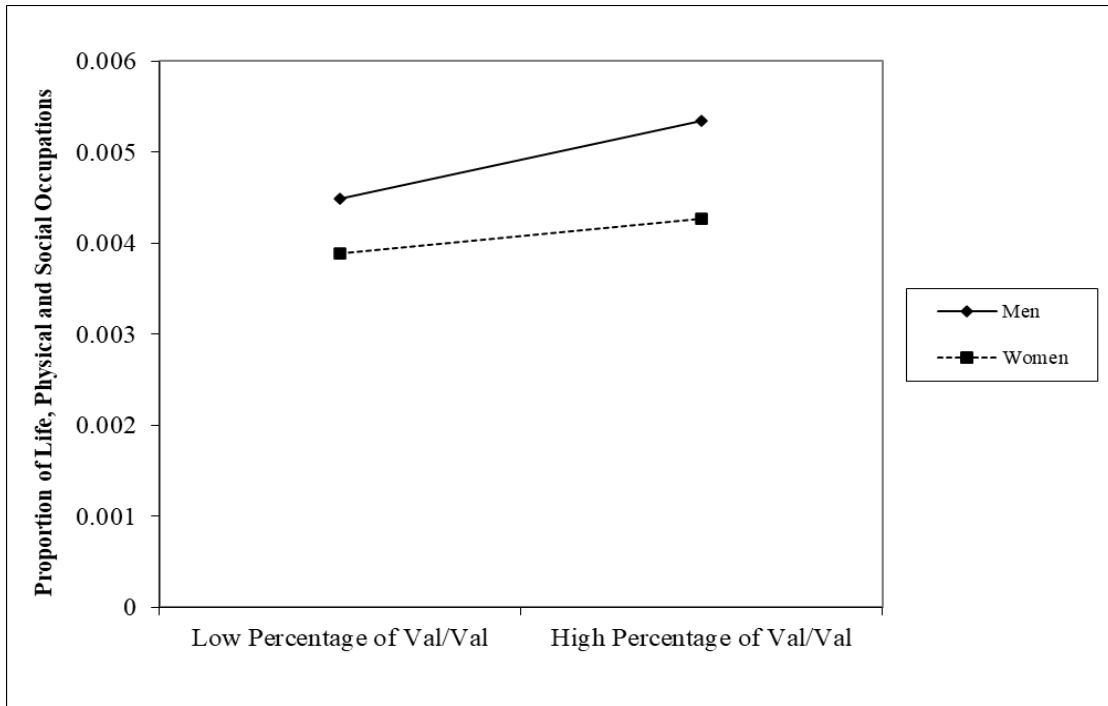


Figure 8. Low percentage of Val/Val and high percentage of Val/Val for men and women in life, physical, and social science occupations.

## 2.6 Discussion

These results highlight a function of the Val/Val polymorphism: as the distribution of Val/Val types increases, the number of individuals increase in these two categories of STEM fields. Separately from the Val/Val effect, a gender effect was observed. There were significantly fewer women in both categories of STEM occupation than males. Interestingly, in the life, physical and social science category, there is a significant gender by Val/Val effect for males; contrary to the hypothesis the relationship between val/val and occupation was stronger for men compared to women

Given the unexpected finding that men with the Val/Val SNP held more occupations in the life, physical and social science field compared to women, exploratory analysis examining regional stereotypes was conducted using IAT score

to attempt to explain this discrepancy Surprisingly, as the gender bias stereotype is more prevalent, the number of males in the field decreases significantly for the computer and mathematical field. For the life, physical and social sciences field, the results are in line with expectations: as the gender bias stereotype is more prevalent, the number of females in the field significantly decreases. These conflicting results may be due to the cultural differences that vary from state to state, and the possible gender stereotypes that already exist within different states. Women that do not feel threatened by men's presence in STEM may be less susceptible to stress and subsequently not be averted by the STEM field (Forbes et. al, 2018).

Another explanation for these results is the lack of available regional BDNF data. The distribution of sample size, particularly in the Midwest (n=796), was low compared to the other three regions. Most BDNF data was produced in major cities on either the east or west coast, and less so within the Midwest, so SNP data from these states may be lacking. Additionally, since all 50 states were grouped into only 4 regions, it is possible that one state may have a different BDNF distribution than another state in the same assigned region and that difference could not be accounted for.

## Chapter 3

### STUDY 3: GLOBAL LEVEL

Study 3 was modeled based on Study 2, but on a global scale. The effects of BDNF SNP type on occupation and gender were observed, with covariates including international assessment testing, gross domestic product for each country, and the percent of a population above the poverty line, all described in the methods below.

#### 3.1 Methods

First, an extensive literature study was conducted using Science Direct, PubMed, and PsycInfo to gather genetic BDNF data. Search terms included “BDNF, Val66Met, rs6265, Val/Val, Val/Met,” and “Met/Met.” To meet the criteria to be included in the data set, the study had to include 1) BDNF polymorphism of participants, and 2) Ethnicity of the participants. The final list of countries (n=22) was largely based on availability of data and organized into three subcategories according to ethnicity: Caucasian (n= 40934), Asian (n=46168) and Middle Eastern (n=1314). A full list of countries can be found in Appendix A.

After the countries had been chosen based on BDNF data availability, job data for each country split by gender was obtained from the International Labor Organization (ILO) (International Labour Organization, 2020.) Specifically, the percent of men and women holding jobs in a professional field and the percent of men and women in a technical field from the years 2014 to 2018 (refer to Appendix B for professional and technical field classifications).

Multiple covariates were identified. First, standardized testing scores were obtained to provide a control measure of proficiency in math, science, and reading ability for each country. Test scores from the Programme of International Student

Assessment (PISA) were collected from the OECD database (OECD, n.d.) for the years 2014-2018. The PISA is a measure of how well 15-year old's use their reading, mathematics, and science abilities and apply their skills to real-life challenges. The second, GDP (Gross domestic product) was compiled from Worldbank's database (World Bank Group - International Development, Poverty, & Sustainability, n.d.) to consider countries' wealth and subsequently access to commodities such technology and education. All covariates used data from the years 2014-2019, or if 2019 was not yet available, data was gathered up to the most recent year.

## **3.2 Results**

### **3.2.1 Professional Field**

A linear mixed model was used to examine gender differences between men and women in a professional field based on the distribution of the Val/Val polymorphism. BDNF SNP type was used as a predictor for the outcome of the number of men and women in the professional field. The model revealed a gender by Val/Val interaction ( $F(1,100)=15.603, p<0.001$ ). Simple slopes analysis indicate that the slopes are significant for both females ( $\beta=5.823, t(75)=9.167, p<0.001, CI=[4.56,7.08]$ ) and males ( $\beta=4.005, t(75)=6.306, p<0.001, CI=[2.74, 5.26]$ ). However, this relationship between Val/Val percentage and professional occupation percentage is stronger for females ( $\beta=1.817, p<0.001$ ). Additionally, there was a gender effect separate from Val/Val, with the percentage of female professionals increasing significantly ( $\beta=5.57, p<0.001$ ).

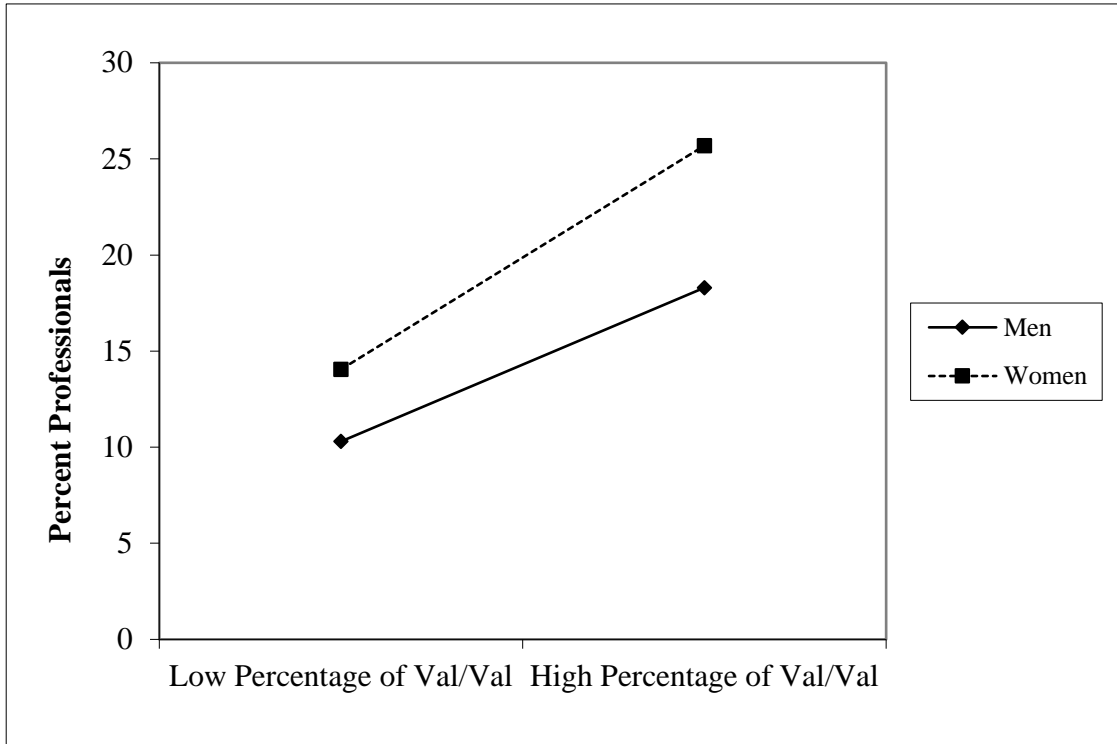


Figure 9. Low percentage of Val/Val and high percentage of Val/Val of men and women in the professional field.

### 3.2.2 Technical Field

The linear mixed model also examined the effects of BDNF polymorphism on men and women in the technical field. The model revealed a gender by Val/Val interaction ( $F(1,86)=14.152, p<0.001$ ). Simple slopes analysis indicated that the slopes are significant for both females ( $\beta=2.581, t(48)=4.239, p<0.001, CI=[1.36,3.79]$ ) and males ( $\beta=1.345, t(48)=2.21, p<0.05, CI=[0.12, 2.57]$ ). While the slopes were significant for both men and women, the significant gender by Val/Val interaction indicates that this relationship between Val/Val and tech representation was stronger for women than for men. Similar to the professional field, this relationship between

Val/Val percentage and technical occupation percentage is stronger for females ( $\beta=1.235, p<0.001$ ).

There was also a gender effect separate from Val/Val for females in the technical field, with the percentage increasing significantly ( $\beta=0.88, p<0.05$ ).

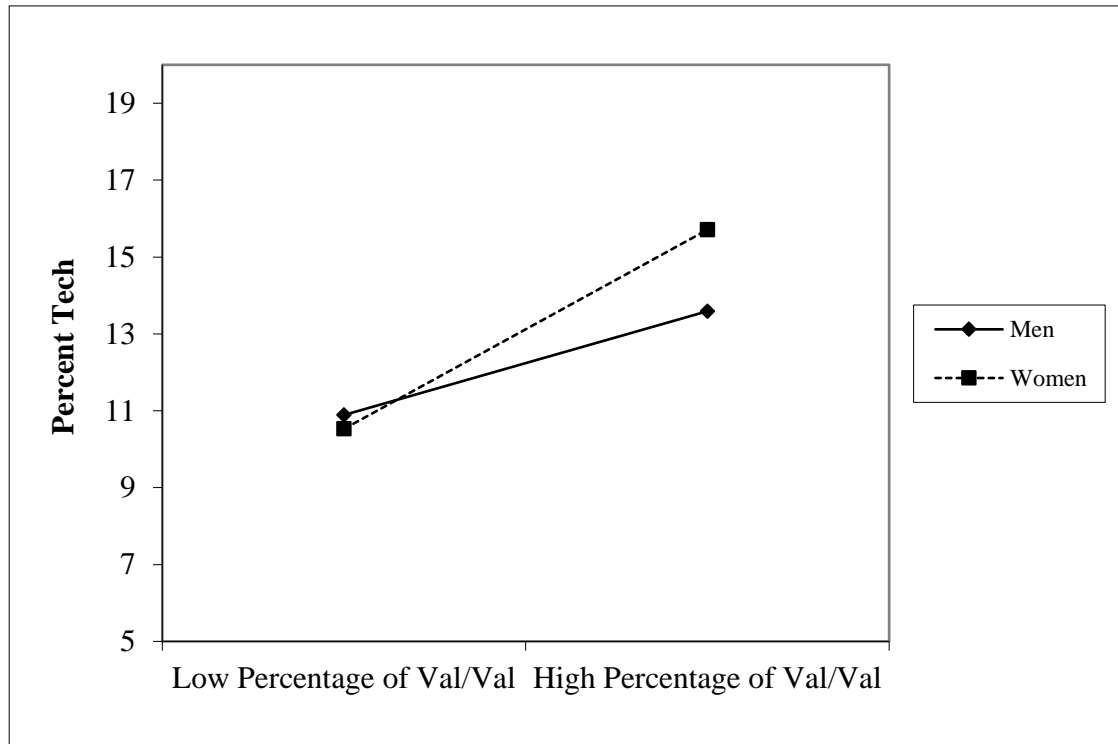


Figure 10. Low percentage of Val/Val and high percentage of Val/Val of men and women in the technical field.

### 3.3 Discussion

These large-scale findings are consistent with the hypothesis that individuals with the Val/Val polymorphism, specifically females, will hold more STEM jobs than those with the Met/Val polymorphism. These findings demonstrate that even when controlling for economic and educational differences between countries, genetic

polymorphism may play an important role in modulating the likelihood that individuals, and particularly women, enter the STEM workforce, specifically in the technical field. Women with the Val/Val polymorphism seem to be particularly likely to choose a career in a technical field.

Some limitations to this study may be a lack of representation for certain countries in both genetic and occupation data. BDNF studies that did not specify the ethnicity of participants were unable to be included, and there may very well be studies that were missed in the data search. Access to occupation data for some countries was restricted, and there may also be a lack of STEM specific job data, given the blanket terms “Professionals” and “Technicians” that were assigned to include a large sector of job types.

## Chapter 4

### GENERAL DISCUSSION

Consistent with past research, findings across three studies suggest that the Val/Met BDNF polymorphism may have morphological effects on individuals' broader executive function capacities insofar as these processes are important for emotion regulation and performance on cognitively intensive tasks such as difficult math tasks (Egan et. al, 2003; Molendijk et. al, 2012).

In Study 1, simulation results based off participant data at the individual level provided initial evidence that BDNF SNPs may have a relationship with performance on cognitively intensive tasks and memory tasks completed in stressful contexts. In the math task, women in the DMT condition with the Val/Val SNP significantly outperformed women who were Met carriers. This pattern was reversed in the PST condition, however: women with the Val/Val SNP underperformed compared to women who were Met carriers. This trend was found in the memory task as well. Simulation data suggested DMT women with the Val/Val SNP performed significantly better on a surprise memory test compared to those who were Met carriers. This suggests a potential relationship between stress elicited by identity threatening contexts and executive function and memory encoding processes that are moderated by BDNF SNP type. These findings are also consistent with past research exhibiting links between BDNF SNPs and executive function and memory encoding processes. Met carriers have also been shown to underperform on measures of executive function in relation to Val/Val carriers, particularly working memory (e.g., Alfimova et al., 2011). Such patterns of aberrant emotional regulation and executive function suggest that Met carriers would be particularly susceptible to

underperforming on cognitively intensive tasks, experiencing more negative affective qualia, and encoding more negative affective oriented memories in identity threatening, i.e., stressful contexts. Those who are Met carriers may be more susceptible to stress and encoding of negative aspects of identity-threatening situations over time. If true, consistent with Steele's (1997) hypothesis that stigmatized individuals leave stigmatized domains to avoid chronic self-threats and decreased self-esteem, this could serve as one mechanism for why women tend to leave STEM fields and/or not pursue STEM careers at disproportionate rates compared to men.

Consistent with this possibility, Study 2 found evidence that indeed, at the national level, women's representation in STEM fields increased as a function of Val/Val SNP type distributions in regions across the United States, at least among careers in life, social and physical sciences. Conversely, Met carriers were found to hold less STEM positions than non-Met carriers, possibly because these contexts may be more chronically stressful for them. While this study highlights the potential ramifications the Met SNP may have for the representation of stigmatized individuals in STEM fields, it's important to note that this effect was tenuous for multiple reasons. For one, based on assessments of BDNF SNP distributions in general there are naturally fewer individuals who possess the Met allele compared to the Val/Val allele (typically approximately 66% of the population possess the Val/Val allele). Furthermore, despite this study being conducted at the national level the sample size for analyses were still quite small compared to gold standards for typical genetic studies.

Fortunately, Study 3 helps accounts for these issues by examining patterns at the global level. Indeed, we found additional support for findings from Study 2, but

here patterns among BDNF SNP and women's STEM representation were more pronounced. Specifically, Study 3 found that women with the Val/Val SNP tended to hold more positions in technical STEM positions compared to women with the Met polymorphism and even men with the Val/Val SNP. This pattern existed even when considering individual differences between countries (i.e., PISA scores and GDP). Thus overall, findings at the individual and group level suggest that a) stressful experiences for stigmatized individuals may be exacerbated by aberrant executive function and emotion regulation processes induced by the Met SNP (Study 1) and b) to the extent these experiences accrue over time, stigmatized individuals with Met SNPs may be more likely to choose careers outside of STEM domains (Studies 2 and 3).

Though our results tended to be consistent with hypotheses, there were some limitations to the studies. Our results in study 1 show the need for a larger sample size in genetic studies, which was remedied by running a simulation that provided the appropriate statistical power. Recruiting more participants for our study would directly solve this issue. Additionally, implementing a longitudinal study for our lab's participants by monitoring science class grades, college major choice, and ultimately, career choice would allow an individualized look at STEM career choices over time. In our national level study 2, further analysis within both professional and technical occupation sectors would allow for more precise sub-fields within STEM to be observed. By including more genetic studies representative of specific states, it would be possible to better account for genetic variation within each state. The global level study 3 would also be improved by further breaking down the broad categorical STEM fields set in place by the Census Bureau. Expanding the selection of countries used to

obtain BDNF data would permit a more complete analysis of STEM career choice and BDNF SNP distribution across the world.

While some evidence suggests the Val66Met SNP may moderate how individuals process information in stressful situations, it is important to evaluate findings from these studies with respect to the sheer complexity of neural networks within the brain, how these networks interact during complex cognitive tasks in general, and how exactly one SNP known to be involved in neurotrophic processes may ultimately modulate these massively complex network interactions. Additionally, our study only analyzed one polymorphism of the BDNF gene; given that there are at least dozens of BDNF polymorphisms it is possible that there are other polymorphisms that may have differentiating effects on how an individual copes with stressors like those experienced in identity threatening stressful situations. It is also quite likely that there are a number of integral interactions between myriad genes, and SNPs of those genes, that may modulate interactions between neural networks and the complex psychological processes instantiated by given networks. Nevertheless, findings from these studies suggest that BDNF SNPs may play a modest to oversized role in modulating neural network interactions involved in complex cognitive processes like those required for efficacious emotion regulation and executive functions. Overall, our studies could be supplemented by simulated performance scores on a broader scale, and more random sampling of BDNF SNPs from a wider array of states and countries. This would allow for exploration of the Val/Val SNP moderating effect on an even larger scale.

It has been shown that the Val66Met polymorphism yields alterations in executive function and emotion regulation processes (Soliman et al., 2010; Molendjik

et al., 2012). Findings across three studies find evidence that these alterations may play important roles in other situationally stressful contexts such as those incurred in domains in which individuals are the targets of negative stereotypes. Differences in how emotions in these contexts are regulated may not only effect performance and memory in the moment, but they may in fact affect meaningful decisions over time, including ultimately an avoidance of STEM careers due to negative associations from stressful past experiences. Awareness of this genetic relationship offers insight on the gender differences seen in the STEM workforce. While largely observational at this point, these studies could serve as a starting point for more large-scale tailored interventions that can help all individuals thrive in any career they so choose, thus providing a means for more equal opportunity STEM education and equal representation of all genders in STEM.

## REFERENCES

- 2018 SOC System. (n.d.). Retrieved April 20, 2020, from <https://www.bls.gov/soc/2018/home.htm>
- Aleman, S., Arias, B., Aguilera, M., Villa, H., Moya, J., Ibáñez, M. I., Vossen, H., Gastó, C., Ortet, G., & Fañanás, L. (2011). Childhood abuse, the BDNF-Val66Met polymorphism and adult psychotic-like experiences. *British Journal of Psychiatry*, *199*(1), 38–42. <https://doi.org/10.1192/bjp.bp.110.083808>
- [Alfimova, M. V., Korovaitseva, G. I., Lezheiko, T. V., & Golimbet, V. E. \(2012\). Effect of BDNF Val66Met polymorphism on normal variability of executive functions. \*Bulletin of experimental biology and medicine\*, \*152\*\(5\), 606-609.](#)
- Altshuler, D. B., Wang, L., Zhao, L., Miklja, Z., Linzey, J., Brezzell, A., Kakaizada, S., Krishna, S., Orringer, D. A., Briceño, E. M., Gabel, N., & Hervey-Jumper, S. L. (2019). BDNF, COMT, and DRD2 polymorphisms and ability to return to work in adult patients with low- and high-grade glioma. *Neuro-Oncology Practice*, *6*(5), 375–385. <https://doi.org/10.1093/nop/npy059>
- Binder, D. K., & Scharfman, H. E. (2004). Brain-derived neurotrophic factor. *Growth factors (Chur, Switzerland)*, *22*(3), 123.
- Cao, B., Bauer, I. E., Sharma, A. N., Mwangi, B., Frazier, T., Lavagnino, L., Zunta-Soares, G. B., Walss-Bass, C., Glahn, D. C., Kapczinski, F., Nielsen, D. A., & Soares, J. C. (2016). Reduced hippocampus volume and memory performance in bipolar disorder patients carrying the BDNF val66met met allele. *Journal of Affective Disorders*, *198*, 198–205. <https://doi.org/10.1016/j.jad.2016.03.044>
- Chen, J., Li, X., & McGue, M. (2012). Interacting effect of BDNF Val66Met polymorphism and stressful life events on adolescent depression: BDNF gene, stressful life events and depression. *Genes, Brain and Behavior*, n/a-n/a. <https://doi.org/10.1111/j.1601-183X.2012.00843.x>
- Chen, Q.-Y., Chen, Q., Feng, G.-Y., Wan, C.-L., Lindpaintner, K., Wang, L.-J., Chen, Z.-X., Gao, Z.-S., Tang, J.-S., Li, X.-W., & He, L. (2006). Association between the brain-derived neurotrophic factor (BDNF) gene and Schizophrenia in the Chinese population. *Neuroscience Letters*, *397*(3), 285–290. <https://doi.org/10.1016/j.neulet.2005.12.033>

- Cheng, C.-Y., Hong, C.-J., Yu, Y. W.-Y., Chen, T.-J., Wu, H.-C., & Tsai, S.-J. (2005). Brain-derived neurotrophic factor (Val66Met) genetic polymorphism is associated with substance abuse in males. *Molecular Brain Research*, *140*(1–2), 86–90. <https://doi.org/10.1016/j.molbrainres.2005.07.008>
- Chi, M. H., Chang, H. H., Lee, S.-Y., Lee, I. H., Gean, P. W., Yang, Y. K., Lu, R.-B., & Chen, P. S. (2010). Brain derived neurotrophic factor gene polymorphism (Val66Met) and short-term antidepressant response in major depressive disorder. *Journal of Affective Disorders*, *126*(3), 430–435. <https://doi.org/10.1016/j.jad.2010.07.006>
- Choi, M.-J., Kang, R.-H., Lim, S.-W., Oh, K.-S., & Lee, M.-S. (2006). Brain-derived neurotrophic factor gene polymorphism (Val66Met) and citalopram response in major depressive disorder. *Brain Research*, *1118*(1), 176–182. <https://doi.org/10.1016/j.brainres.2006.08.012>
- Clasen, P. C., Wells, T. T., Knopik, V. S., McGeary, J. E., & Beevers, C. G. (2011). 5-HTTLPR and BDNF Val66Met polymorphisms moderate effects of stress on rumination. *Genes, Brain and Behavior*, *10*(7), 740–746. <https://doi.org/10.1111/j.1601-183X.2011.00715.x>
- Daily, J. W., & Park, S. (2017). Interaction of BDNF rs6265 variants and energy and protein intake in the risk for glucose intolerance and type 2 diabetes in middle-aged adults. *Nutrition*, *33*, 187–194. <https://doi.org/10.1016/j.nut.2016.07.001>
- de Krom, M., Bakker, S. C., Hendriks, J., van Elburg, A., Hoogendoorn, M., Verduijn, W., ... & Adan, R. A. (2005). Polymorphisms in the brain-derived neurotrophic factor gene are not associated with either anorexia nervosa or schizophrenia in Dutch patients. *Psychiatric genetics*, *15*(2), 81.
- Deemer, E. D., Thoman, D. B., Chase, J. P., & Smith, J. L. (2014). Feeling the threat: Stereotype threat as a contextual barrier to women's science career choice intentions. *Journal of Career Development*, *41*(2), 141-158.
- Doherty, C., Hogue, O., Floden, D. P., Altemus, J. B., Najm, I. M., Eng, C., & Busch, R. M. (2019). BDNF and COMT, but not APOE, alleles are associated with psychiatric symptoms in refractory epilepsy. *Epilepsy & Behavior*, *94*, 131–136. <https://doi.org/10.1016/j.yebeh.2019.02.032>
- Ece, A., Coşkun, S., Şahin, C., Tan, İ., Karabel, D., & Çim, A. (2019). BDNF and NGF gene polymorphisms and urine BDNF–NGF levels in children with primary monosymptomatic nocturnal enuresis. *Journal of Pediatric Urology*, *15*(3), 255.e1-255.e7. <https://doi.org/10.1016/j.jpuro.2019.03.010>

- Egan, M. F., Kojima, M., Callicott, J. H., Goldberg, T. E., Kolachana, B. S., Bertolino, A., Zaitsev, E., Gold, B., Goldman, D., Dean, M., Lu, B., & Weinberger, D. R. (2003). The BDNF val66met Polymorphism Affects Activity-Dependent Secretion of BDNF and Human Memory and Hippocampal Function. *Cell*, *112*(2), 257–269. [https://doi.org/10.1016/S0092-8674\(03\)00035-7](https://doi.org/10.1016/S0092-8674(03)00035-7)
- Egan, M. F., Kojima, M., Callicott, J. H., Goldberg, T. E., Kolachana, B. S., Bertolino, A., ... & Lu, B. (2003). The BDNF val66met polymorphism affects activity-dependent secretion of BDNF and human memory and hippocampal function. *Cell*, *112*(2), 257-269.
- Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: a meta-analysis. *Psychological bulletin*, *136*(1), 103.
- Elzinga, B. M., & Roelofs, K. (2005). Cortisol-induced impairments of working memory require acute sympathetic activation. *Behavioral neuroscience*, *119*(1), 98.
- Enoch, M.-A., White, K. V., Waheed, J., & Goldman, D. (2008). Neurophysiological and genetic distinctions between pure and comorbid anxiety disorders. *Depression and Anxiety*, *25*(5), 383–392. <https://doi.org/10.1002/da.20378>
- Enoch, M.-A., White, K. V., Waheed, J., & Goldman, D. (2008). Neurophysiological and genetic distinctions between pure and comorbid anxiety disorders. *Depression and Anxiety*, *25*(5), 383–392. <https://doi.org/10.1002/da.20378>
- Forbes, C. E., Amey, R., Magerman, A. B., Duran, K., & Liu, M. (2018). Stereotype-based stressors facilitate emotional memory neural network connectivity and encoding of negative information to degrade math self-perceptions among women. *Social cognitive and affective neuroscience*, *13*(7), 719-740.
- Forbes, C. E., Duran, K. A., Leitner, J. B., & Magerman, A. (2015). Stereotype threatening contexts enhance encoding of negative feedback to engender underperformance and anxiety. *Social Cognition*, *33*(6), 605-625.
- Frey, B. N., Walss-Bass, C., Nicoletti, M. A., Hatch, J. P., Bowden, C. L., Escamilla, M. A., & Soares, J. C. (n.d.). *Brain-derived neurotrophic factor val66met polymorphism affects prefrontal energy metabolism in bipolar disorder*. 4.

- Frodl, T., Schüle, C., Schmitt, G., Born, C., Baghai, T., Zill, P., Bottlender, R., Rupprecht, R., Bondy, B., Reiser, M., Möller, H.-J., & Meisenzahl, E. M. (2007). Association of the Brain-Derived Neurotrophic Factor Val66Met Polymorphism With Reduced Hippocampal Volumes in Major Depression. *Archives of General Psychiatry*, *64*(4), 410. <https://doi.org/10.1001/archpsyc.64.4.410>
- Gatt meta analysis.docx*. (n.d.).
- Gatt, J. M., Burton, K. L. O., Williams, L. M., & Schofield, P. R. (2015). Specific and common genes implicated across major mental disorders: A review of meta-analysis studies. *Journal of Psychiatric Research*, *60*, 1–13. <https://doi.org/10.1016/j.jpsychires.2014.09.014>
- Gourion, D., Goldberger, C., Leroy, S., Bourdel, M.-C., Oli??, J.-P., & Krebs, M.-O. (2005). Age at onset of schizophrenia: Interaction between brain-derived neurotrophic factor and dopamine D3 receptor gene variants: *NeuroReport*, *16*(12), 1407–1410. <https://doi.org/10.1097/01.wnr.0000175245.58708.6b>
- Greenwald, A. G., McGhee, D. E., and Schwartz, J. L. K. (1998). Measuring individual differences in implicit cognition: the implicit association test. *J. Pers. Soc. Psychol.* *74*, 1464–1480. doi: 10.1037/0022-3514.74.6.1464
- Greenwald, M. K., Steinmiller, C. L., Śliwerska, E., Lundahl, L., & Burmeister, M. (2013). BDNF Val<sup>66</sup> Met genotype is associated with drug-seeking phenotypes in heroin-dependent individuals: A pilot study: BDNF and drug-seeking behavior. *Addiction Biology*, *18*(5), 836–845. <https://doi.org/10.1111/j.1369-1600.2011.00431.x>
- Gruber, O., Hasan, A., Scherk, H., Wobrock, T., Schneider-Axmann, T., Ekawardhani, S., Schmitt, A., Backens, M., Reith, W., Meyer, J., & Falkai, P. (2012). Association of the brain-derived neurotrophic factor val66met polymorphism with magnetic resonance spectroscopic markers in the human hippocampus: In vivo evidence for effects on the glutamate system. *European Archives of Psychiatry and Clinical Neuroscience*, *262*(1), 23–31. <https://doi.org/10.1007/s00406-011-0214-6>
- Hashimoto, R., Moriguchi, Y., Yamashita, F., Mori, T., Nemoto, K., Okada, T., Hori, H., Noguchi, H., Kunugi, H., & Ohnishi, T. (2008). Dose-dependent effect of the Val66Met polymorphism of the brain-derived neurotrophic factor gene on memory-related hippocampal activity. *Neuroscience Research*, *61*(4), 360–367. <https://doi.org/10.1016/j.neures.2008.04.003>

- Hilt, L. M., Sander, L. C., Nolen-Hoeksema, S., & Simen, A. A. (2007). The BDNF Val66Met polymorphism predicts rumination and depression differently in young adolescent girls and their mothers. *Neuroscience Letters*, 429(1), 12–16. <https://doi.org/10.1016/j.neulet.2007.09.053>
- Ho, B.-C., Milev, P., O’Leary, D. S., Librant, A., Andreasen, N. C., & Wassink, T. H. (2006). Cognitive and Magnetic Resonance Imaging Brain Morphometric Correlates of Brain-Derived Neurotrophic Factor Val66Met Gene Polymorphism in Patients With Schizophrenia and Healthy Volunteers. *Archives of General Psychiatry*, 63(7), 731. <https://doi.org/10.1001/archpsyc.63.7.731>
- Hoffjan, S., Parwez, Q., Petrasch-Parwez, E., & Stemmler, S. (2009). Variation in the BDNF and NGFB genes in German atopic dermatitis patients. *Molecular and Cellular Probes*, 23(1), 35–38. <https://doi.org/10.1016/j.mcp.2008.10.005>
- Hong, C.-J., Yu, Y. W.-Y., Lin, C.-H., & Tsai, S.-J. (2003). An association study of a brain-derived neurotrophic factor Val66Met polymorphism and clozapine response of schizophrenic patients. *Neuroscience Letters*, 349(3), 206–208. [https://doi.org/10.1016/S0304-3940\(03\)00828-0](https://doi.org/10.1016/S0304-3940(03)00828-0)
- Hong, E. P., & Park, J. W. (2012). Sample size and statistical power calculation in genetic association studies. *Genomics & informatics*, 10(2), 117–122. <https://doi.org/10.5808/GI.2012.10.2.117>
- Hong, K.-W., Lim, J.-E., Go, M. J., Shin Cho, Y., Ahn, Y., Han, B.-G., & Oh, B. (2012). Recapitulation of the Association of the Val66Met Polymorphism of BDNF Gene With BMI in Koreans. *Obesity*, 20(9), 1871–1875. <https://doi.org/10.1038/oby.2011.352>
- Hünnerkopf, R., Strobel, A., Gutknecht, L., Brocke, B., & Lesch, K. P. (2007). Interaction between BDNF Val66Met and Dopamine Transporter Gene Variation Influences Anxiety-Related Traits. *Neuropsychopharmacology*, 32(12), 2552–2560. <https://doi.org/10.1038/sj.npp.1301383>
- Hwang, J.-P., Tsai, S.-J., Hong, C.-J., Yang, C.-H., Lirng, J.-F., & Yang, Y.-M. (2006). The Val66Met polymorphism of the brain-derived neurotrophic-factor gene is associated with geriatric depression. *Neurobiology of Aging*, 27(12), 1834–1837. <https://doi.org/10.1016/j.neurobiolaging.2005.10.013>
- Hyman, C., Hofer, M., Barde, Y.-A., Juhasz, M., Yancopoulos, G. D., Squinto, S. P., & Lindsay, R. M. (1991). BDNF is a neurotrophic factor for dopaminergic neurons of the substantia nigra. *Nature*, 350(6315), 230–232. <https://doi.org/10.1038/350230a0>

- Iga, J.-I., Ueno, S.-I., Yamauchi, K., Numata, S., Tayoshi-Shibuya, S., Kinouchi, S., Nakataki, M., Song, H., Hokoishi, K., Tanabe, H., Sano, A., & Ohmori, T. (2007). The Val66Met polymorphism of the brain-derived neurotrophic factor gene is associated with psychotic feature and suicidal behavior in Japanese major depressive patients. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, *144B*(8), 1003–1006. <https://doi.org/10.1002/ajmg.b.30520>
- International Labour Organization. (2020). Retrieved 10 April 2020, from <https://www.ilo.org/global/lang--en/index.htm>
- Inzlicht, M., & Ben-Zeev, T. (2000). A threatening intellectual environment: Why females are susceptible to experiencing problem-solving deficits in the presence of males. *Psychological Science*, *11*(5), 365-371.
- Iqbal, M. un N., Yaqoob, T., Ali, S. A., & Khan, T. A. (2019). A Functional Polymorphism (rs6265, G>A) of Brain-Derived Neurotrophic Factor Gene and Breast Cancer: An Association Study. *Breast Cancer: Basic and Clinical Research*, *13*, 117822341984497. <https://doi.org/10.1177/1178223419844977>
- Itoh, K., Hashimoto, K., Shimizu, E., Sekine, Y., Ozaki, N., Inada, T., Harano, M., Iwata, N., Komiyama, T., Yamada, M., Sora, I., Nakata, K., Ujike, H., & Iyo, M. (2005). Association study between brain-derived neurotrophic factor gene polymorphisms and methamphetamine abusers in Japan. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, *132B*(1), 70–73. <https://doi.org/10.1002/ajmg.b.30097>
- Jasińska, K. K., Molfese, P. J., Kornilov, S. A., Mencl, W. E., Frost, S. J., Lee, M., Pugh, K. R., Grigorenko, E. L., & Landi, N. (2017). The BDNF Val 66 Met polymorphism is associated with structural neuroanatomical differences in young children. *Behavioural Brain Research*, *328*, 48–56. <https://doi.org/10.1016/j.bbr.2017.03.014>
- Jiang, H., Wang, R., Liu, Y., Zhang, Y., & Chen, Z.-Y. (2009). BDNF Val66Met polymorphism is associated with unstable angina. *Clinica Chimica Acta*, *400*(1–2), 3–7. <https://doi.org/10.1016/j.cca.2008.10.017>
- Jönsson, E. G., Edman-Ahlbom, B., Sillén, A., Gunnar, A., Kulle, B., Frigessi, A., Vares, M., Ekholm, B., Wode-Helgødt, B., Schumacher, J., Cichon, S., Agartz, I., Sedvall, G. C., Hall, H., & Terenius, L. (2006). Brain-derived neurotrophic factor gene (BDNF) variants and schizophrenia: An association study. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *30*(5), 924–933. <https://doi.org/10.1016/j.pnpbp.2006.02.008>

- Kang, S.-G., Choi, J.-E., An, H., Lim, S.-W., Lee, H.-J., Han, C., Kim, Y.-K., Kim, S.-H., Cho, S. N., Lee, M.-S., Joe, S.-H., Jung, I.-K., & Kim, L. (2008). No association between the brain-derived neurotrophic factor gene Val66Met polymorphism and tardive dyskinesia in schizophrenic patients. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 32(6), 1545–1548. <https://doi.org/10.1016/j.pnpbp.2008.05.016>
- Koizumi, H., Hashimoto, K., Itoh, K., Nakazato, M., Shimizu, E., Ohgake, S., Koike, K., Okamura, N., Matsushita, S., Suzuki, K., Murayama, M., Higuchi, S., & Iyo, M. (2004). Association between the brain-derived neurotrophic factor 196G/A polymorphism and eating disorders. *American Journal of Medical Genetics*, 127B(1), 125–127. <https://doi.org/10.1002/ajmg.b.20153>
- Kunugi, H., Iijima, Y., Tatsumi, M., Yoshida, M., Hashimoto, R., Kato, T., Sakamoto, K., Fukunaga, T., Inada, T., Suzuki, T., Iwata, N., Ozaki, N., Yamada, K., & Yoshikawa, T. (2004). No association between the Val66Met polymorphism of the brain-derived neurotrophic factor gene and bipolar disorder in a Japanese population: A multicenter study. *Biological Psychiatry*, 56(5), 376–378. <https://doi.org/10.1016/j.biopsych.2004.06.017>
- Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (2008). International affective picture System (IAPS): Affective ratings of pictures and instruction manual. Technical Report A-8. University of Florida, Gainesville, FL.
- Lang, U. E., Hellweg, R., Kalus, P., Bajbouj, M., Lenzen, K. P., Sander, T., Kunz, D., & Gallinat, J. (2005). Association of a functional BDNF polymorphism and anxiety-related personality traits. *Psychopharmacology*, 180(1), 95–99. <https://doi.org/10.1007/s00213-004-2137-7>
- Lee, H.-J., Kang, R.-H., Lim, S.-W., Paik, J.-W., Choi, M.-J., & Lee, M.-S. (2006). No association between the brain-derived neurotrophic factor gene Val66Met polymorphism and post-traumatic stress disorder. *Stress and Health*, 22(2), 115–119. <https://doi.org/10.1002/smi.1085>
- Lim, S.-W., Lee, H.-J., Lee, M.-S., & Oh, K.-S. (n.d.). *Lack of Association between Brain-Derived Neurotrophic Factor Gene Val66Met Polymorphisms and Panic Disorder in Korean Population*. 4.
- Lindberg, S. M., Hyde, J. S., Petersen, J. L., & Linn, M. C. (2010). New trends in gender and mathematics performance: A meta-analysis. *Psychological Bulletin*, 136(6), 1123-1135.

- Liu, Q.-R., Walther, D., Drgon, T., Polesskaya, O., Lesnick, T. G., Strain, K. J., de Andrade, M., Bower, J. H., Maraganore, D. M., & Uhl, G. R. (2005). Human brain derived neurotrophic factor (BDNF) genes, splicing patterns, and assessments of associations with substance abuse and Parkinson's Disease. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, *134B*(1), 93–103. <https://doi.org/10.1002/ajmg.b.30109>
- Loewenstern, J., You, X., Merchant, J., Gordon, E. M., Stollstorff, M., Devaney, J., & Vaidya, C. J. (2019). Interactive effect of 5-HTTLPR and BDNF polymorphisms on amygdala intrinsic functional connectivity and anxiety. *Psychiatry Research: Neuroimaging*, *285*, 1–8. <https://doi.org/10.1016/j.psychres.2019.01.010>
- Lohoff, F. W., Sander, T., Ferraro, T. N., Dahl, J. P., Gallinat, J., & Berrettini, W. H. (2005). Confirmation of association between the Val66Met polymorphism in the brain-derived neurotrophic factor (BDNF) gene and bipolar I disorder. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, *139B*(1), 51–53. <https://doi.org/10.1002/ajmg.b.30215>
- Low, I., Kuo, P.-C., Tsai, C.-L., Liu, Y.-H., Lin, M.-W., Chao, H.-T., Chen, Y.-S., Hsieh, J.-C., & Chen, L.-F. (2018). Interactions of BDNF Val66Met Polymorphism and Menstrual Pain on Brain Complexity. *Frontiers in Neuroscience*, *12*, 826. <https://doi.org/10.3389/fnins.2018.00826>
- Lu, W., Zhang, C., Yi, Z., Li, Z., Wu, Z., & Fang, Y. (2012). Association Between BDNF Val66Met Polymorphism and Cognitive Performance in Antipsychotic-Naïve Patients with Schizophrenia. *Journal of Molecular Neuroscience*, *47*(3), 505–510. <https://doi.org/10.1007/s12031-012-9750-4>
- Matsuo, K., Walss-Bass, C., Nery, F. G., Nicoletti, M. A., Hatch, J. P., Frey, B. N., Monkul, E. S., Zunta-Soares, G. B., Bowden, C. L., Escamilla, M. A., & Soares, J. C. (2009). Neuronal Correlates of Brain-derived Neurotrophic Factor Val66Met Polymorphism and Morphometric Abnormalities in Bipolar Disorder. *Neuropsychopharmacology*, *34*(8), 1904–1913. <https://doi.org/10.1038/npp.2009.23>
- Matsushita, S., Arai, H., Matsui, T., Yuzuriha, T., Urakami, K., Masaki, T., & Higuchi, S. (2005). Brain-derived neurotrophic factor gene polymorphisms and Alzheimer's disease. *Journal of Neural Transmission*, *112*(5), 703–771. <https://doi.org/10.1007/s00702-004-0210-3>
- McEwen, B. S. (1998). Stress, adaptation, and disease: Allostasis and allostatic load. *Annals of the New York academy of sciences*, *840*(1), 33-44.

- Mendes, W. B., Blascovich, J., Lickel, B., & Hunter, S. (2002). Challenge and threat during social interactions with White and Black men. *Personality and Social Psychology Bulletin*, 28(7), 939-952.
- Milad, M. R., & Quirk, G. J. (2002). Neurons in medial prefrontal cortex signal memory for fear extinction. *Nature*, 420(6911), 70.
- Miller, D. I., Eagly, A. H., & Linn, M. C. (2015). Women's Representation in Science Predicts National Gender-Science Stereotypes: Evidence From 66 Nations.
- Molendijk, M. L., Van Tol, M. J., Penninx, B. W. J. H., Van Der Wee, N. J. A., Aleman, A., Veltman, D. J., ... & Elzinga, B. M. (2012). BDNF val 66 met affects hippocampal volume and emotion-related hippocampal memory activity. *Translational psychiatry*, 2(1), e74.
- Monteleone, P., Zanardini, R., Tortorella, A., Gennarelli, M., Castaldo, E., Canestrelli, B., & Maj, M. (2006). The 196G/A (val66met) polymorphism of the BDNF gene is significantly associated with binge eating behavior in women with bulimia nervosa or binge eating disorder. *Neuroscience Letters*, 406(1-2), 133-137. <https://doi.org/10.1016/j.neulet.2006.07.040>
- Nakata, K., Ujike, H., Sakai, A., Uchida, N., Nomura, A., Imamura, T., Katsu, T., Tanaka, Y., Hamamura, T., & Kuroda, S. (2003). Association study of the brain-derived neurotrophic factor (BDNF) gene with bipolar disorder. *Neuroscience Letters*, 337(1), 17-20. [https://doi.org/10.1016/S0304-3940\(02\)01292-2](https://doi.org/10.1016/S0304-3940(02)01292-2)
- Neves-Pereira, M., Cheung, J. K., Pasdar, A., Zhang, F., Breen, G., Yates, P., Sinclair, M., Crombie, C., Walker, N., & St Clair, D. M. (2005). BDNF gene is a risk factor for schizophrenia in a Scottish population. *Molecular Psychiatry*, 10(2), 208-212. <https://doi.org/10.1038/sj.mp.4001575>
- Nociti, V., Santoro, M., Quaranta, D., Losavio, F. A., De Fino, C., Giordano, R., Palomba, N., Rossini, P. M., Guerini, F. R., Clerici, M., Caputo, D., & Mirabella, M. (2018). BDNF rs6265 polymorphism methylation in Multiple Sclerosis: A possible marker of disease progression. *PLOS ONE*, 13(10), e0206140. <https://doi.org/10.1371/journal.pone.0206140>
- Noonan, R. (n.d.). Economics & Statistics Administration. Retrieved from <http://www.esa.doc.gov/reports/women-stem-2017-update>

- Numata, S., Ueno, S., Iga, J., Yamauchi, K., Hongwei, S., Ohta, K., Kinouchi, S., Shibuya-Tayoshi, S., Tayoshi, S., Aono, M., Kameoka, N., Sumitani, S., Tomotake, M., Kaneda, Y., Taniguchi, T., Ishimoto, Y., & Ohmori, T. (2006). Brain-derived neurotrophic factor (BDNF) Val66Met polymorphism in schizophrenia is associated with age at onset and symptoms. *Neuroscience Letters*, *401*(1–2), 1–5. <https://doi.org/10.1016/j.neulet.2006.02.054>
- OECD. (n.d.). Retrieved from <http://www.oecd.org/>
- Oswald, P., Del-Favero, J., Massat, I., Souery, D., Claes, S., Van Broeckhoven, C., & Mendlewicz, J. (2004). Non-replication of the brain-derived neurotrophic factor (BDNF) association in bipolar affective disorder: A Belgian patient-control study. *American Journal of Medical Genetics*, *129B*(1), 34–35. <https://doi.org/10.1002/ajmg.b.30056>
- Oswald, P., Del-Favero, J., Massat, I., Souery, D., Claes, S., Van Broeckhoven, C., & Mendlewicz, J. (2005). No implication of brain-derived neurotrophic factor (BDNF) gene in unipolar affective disorder: Evidence from Belgian first and replication patient-control studies. *European Neuropsychopharmacology*, *15*(5), 491–495. <https://doi.org/10.1016/j.euroneuro.2005.01.001>
- Phelps, E. A., Delgado, M. R., Nearing, K. I., & LeDoux, J. E. (2004). Extinction learning in humans: role of the amygdala and vmPFC. *Neuron*, *43*(6), 897–905.
- Pivac, N., Kozaric-Kovacic, D., Grubisic-Ilic, M., Nedic, G., Rakos, I., Nikolac, M., Blazev, M., & Muck-Seler, D. (2012). The association between brain-derived neurotrophic factor Val66Met variants and psychotic symptoms in posttraumatic stress disorder. *The World Journal of Biological Psychiatry*, *13*(4), 306–311. <https://doi.org/10.3109/15622975.2011.582883>
- Qian, L., Zhao, J., Shi, Y., Zhao, X., Feng, G., Xu, F., Zhu, S., & He, L. (2007). Brain-derived neurotrophic factor and risk of schizophrenia: An association study and meta-analysis. *Biochemical and Biophysical Research Communications*, *353*(3), 738–743. <https://doi.org/10.1016/j.bbrc.2006.12.121>
- Raz, N. (2008). Brain-Derived Neurotrophic Factor Val66Met and Blood Glucose: A Synergistic Effect on Memory. *Frontiers in Human Neuroscience*, *2*. <https://doi.org/10.3389/neuro.09.012.2008>
- Ribases, M. (2004). Association of BDNF with anorexia, bulimia and age of onset of weight loss in six European populations. *Human Molecular Genetics*, *13*(12), 1205–1212. <https://doi.org/10.1093/hmg/ddh137>

- Salganik L.H., Dogan E. (2014) National Assessment of Educational Progress (NAEP). In: Michalos A.C. (eds) Encyclopedia of Quality of Life and Well-Being Research. Springer, Dordrecht  
*San Diego.pdf*. (n.d.).
- Schmader, T., Johns, M., & Forbes, C. (2008). An integrated process model of stereotype threat effects on performance. *Psychological review*, 115(2), 336.
- Schumacher, J., Jamra, R. A., Becker, T., Ohlraun, S., Klopp, N., Binder, E. B., Schulze, T. G., Deschner, M., Schmä, C., Höfels, S., Zobel, A., Illig, T., Propping, P., Holsboer, F., Rietschel, M., Nöthen, M. M., & Cichon, S. (2005). Evidence for a Relationship Between Genetic Variants at the Brain-Derived Neurotrophic Factor (BDNF) Locus and Major Depression. *Biological Psychiatry*, 58(4), 307–314. <https://doi.org/10.1016/j.biopsych.2005.04.006>
- Shimizu, E., Hashimoto, K., & Iyo, M. (2004). Ethnic difference of the BDNF 196G/A (val66met) polymorphism frequencies: The possibility to explain ethnic mental traits. *American Journal of Medical Genetics*, 126B(1), 122–123. <https://doi.org/10.1002/ajmg.b.20118>
- Shimizu, E., Hashimoto, K., & Iyo, M. (2004). Ethnic difference of the BDNF 196G/A (val66met) polymorphism frequencies: The possibility to explain ethnic mental traits. *American Journal of Medical Genetics*, 126B(1), 122–123. <https://doi.org/10.1002/ajmg.b.20118>
- Shimizu, E., Hashimoto, K., Koizumi, H., Kobayashi, K., Itoh, K., Mitsumori, M., Ohgake, S., Okamura, N., Koike, K., Matsuzawa, D., Zhang, L., Kumakiri, C., Nakazato, M., Komatsu, N., & Iyo, M. (2005). No association of the brain-derived neurotrophic factor (BDNF) gene polymorphisms with panic disorder. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 29(5), 708–712. <https://doi.org/10.1016/j.pnpbp.2005.04.018>
- Skibinska, M., Hauser, J., Czerski, P. M., Leszczynska-rodziewicz, A., Kosmowska, M., Kapelski, P., Slopian, A., Zakrzewska, M., & Rybakowski, J. K. (2004). Association analysis of brain-derived neurotrophic factor (BDNF) gene Val66Met polymorphism in schizophrenia and bipolar affective disorder. *The World Journal of Biological Psychiatry*, 5(4), 215–220. <https://doi.org/10.1080/15622970410029936>
- Soliman, F., Glatt, C. E., Bath, K. G., Levita, L., Jones, R. M., Pattwell, S. S., ... & Voss, H. U. (2010). A genetic variant BDNF polymorphism alters extinction learning in both mouse and human. *Science*, 327(5967), 863-866.

- Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of experimental social psychology*, 35(1), 4-28
- Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of personality and social psychology*, 69(5), 797.
- Sublette, M. E., Baca-Garcia, E., Parsey, R. V., Oquendo, M. A., Rodrigues, S. M., Galfalvy, H., Huang, Y.-Y., Arango, V., & Mann, J. J. (2008). Effect of BDNF val66met polymorphism on age-related amygdala volume changes in healthy subjects. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 32(7), 1652–1655. <https://doi.org/10.1016/j.pnpbp.2008.06.009>
- Szeszko, P. R., Lipsky, R., Mentschel, C., Robinson, D., Gunduz-Bruce, H., Sevy, S., Ashtari, M., Napolitano, B., Bilder, R. M., Kane, J. M., Goldman, D., & Malhotra, A. K. (2005). Brain-derived neurotrophic factor Val66met polymorphism and volume of the hippocampal formation. *Molecular Psychiatry*, 10(7), 631–636. <https://doi.org/10.1038/sj.mp.4001656>
- Taj M J, R. J., Ganesh, S., Shukla, T., Deolankar, S., Nadella, R. K., Sen, S., Purushottam, M., Reddy, Y. C. J., Jain, S., & Viswanath, B. (2018). BDNF gene and obsessive compulsive disorder risk, symptom dimensions and treatment response. *Asian Journal of Psychiatry*, 38, 65–69. <https://doi.org/10.1016/j.ajp.2017.10.014>
- Tan, Y. L., Zhou, D. F., Cao, L. Y., Zou, Y. Z., & Zhang, X. Y. (2005). Decreased BDNF in serum of patients with chronic schizophrenia on long-term treatment with antipsychotics. *Neuroscience Letters*, 382(1–2), 27–32. <https://doi.org/10.1016/j.neulet.2005.02.054>
- Taylor, W. D., McQuoid, D. R., Ashley-Koch, A., MacFall, J. R., Bridgers, J., Krishnan, R. R., & Steffens, D. C. (2011). BDNF Val66Met genotype and 6-month remission rates in late-life depression. *The Pharmacogenomics Journal*, 11(2), 146–154. <https://doi.org/10.1038/tpj.2010.12>
- Terracciano, A., Piras, M. G., Lobina, M., Mulas, A., Meirelles, O., Sutin, A. R., Chan, W., Sanna, S., Uda, M., Crisponi, L., & Schlessinger, D. (2013). Genetics of serum BDNF: Meta-analysis of the Val66Met and genome-wide association study. *The World Journal of Biological Psychiatry*, 14(8), 583–589. <https://doi.org/10.3109/15622975.2011.616533>

- the International Consortium for Childhood-Onset Mood Disorders, Strauss, J., Barr, C. L., George, C. J., Devlin, B., Vetró, Á., Kiss, E., Baji, I., King, N., Shaikh, S., Lanktree, M., Kovacs, M., & Kennedy, J. L. (2005). Brain-derived neurotrophic factor variants are associated with childhood-onset mood disorder: Confirmation in a Hungarian sample. *Molecular Psychiatry*, *10*(9), 861–867. <https://doi.org/10.1038/sj.mp.4001685>
- Timpano, K. R., Schmidt, N. B., Wheaton, M. G., Wendland, J. R., & Murphy, D. L. (2011). Consideration of the BDNF gene in relation to two phenotypes: Hoarding and obesity. *Journal of Abnormal Psychology*, *120*(3), 700–707. <https://doi.org/10.1037/a0024159>
- Tochigi, M., Otowa, T., Suga, M., Rogers, M., Minato, T., Yamasue, H., Kasai, K., Kato, N., & Sasaki, T. (2006). No evidence for an association between the BDNF Val66Met polymorphism and schizophrenia or personality traits. *Schizophrenia Research*, *87*(1–3), 45–47. <https://doi.org/10.1016/j.schres.2006.06.029>
- Trucco, E. M., Villafuerte, S., Hussong, A., Burmeister, M., & Zucker, R. A. (2018). Biological underpinnings of an internalizing pathway to alcohol, cigarette, and marijuana use. *Journal of Abnormal Psychology*, *127*(1), 79–91. <https://doi.org/10.1037/abn0000310>
- Tsai, S.-J., Cheng, C.-Y., Yu, Y. W.-Y., Chen, T.-J., & Hong, C.-J. (2003). Association study of a brain-derived neurotrophic-factor genetic polymorphism and major depressive disorders, symptomatology, and antidepressant response. *American Journal of Medical Genetics*, *123B*(1), 19–22. <https://doi.org/10.1002/ajmg.b.20026>
- United States, & Bureau of the Census. (1993). Statistical abstract of the United States, 1993. U.S. Dept. of Commerce, Bureau of the Census : For sale by the Supt. of Docs., U.S. G.P.O.
- Vinberg, M., Trajkovska, V., Bennike, B., Knorr, U., Knudsen, G. M., & Kessing, L. V. (2009). The BDNF Val66Met polymorphism: Relation to familiar risk of affective disorder, BDNF levels and salivary cortisol. *Psychoneuroendocrinology*, *34*(9), 1380–1389. <https://doi.org/10.1016/j.psyneuen.2009.04.014>
- Wang, L., Ashley-Koch, A., Steffens, D. C., Krishnan, K. R. R., & Taylor, W. D. (2012). Impact of BDNF Val66Met and 5-HTTLPR polymorphism variants on neural substrates related to sadness and executive function. *Genes, Brain and Behavior*, *11*(3), 352–359. <https://doi.org/10.1111/j.1601-183X.2012.00764.x>

- Watanabe, Y., Muratake, T., Kaneko, N., Nunokawa, A., & Someya, T. (2006). No association between the brain-derived neurotrophic factor gene and schizophrenia in a Japanese population. *Schizophrenia Research*, 84(1), 29–35. <https://doi.org/10.1016/j.schres.2006.03.011>
- Wickens, C.D. (2002). Multiple resources and performance prediction. *Theoretical Issues in Ergonomics Science*, 3(2), 159–77.
- World Bank Group - International Development, Poverty, & Sustainability. (n.d.). Retrieved from <https://www.worldbank.org/>
- Xu, M.-Q., St Clair, D., Ott, J., Feng, G.-Y., & He, L. (2007). Brain-derived neurotrophic factor gene C-270T and Val66Met functional polymorphisms and risk of schizophrenia: A moderate-scale population-based study and meta-analysis. *Schizophrenia Research*, 91(1–3), 6–13. <https://doi.org/10.1016/j.schres.2006.12.008>
- Zai, C. C., George, J., Cheema, S. Y., Zai, G. C., Fonseka, T. M., Danesi, M., Shaikh, S. A., Irwin, D., Tampakeras, M., Freeman, N., Rehm, J., Wells, S., & Kennedy, J. L. (2019). An examination of genes, stress and suicidal behavior in two First Nations communities: The role of the brain-derived neurotrophic factor gene. *Psychiatry Research*, 275, 247–252. <https://doi.org/10.1016/j.psychres.2019.02.034>
- Zamani, M., Hosseini, S. V., Behrouj, H., Erfani, M., Dastghaib, S., Ahmadi, M., Shamsdin, S. A., & Mokarram, P. (2019). BDNF Val66Met genetic variation and its plasma level in patients with morbid obesity: A case-control study. *Gene*, 705, 51–54. <https://doi.org/10.1016/j.gene.2019.04.045>
- [Zhang, L., Benedek, D. M., Fullerton, C. S., Forsten, R. D., Naifeh, J. A., Li, X. X., ... & Benevides, K. N. \(2014\). PTSD risk is associated with BDNF Val66Met and BDNF overexpression. \*Molecular psychiatry\*, 19\(1\), 8-10.](https://doi.org/10.1016/j.mpsych.2014.01.001)
- Zhang, H., Ozbay, F., Lappalainen, J., Kranzler, H. R., van Dyck, C. H., Charney, D. S., Price, L. H., Southwick, S., Yang, B.-Z., Rasmussen, A., & Gelernter, J. (2006). Brain derived neurotrophic factor ( *BDNF* ) gene variants and Alzheimer’s disease, affective disorders, posttraumatic stress disorder, schizophrenia, and substance dependence. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, 141B(4), 387–393. <https://doi.org/10.1002/ajmg.b.30332>

- Zhang, H., Ozbay, F., Lappalainen, J., Kranzler, H. R., van Dyck, C. H., Charney, D. S., Price, L. H., Southwick, S., Yang, B.-Z., Rasmussen, A., & Gelernter, J. (2006). Brain derived neurotrophic factor ( *BDNF* ) gene variants and Alzheimer's disease, affective disorders, posttraumatic stress disorder, schizophrenia, and substance dependence. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, *141B*(4), 387–393. <https://doi.org/10.1002/ajmg.b.30332>
- Zhang, Q. Y., Guan, Q., Wang, Y., Feng, X., Sun, W., Kong, F. Y., Wen, J., Cui, W., Yu, Y., & Chen, Z. Y. (2012). BDNF Val66Met polymorphism is associated with Stage III-IV endometriosis and poor in vitro fertilization outcome. *Human Reproduction*, *27*(6), 1668–1675. <https://doi.org/10.1093/humrep/des094>
- Zhang, X. Y., Chen, D. C., Xiu, M. H., Haile, C. N., Luo, X., Xu, K., Zhang, H. P., Zuo, L., Zhang, Z., Zhang, X., Kosten, T. A., & Kosten, T. R. (2012). Cognitive and serum BDNF correlates of BDNF Val66Met gene polymorphism in patients with schizophrenia and normal controls. *Human Genetics*, *131*(7), 1187–1195. <https://doi.org/10.1007/s00439-012-1150-x>

## Appendix A

### BDNF GLOBAL STUDY SOURCES

Study	Country	Ethnicity	Val Carriers (N)	Met Carriers (N)	Total N
Oswald 2004	Belgium	Caucasian	156	110	226
Oswald 2005	Belgium	Caucasian	336	117	453
Pivac 2012	Croatia	Caucasian	374	202	576
Gourion 2005	France	Caucasian	217	92	309
de Krom 2005	Germany	Caucasian	502	273	775
Schumacher 2005	Germany	Caucasian	1985	1147	3132
Hoffjan 2009	Germany	Caucasian	457	224	681
Hunnerkopf 2007	Germany	Caucasian	189	83	272
Lang 2005	Germany	Caucasian	218	125	343
Frodl 2007	Germany	Caucasian	77	43	120
Gruber 2012	Germany	Caucasian	94	64	158
Donohoe 2007	Ireland	Caucasian	67	24	91
Shimizu 2004	Italy	Caucasian	54	57	111
Monteleone 2006	Italy	Caucasian	210	121	331
Nociti 2018	Italy	Caucasian	122	87	209
Tarracciano 2013	Italy	Caucasian	844	1180	2054
Zai 2019	Canada (Ontario)	Caucasian	388	67	455
Skibinska 2004	Poland	Caucasian	735	328	1063
Alemaný 2011	Spain	Caucasian	282	188	470

Ribasés 2004	Spain, Italy, Germany	Caucasian	1314	741	2055
Johnsson 2006	Sweden	Caucasian	313	145	458
Comasco 2011	Sweden	Caucasian	152	67	219
Ece 2019	Turkey	Caucasian	15	32	47
Neves- Pereira 2005	United Kingdom	Caucasian	565	339	904
Gatt 2015 (BWHHS)	United Kingdom	Caucasian	2696	1441	4137
Gatt 2015 (ALSPAC)	United Kingdom	Caucasian	4513	2325	6838
Egan 2003	USA	Caucasian	271	192	336
Liu 2005	USA	Caucasian	109	51	160
Lohoff 2005	USA	Caucasian	1040	579	1619
Strauss 2004	USA	Caucasian	130	68	198
Zhang 2006	USA	Caucasian	515	254	769
Timpano 2011	USA	Caucasian	193	108	301
Shimizu 2004	USA	Caucasian	91	42	133
Enoch 2008	USA	Caucasian	146	54	200
Chen 2006	China	Asian	315	821	1136
Hong 2003	China	Asian	149	435	584
Hwang 2005	China	Asian	92	189	281
Qian 2006	China	Asian	326	928	1254
Tan 2005	China	Asian	72	181	253
Xu 2007	China	Asian	163	409	572
Chen 2012	China	Asian	446	1114	1560
Jaing 2009	China	Asian	393	1024	1417
Lu 2012	China	Asian	138	368	506
Zhang 2012	China	Asian	258	722	980
Zhang 2012	China	Asian	186	483	669
Shimizu 2004	Japan	Asian	51	100	151
Iga 2007	Japan	Asian	96	212	308
Itoh 2005	Japan	Asian	140	251	391

Koizumi 2004	Japan	Asian	134	286	420
Kunugi 2004	Japan	Asian	404	703	1107
Matsushita 2004	Japan	Asian	247	466	713
Nakata 2003	Japan	Asian	105	215	320
Numata 2006	Japan	Asian	65	94	159
Shimizu 2005	Japan	Asian	117	245	362
Tochigi 2006	Japan	Asian	352	618	970
Watanabe 2006	Japan	Asian	264	508	772
Hashimoto 2008	Japan	Asian	17	41	58
Choi 2006	Korea	Asian	59	152	211
Hong 2012	Korea	Asian	6045	14224	20269
Lee 2006	Korea	Asian	76	192	268
Lim 2007	Korea	Asian	86	224	310
Daily 2017	Korea	Asian	2686	6156	8842
Kang 2008	Korea	Asian	56	153	209
Lee 2013	Korea	Asian	17	36	53
Cheng 2005	Taiwan	Asian	116	309	425
Chi 2010	Taiwan	Asian	70	153	223
Low 2018	Taiwan	Asian	45	111	156
Iqbal 2019	Pakistan	Asian	9	271	280
Tai 2017	India	Asian	576	250	826
Zamani 2019	Iran	Asian	135	73	208

## Appendix A.1

### BDNF UNITED STATES OF AMERICA STUDIES

Study	Region	Ethnicity	Val Carriers (N)	Met Carriers (N)	Total N
Rowland 2005	West	Caucasian	344	241	585
Zhang 2006	Northeast	Caucasian	515	254	769
Enoch 2008	South	Caucasian	146	54	200
Ho 2006	Midwest	Caucasian	277	160	437
Greenwald 2014	Midwest	Caucasian	103	25	128
Raz 2008	Midwest	Caucasian	62	41	103
Atshuler 2019	Midwest	Caucasian	87	41	128
Wang 2012	South	Caucasian	22	12	34
Hilt 2007	Northeast	Caucasian	136	49	185
Sublette 2008	Northeast	Caucasian	33	22	55
Clasen 2011	South	Caucasian	161	112	273
Frey 2007	South	Caucasian	51	24	75
Rowland 2005	West	Caucasian	625	249	874
Cao 2016	South	Caucasian	101	40	141
Loewenstern 2019	West	Caucasian	44	36	80
Matsuo 2009	South	Caucasian	53	31	84
Szeszko 2005	Northeast	Caucasian	27	17	44
Taylor 2011	South	Caucasian	139	90	229

## Appendix A.2

### ISCO-08 CLASSIFICATIONS

<b>Major Label</b>	<b>Sub Major</b>	<b>Description</b>
Professionals	21	Science and Engineering Professionals
	22	Health Professionals
	23	Teaching Professionals
	24	Business and Administration Professionals
	25	Information and Communications Technology Professionals
	26	Legal, Social and Cultural Professionals
Technicians and Associate Professionals	31	Science and Engineering Associate Professionals
	32	Health Associate Professionals
	33	Business and Administration Associate Professionals
	34	Legal, Social, Cultural and Related Associate Professionals
	35	Information and Communications Technicians

### Appendix A.3

#### 2018 SOC Classifications

<b>Major Occupation</b>	<b>Detailed Occupation</b>
15-1200 Computer Occupations	Comp. and Information Analysts, Comp. and Information Research Scientists, Comp. Support Specialists, Database and Network Admins. And Architects, Software and Web Developers, Programmers and Testers, Misc. Computer Occupations
15-200 Mathematical Occupations	Actuaries, Mathematicians, Operations Research Analysts, Statisticians, Data Scientists, Misc. Mathematical Science Occupations
19-000 Life Scientists	Agricultural and Food Scientists, Biological Scientists, Conservation Scientists and Foresters, Medical Scientists, Misc. Life Scientists
19-2000 Physical Scientists	Astronomers and Physicists, Atmospheric and Space Scientists, Chemists and Materials Scientists, Environmental and Geoscientists, Misc. Physical Scientists

<p>19-3000 Social Scientists and Related Workers</p>	<p>Economists, Survey Researchers, Psychologists, Sociologists, Urban and Regional Planners, Misc. Social Scientists and Related Workers</p>
<p>19-4000 Life, Physical, and Social Science Technicians</p>	<p>Agricultural and Food Science Technicians, Biological Technicians, Chemical Technicians, Environmental Science and Geoscience Technicians, Nuclear Technicians, Social Science Research Assistants, Forest and Conservation Technicians, Misc. Life, Physical and Social Science Technicians</p>
<p>19-5000 Occupational Health and Safety Specialists and Technicians</p>	<p>Occupational Health and Safety Specialists and Technicians</p>

## Appendix A.4

### Regional Correlation Table

Table A.1 Math Task Correlation Table

		Gender	imatscor	Val_Val	Zscore(Income)
Gender	Pearson Correlation	1	.261**	-.088	-.101
	Sig. (2-tailed)		.000	.246	.195
	N	175	175	175	166
imatscor	Pearson Correlation	.261**	1	.002	-.024
	Sig. (2-tailed)	.000		.979	.755
	N	175	175	175	166
Val_Val	Pearson Correlation	-.088	.002	1	.083
	Sig. (2-tailed)	.246	.979		.286
	N	175	175	175	166
Zscore(Income)	Pearson Correlation	-.101	-.024	.083	1
	Sig. (2-tailed)	.195	.755	.286	
	N	166	166	166	166

\*\* . Correlation is significant at the 0.01 level (2-tailed).

Table A.2 Memory Task Correlation Table

		Coratm pt	Val_Val	Zscore(Inco me)	Gender
Coratmpt	Pearson Correlation	1	-.140	.077	.204
	Sig. (2-tailed)		.196	.478	.058
	N	87	87	86	87
Val_Val	Pearson Correlation	-.140	1	.054	-.070
	Sig. (2-tailed)	.196		.623	.518
	N	87	87	86	87
Zscore(Inco me)	Pearson Correlation	.077	.054	1	.057
	Sig. (2-tailed)	.478	.623		.605
	N	86	86	86	86
Gender	Pearson Correlation	.204	-.070	.057	1
	Sig. (2-tailed)	.058	.518	.605	
	N	87	87	86	87

## Appendix A.5

### National Correlation Table

Table A.3 National Correlation Table

		Val/Val	Poverty	Personal Income
Val/Val	Pearson Correlation	1	-0.039	0.041
	Sig. (2-tailed)		0.434	0.356
	N	600	400	500
Poverty	Pearson Correlation	-0.039	1	-0.738
	Sig. (2-tailed)	0.434		0
	N	400	400	400
Personal Income	Pearson Correlation	0.041	-0.738	1
	Sig. (2-tailed)	0.356	0	
	N	500	400	500
Population of Occupations	Pearson Correlation	-0.026	0.117	0.207
	Sig. (2-tailed)	0.602	0.019	0
	N	400	400	400
pIAT Score	Pearson Correlation	-0.072	0.001	-0.185
	Sig. (2-tailed)	0.079	0.978	0
	N	600	400	500
pIAT Ability Attitude	Pearson Correlation	-0.159	0.259	-0.253
	Sig. (2-tailed)	0	0	0
	N	600	400	500
pIAT Gender Diff. Attitude	Pearson Correlation	-0.23	0.412	-0.425
	Sig. (2-tailed)	0	0	0
	N	600	400	500
Comp. and Math Occ.	Pearson Correlation			
	Sig. (2-tailed)			
	N			

Life, Phys. Social Occ	Pearson Correlation	0.244	-0.376	0.457
	Sig. (2-tailed)	0	0	0
	N	400	400	400

## Appendix A.6

### Global Correlation Table

Table A.4 Global Correlation Table

		Year	Gender	GDP_log	Zscore(val_val)	Zscore(PISA_score)	Zscore(GDP_log)
Year	Pearson Correlation	1	0.000	0.033	0.000	0.000	0.033
	Sig. (2-tailed)		1.000	0.633	1.000	1.000	0.633
	N	210	210	208	210	210	208
Gender	Pearson Correlation	0.000	1	0.000	0.000	0.000	0.000
	Sig. (2-tailed)	1.000		1.000	1.000	1.000	1.000
	N	210	210	208	210	210	208
GDP_log	Pearson Correlation	0.033	0.000	1	-0.061	.244**	1.000**
	Sig. (2-tailed)	0.633	1.000		0.378	0.000	0.000
	N	208	208	208	208	208	208
Zscore(val_val)	Pearson Correlation	0.000	0.000	-0.061	1	.329**	-0.061
	Sig. (2-tailed)	1.000	1.000	0.378		0.000	0.378
	N	210	210	208	210	210	208
Zscore(PISA_score)	Pearson Correlation	0.000	0.000	.244**	.329**	1	.244**
	Sig. (2-tailed)	1.000	1.000	0.000	0.000		0.000
	N	210	210	208	210	210	208
Zscore(GDP_log)	Pearson Correlation	0.033	0.000	1.000**	-0.061	.244**	1
	Sig. (2-tailed)	0.633	1.000	0.000	0.378	0.000	
	N	208	208	208	208	208	208

Percent_Professionals	Pearson Correlation	0.039	-.347**	-.155*	.612**	.405**	-.155*
	Sig. (2-tailed)	0.575	0.000	0.025	0.000	0.000	0.025
	N	210	210	208	210	210	208
Percent_Tech	Pearson Correlation	0.023	-0.073	0.011	.499**	.370**	0.011
	Sig. (2-tailed)	0.735	0.293	0.871	0.000	0.000	0.871
	N	210	210	208	210	210	208
Country	Pearson Correlation	0.000	0.000	.175*	-.173*	-0.080	.175*
	Sig. (2-tailed)	1.000	1.000	0.011	0.012	0.248	0.011
	N	210	210	208	210	210	208