Adopting A Growth Mindset:

Effects of Mindset Manipulations on Frontal Alpha Asymmetry

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Abstract

Mindsets are different beliefs that individuals can hold about personality trait stability. For example, regarding intelligence, individuals with a growth mindset believe that through hard work, intelligence can be changed, whereas individuals with a fixed mindset believe that intelligence cannot be altered. The present study aimed to delineate the relationship between growth mindset and frontal alpha asymmetry. Participants completed two resting-state EEG recordings, before and after participants read a passage that either induces a growth mindset, or a fixed mindset. Participants were also asked to answer questions regarding depressive symptoms, general motivation, and growth mindset. It was hypothesized that the growth mindset manipulation would induce a greater change in frontal alpha asymmetry than the fixed mindset manipulation. Results supported that an increase in growth mindset was related to increased activation in the left frontal lobe—a region associated with positive approach-related behaviors. This provides evidence that mindsets can be induced immediately, and this change is observable on the neural level. The results of this study enhance our understanding of growth mindset and associated neural patterns.

Adopting a Growth Mindset: Effects of Mindset Manipulations on Frontal Alpha Asymmetry

For years, educational psychologists have explored ways to increase learner motivation, promote productivity, and improve the overall educational experience of individuals (Maehr & Midgley, 1991; Miele & Molden, 2010). One avenue of exploration that psychologists have utilized is the manipulation of mindsets. Mindset theory holds that individuals have differing opinions on the stability of different traits, such as intelligence, throughout the lifespan (Dweck, 1999). For example, intelligence is thought by some to be a relatively fixed trait but thought by others to be a trait that can be altered by hard work (Dweck, 2006). Those who have adopted the belief that intelligence can be changed are referred to as having a growth mindset, whereas those who have adopted the belief that intelligence is a stable trait that cannot be altered are referred to as having a fixed mindset (Dweck, 2006). Throughout the years, behavioral changes associated with growth mindset manipulations have been observed, such as improvements on tests of fluid intelligence (Li & Bates, 2019; Mueller & Dweck, 1998) and perceived enhanced performance on comprehension tests (Miele & Molden, 2010). Limited research has explored the neural correlates of growth mindset (Daly et al., 2019; Mangels et al., 2006; Moser et al., 2011; Myers et al., 2016; Schroder et al., 2017). However, related personality research suggests that EEG frontal alpha asymmetry may be a viable method for measuring individual differences in personality (Coan et al., 2006). If so, frontal alpha asymmetry would reflect the effects of growth mindset manipulations on neural activity, which is the focus of this study.

Individuals who possess a growth mindset believe that intelligence is malleable and can be changed over time through hard work (Dweck, 2006). Those with a growth mindset are more likely to overcome challenges and work harder when faced with failure (Blackwell et al., 2007). As such, a growth mindset also contributes to greater academic success (Blackwell et al., 2007). Those who believe that intelligence is relatively stable and cannot be changed are referred to as having a fixed mindset (Dweck, 2006). Those with a fixed mindset often avoid challenges, become debilitated by failure, and put minimal effort into learning (Dweck, 2006). When faced with failure, individuals with a fixed mindset view their failure as a reflection of their intellectual abilities that they cannot change, which results in academic decline (Dweck, 2006). As such, it is important to foster a growth mindset in the learning community.

Research has, therefore, focused on ways to manipulate a growth mindset (Daly et al., 2019; Li & Bates, 2019; Miele & Molden, 2010; Mueller & Dweck, 1998). Mindset manipulations center around instilling beliefs in participants about the plasticity of intelligence (Li & Bates, 2019; Miele & Molden, 2010; Mueller & Dweck, 1998). The specific wording of praise given to children regarding academic performance on a test of fluid intelligence has been a popular manipulation in the mindset literature (Mueller & Dweck, 1998; Li & Bates, 2019). This is done through altering whether participants hear praise about their innate intelligence or praise about their hard work. Growth mindsets have also been induced through reading passages that "scientifically" support the malleability of intelligence (Miele & Molden, 2010) and math problems that allow multiple pathways of completion and include visual stimuli (Daly et al., 2019).

In terms of behavioral changes, possessing a growth mindset has been previously shown to increase performance on tests of fluid intelligence (Mueller & Dweck, 1998; Li & Bates, 2019) and perceived performance on reading comprehension tests (Miele & Molden, 2010). For example, Mueller and Dweck (1998) found improved performance on fluid intelligence tests after believed failure on earlier fluid intelligence problems for participants subjected to a growth mindset condition, but not for participants in the fixed mindset condition. Manipulation of mindset was conducted through variations in praise for performance on fluid intelligence problems. One group of children was praised for "being smart at these" problems, which induced a fixed mindset, while the other group was praised for being "hard workers", which induced a growth mindset (Mueller & Dweck, 1998). Scores on the Raven's

Progressive Matrices (RPM), which measures fluid intelligence, after praise showed that "hard workers" scored higher than the students praised for their intelligence (Mueller & Dweck, 1998).

Li and Bates (2019) attempted to replicate Mueller and Dweck's 1998 study, implementing the same measure of intelligence and manipulations of mindset. However, Li and Bates believed that praise about being a hard worker may have primed beliefs about conscientiousness, defined as the drive to excel and succeed (Costa & McCrae, 1992). Conscientiousness has been found to be a significant predictor of academic success, with an increase in conscientiousness correlating with improved academic performance (Rosander & Backstrom, 2014). Therefore, it was unknown whether the results Mueller and Dweck (1998) observed were related to an increase in growth mindset, or encouragement of hard work and conscientiousness. Li and Bates assessed this possibility by creating an active control condition, where students were told after completion of the task, "Even though we cannot change our basic ability, you work hard at hard problems and that's how we get hard things done." This condition implemented a fixed mindset (we cannot change our basic abilities) while also emphasizing the belief of hard work being required to complete difficult tasks. Participants in this condition scored higher on moderately difficult items than participants in the fixed mindset condition, leading to the conclusion that the manipulation used did encourage conscientiousness to some level (Li & Bates, 2019).

Participants with an induced growth mindset have also reported higher perceived comprehension on reading tasks than participants with an induced fixed mindset (Miele & Molden, 2010). Miele and Molden (2010) induced mindsets by having participants read passages modeled from Bergen's (1992) paper, which studied the interaction between mindset theory and "generality beliefs" (the degree that an individual believes intelligence is generally instrumental to achievement) on reactions to failure. The reading passages were modeled to look as though they had appeared in an issue of Psychology Today, with one passage containing scientific "evidence" that intelligence is based on genetics (fixed mindset), and the other passage supporting that intelligence is based on environmental factors that can be altered (growth mindset) (Miele & Molden, 2010). After being exposed to one of the manipulation conditions, participants were presented with coherent or incoherent versions of text with subsequent questions assessing perceived comprehension and actual comprehension (Miele & Molden, 2010). Mindset condition did not affect the actual comprehension of the incoherent or coherent versions of the text. That is, participants in both mindset conditions did not show significant differences in actual comprehension scores between the incoherent and coherent versions of the text (Miele & Molden, 2010). However, it was found that participants in the growth mindset condition did not show a difference in perceived comprehension between the incoherent and coherent versions of the text, while participants in the fixed mindset condition reported lower perceived comprehension on the incoherent version of the text than the coherent version (Miele & Molden, 2010). According to Miele and Molden, this shows that individuals who possess a growth mindset are more likely to perceive a challenge as a positive learning experience, whereas those who possess a fixed mindset are more likely to perceive a challenge as a lack of their innate intellectual ability.

Growth mindset also correlates with levels of motivation. This correlation has specifically been tested in studies involving growth mindset and motivation in mathematics (e.g., Degol et al., 2017). Degol et al. (2017) tested high school students from various math classes who completed questionnaires to assess mindset and motivational beliefs regarding math. Motivational beliefs were broken down into expectancy beliefs and task value. Expectancy beliefs asked students the degree to which they agree with certain statements such as, “I am good at math”, “Compared to most other subjects, math is easy for me”, and other similar questions. Task value was assessed by measuring the degree of agreement with statements such as, “I’m really eager to learn a lot in math”, “I will need good math skills for my daily life outside school”, “If I can learn something new in math, I’m prepared to use my free time to do so”, and other similar questions. Results showed that individuals who held a growth mindset also had a higher math task value, supporting that growth mindset was correlated with motivation in mathematics (Degol et al., 2017).

In related work on growth mindset and motivation in mathematics, Daly et al. (2019) asked undergraduates who were enrolled in a math course to report their current level of motivation before and after completing math problems. Levels of motivation were established by degree of agreement with statements such as, “I am strongly motivated to solve the problem,” “I intend to put in a good effort solving this problem,” and “Doing well at this problem means a lot to me”. Participants were then exposed to either a standard style mathematical problem, or one in the style of mathematical mindset theory. Mathematical mindset (MM) theory is an approach to teaching mathematics created by Jo Boaler that fosters a growth mindset when attempting problems (Daly et al., 2019). Castiglione (2019) found that implementing mathematical mindset style teaching into third-grade students’ curriculum resulted in increased growth mindset at the end of the term. Daly et al. (2019)’s results showed that after participants were exposed to the growth mindset math problems, participants reported a significant increase in levels of motivation. This research offers further support for the link between growth mindset and motivation.

In addition to behavioral changes, the level of growth mindset one possesses also correlates with neural patterns (Daly et al., 2019; Mangels et al., 2006; Moser et al., 2011; Myers et al., 2016; Schroder et al., 2017). In one study, twenty children had their resting-state brain activity recorded with fMRI in addition to completing grit and theory of intelligence (growth mindset) questionnaires (Myers et al., 2016). Resting-state brain activity is recorded while the individual is relaxed but awake and is not engaged in any specific cognitive task. The results showed that a greater growth mindset was correlated with greater connectivity between the dorsal striatum and several brain regions, including the dorsal anterior cingulate cortex (dACC)/anterior midcingulate cortex (ACC), left dorsolateral prefrontal cortex (DLPFC), and the cerebellum (Myers et al., 2016). Greater growth mindset was also positively correlated with stronger connectivity between the ventral striatum and the dorsolateral prefrontal cortex (Myers et al., 2016). Connections between the striatum and DLPFC are related to inhibition and the ability to ignore irrelevant stimuli (Motzkin et al., 2014). Striatum connections with the dACC and the DLPFC are also important in error-monitoring and behavioral response (Stevens et al., 2009). Therefore, individuals with a higher growth mindset also possess a stronger ability to inhibit irrelevant stimuli when focusing on a task and are better able to identify and correct errors.

EEG studies have also shown that growth mindset is associated with increased amplitude of Pe—an ERP component that is positively correlated to attention to mistakes (Moser et al., 2011; Schroder et al., 2017). Mangels et al. (2006) determined that individuals who possessed a higher growth mindset produced greater feedback-related negativity (FRNs), which are negative voltage deflections, in response to both expected and unexpected errors on general knowledge questions from the academic domains such as literature, world and US history, and mathematics. Individuals with a fixed mindset only showed significant FRNs in response to unexpected errors (Mangels et al., 2006). From these findings, Mangels et al. concluded that individuals with a growth mindset are more attentive and receptive to errors.

Frontal alpha asymmetry is the term used to describe differences in alpha bandpower (8-13 Hz) in an EEG recording between the left and right hemispheres of the brain (Davidson et al., 1990). Alpha ~~band~~power is inversely related to brain activity in a region. Therefore, more activation for the left frontal region will result in decreased alpha power over that same region (Gotlib, 1998). Alpha asymmetry can be measured while participants are in a resting state or during task completion. Collecting resting state EEG to measure asymmetry aligns with a dispositional model of personality (Coan et al., 2006). The dispositional model of personality focuses on an individual's pattern of response (i.e. approach or withdrawal) in any situation over an extended period of time (Davidson, 1998). For example, does an individual always respond with approach-related behaviors (i.e., actions aimed at reducing the distance between a person and stimuli) or withdrawal-related behaviors (i.e., actions aimed at increasing the distance between a person and stimuli) (Davidson, 1993, 1998)?

For approximately the past 30 years, frontal alpha asymmetry has mainly been measured while participants are in a resting state (Smith, 2016). Within this body of research, frontal alpha asymmetry has frequently been used to study relationships between brain activity and emotion, psychopathology, and motivation (Smith, 2016). Asymmetries present during the *processing* of emotion (i.e., the perception of facial/vocal expressions) are not the same as the asymmetries present during the *production* of the same emotion (Davidson, 1993). This leads to the conclusion that the experience (production) of an emotion has different underlying neural correlates than the perception of that same emotion (Davidson, 1993). Different neural substrates are observed in posed emotion versus the spontaneous production of the same emotion (Davidson, 1993).

The *experience* of emotion has been lateralized by many researchers into the anterior left and anterior right hemispheres (Davidson, 1984). According to Davidson (1984), the left anterior portion of the brain is active during positive approach-related emotions, while the right anterior portion of the brain is active during negative withdrawal-related emotions. Positive approach-related emotions refer to emotions that lead to actions aimed at reducing the distance between the individual and the stimuli (Davidson, 1993 footnote). Negative withdrawal-related emotions refer to emotions that lead to actions aimed at increasing the distance between the individual and stimuli (Davidson, 1993 footnote). This hemispheric lateralization has been further supported in more recent years, such that participants high in behavioral approach system (BAS) repeatedly show increased activation of the left frontal regions (Coan & Allen, 2003; De Pascalis et al., 2013). Emotional valence, both positive and negative, have also been correlated to asymmetry patterns (De Pascalis et al., 2013; Lee et al., 2020). Because alpha asymmetry is relatively stable over time (i.e., over a three-week period; Tomarken et al., 1992), Davidson concluded that alpha asymmetry is reflective of an emotional response tendency.

The stability of frontal alpha asymmetry over time is further supported by Gotlib's (1998) study of depression and frontal alpha asymmetry. Gotlib (1998) categorized female undergraduates at Northwestern University into one of three groups: never depressed (30 participants), previously depressed (31 participants), and currently depressed (16 participants). After recording 8, 1-minute resting state blocks with EEG (4 blocks of eyes opened, 4 blocks of eyes closed) from each participant, frontal alpha asymmetry was analyzed. Gotlib compared the resting-state frontal alpha asymmetry for participants who had experienced depressive symptoms at some point in their lives (currently and previously depressed participants) to participants who had never experienced depressive symptoms. Gotlib found that currently and previously depressed participants exhibited significantly higher left frontal alpha power compared to right than never depressed participants. Gotlib also compared currently depressed and previously depressed individuals and found that there were no significant differences in alpha asymmetry between these participants. Consistent with the other results, the never depressed participants demonstrated greater left than right frontal activation, which corresponds to lower alpha power in the left hemisphere (Gotlib, 1998). From these results, Gotlib was able to conclude that frontal alpha asymmetry, specifically left hypoactivation, is a stable marker of vulnerability to depression. The role of the left frontal lobe in depression has also been supported in more recent studies (Grajny et al., 2016; Sun et al., 2014). Lesion studies found that left hemispheric lesions increase the risk of post-stroke depression over right hemispheric lesions (Sun et al., 2014). Further, when these lesions occur in the dorsolateral prefrontal cortex of the left hemisphere, it was associated with an increase in depressive symptoms (Grajny et al., 2016). Together, these results provide support that the left frontal lobes play a critical role in the production of depressive symptoms.

There is some evidence that frontal alpha asymmetry may be correlated to growth mindset manipulations. In Daly et al. (2019)'s study where participants were exposed to two different types of mathematical problems—standard style; and one in the style of mathematical mindset theory—a more positive prefrontal asymmetry (greater neural activity in the left hemisphere than right) was observed in participants after trials where participants were exposed to mathematical mindset (MM) problems (Daly et al., 2019). In mathematical mindset problems, participants are provided with suggestions for various ways a problem could be approached to encourage the use of alternate strategies. Greater left than right power was observed across alpha, beta, and gamma frequency bands in the MM group than the standard group, which the researchers suggest stemmed from increased motivation in the MM group. However, because the researchers failed to address the functional relevance of each frequency, it is difficult to determine which frequency band is most closely linked to motivation. Additionally, the researchers fail to address the varying relationships between spectral power and brain activity that exist for the different frequency bands (i.e., a direct relationship between power and activity for beta and gamma, but an inverse relationship between power and activity for alpha), making a clear interpretation of their findings more challenging.

However, it is possible that, as suggested by Daly et al. (2019), greater left than right spectral power (i.e., brain activity in this case) is related to increased motivation, as participants experienced higher motivation after being exposed to the MM problems that induced growth mindset. Therefore, higher levels of motivation could correlate with increased activity in the left hemisphere. The link between frontal alpha asymmetry and motivation is further supported by Schone et al. (2015), who presented male participants with erotic images of women, images of attractive women who were dressed in every-day wear, and images of women engaged in extreme sports to determine the correlation between frontal alpha asymmetry and motivational stimuli. Results showed that erotic images of women produced a relative reduction in alpha power (an increase in brain activity) in the left frontal region when compared to the right (Schone et al., 2015). This finding aligns with Daly et al. (2019)'s work which supported that an active motivational system is associated with increased activity in the left frontal region when compared to the right.

The BIS/BAS Motivational scale, which measures an individual's level of approach or avoidance motivation, has also been used in research regarding frontal alpha asymmetry patterns (Coan & Allen, 2003; Kaack et al., 2020; De Pascalis et al., 2013). It has been shown that individuals high in BAS, which describe an individual's proneness to move towards positive stimuli (Gray, 1987), show correlations to greater activation in the left frontal regions, which are associated with approach-related behaviors (Davidson, 1984; Coan & Allen, 2003; De Pascalis et al., 2013). Individuals high in BIS, on the other hand, which describe an individual's proneness to avoid unpleasant stimuli (Gray, 1987), surprisingly do not show significant increased activation in the right frontal regions, which are associated with withdraw-related behaviors (Davidson, 1984; Coan & Allen, 2003). However, although there is a lack significant correlations between BIS and right frontal activation, a trend of relatively greater right frontal activity relating to greater BIS scores has been observed through EEG recording in the midfrontal region (Coan & Allen, 2003). Further, it has been shown that the revised BIS (r-BIS) is associated with greater relative right frontal asymmetry (Lacey et al., 2020). The r-BIS measures effortful control in situations where participants are faced with a conflict between or within motivational systems (Gray & McNaughton, 2000), such as maintaining engagement with a negative stimulus to gain reward, as was the case in Lacey et al. (2020). These results imply that it may be effortful control of negative emotions that are related to right frontal lobe activation, and not the valence of the emotion alone (Lacey et al., 2020).

It must be noted that not every study has observed the asymmetry patterns associated with BIS/BAS scores mentioned above. Kaack et al. (2020) observed no significant correlations between left frontal asymmetry and BAS subscales. However, a significant relationship between left frontal asymmetry and Effort Expenditure for Rewards Task was observed, indicating that left frontal asymmetry was still associated with motivation to some degree in this study (Kaack et al., 2020). Contrary to previous studies, Coan and Allen (2003) found a significant positive correlation between BIS scores and asymmetry in the central region when Cz-online was used as reference. However, this correlation was not observed when using average or linked-mastoid references (Coan & Allen, 2003). Due to the relationship only being observed in one reference schema and not the others, it could be the case that there are some reference-specific properties that account for the relationship which negate the strength of the relationship found, such as increased extra electrical activity at the reference, as is the case with Cz (Hagemann et al., 2001).

At present, there is limited research that has explored the relationship between growth mindsets and neural patterns, and even fewer prior studies that explore the changes in brain activity associated with a mindset manipulation. Therefore, the goal of the present study was to determine the effects of a growth mindset manipulation on neural activity, as measured using frontal alpha asymmetry. The outcomes of this research would lead to a clearer understanding for academia on the neural changes that accompany a growth mindset that in turn produce behavioral changes that improve the learner's experience.

To accomplish this, participants in the present research were exposed to one of two passages that they were instructed to read. One passage was modeled to support a growth mindset (i.e., "People may be born with a given level of intelligence, but we see increases in IQs up to 50 points when people enter stimulating environments"), and the other was modeled to support a fixed mindset (i.e., "Intelligence seems to have a very strong genetic component"), as modeled by Miele and Molden (2010). At the beginning of the study, participants were asked to complete questionnaires assessing baseline growth mindset, BIS/BAS motivation, and depression. Resting state EEG was recorded before and after participants complete their reading. BIS/BAS motivation and growth mindset measures were administered again after the second EEG recording.

Based on previous findings (Castiglione, 2019; Daly et al., 2019; Davidson, 1984; Miele & Molden, 2010; Schone et al., 2015), I hypothesized that:

1) The manipulation task would result in a significant change in growth or fixed mindset from pre to post, dependent on condition randomly assigned.

2) Because growth mindset shares many commonalities with motivation, there would be differences in motivation between growth mindset and fixed mindset groups. Specifically, I predicted that an increased change in growth motivation would be associated with an increased change in BAS subscale measurements, while a decreased change in growth mindset would be associated with an increased change in BIS measurements.

3) The growth mindset manipulation would result in a reduction from pre to post in alpha power (increase in brain activity) in the frontal left hemisphere relative to the right (i.e., an increase in frontal alpha asymmetry). Because growth mindset and motivation are different constructs, the frontal alpha asymmetry effects following a growth mindset manipulation would remain significant after controlling for motivation.

4) The fixed mindset manipulation would result in an increase from pre to post in alpha power (decrease in brain activity) in the frontal left hemisphere relative to the right (i.e., a decrease in frontal alpha asymmetry). These results would also remain significant after controlling for motivation effects.

Method

Participants

Participants were recruited through the online SONA system at Stockton University. Data were collected from 52 participants; however, 6 participants were dropped due to handedness scores, 9 because they were taking medication, and 1 due to failure to successfully complete the manipulation task. The participant who failed to successfully complete the manipulation task also had an insufficient handedness score, resulting in only 5 participants being dropped for handedness alone. The final sample included 37 undergraduate students (29 female, 8 male) enrolled in a psychology or related course who elected to participate in the experiment as an optional research requirement for their course. Regarding college major, 43.2% of the participants were psychology majors, and 56.8% of participants were other majors such as health science, nursing, or other social sciences. All participants were right-handed. Participants ranged in age from 18 to 50 years, with a mean age of 22.76 years (*SD* = 7.05 years). Regarding race and ethnicity, 56.8% of participants were white/Caucasian. Participants were assigned to one of two groups (i.e., growth mindset or fixed mindset). Gender and age demographics by condition are shown in Table 1.

Materials

Mindset Manipulation

Mindset was manipulated with two versions of text, as modeled by Miele and Molden (2010) (adapted from Bergen, 1992). In the readings, the article titled "The Origins of Intelligence: Is the Nature-Nurture Controversy Resolved?" was edited to look like it was originally published in a 2007 issue of *Psychology Today*. The text has two versions: one version (fixed mindset) that emphasizes new scientific "evidence" that supports "the idea that intelligence is a genetically determined attribute that changes very little over time", and another version (growth mindset) that emphasizes new scientific "evidence" that supports "the idea that intelligence is an environmentally determined attribute that can be improved over time" (Miele & Molden, 2010).

Texts for both conditions, taken from Miele and Molden (2010), are found in Appendix A and B.

As in Miele and Molden (2010), post reading questions were included as a manipulation check and to increase persuasiveness of the reading by having participants relate the article to their own experience. Participants were asked to complete three open-ended questions: "Summarize the main point of the article in one sentence," "Describe the evidence from the article that you found most convincing," and "Describe an example from your own experiences that fits with the main point of the article".

Growth Mindset Questionnaire (Dweck, 2006)

The 8-item Growth Mindset Questionnaire (Dweck, 2006) provides a measurement of participants' growth mindset. Participants rated their agreement (on a scale of 1-6) with statements such as "Your intelligence is something that you can't change very much" and "You can always substantially change how intelligent you are." Responses across statements were averaged, creating a possible range of 1 to 6, with higher scores indicating a stronger growth mindset, and lower scores indicating a weaker growth mindset (i.e., stronger fixed mindset).

Edinburgh Handedness Inventory (Oldfield, 1971)

The Handedness Inventory (Oldfield, 1971) determines the degree of handedness for each participant. Participants were asked to answer which hand they prefer to use for 10 objects or activities. Answers to choose from for each item or activity include "Always Left", "Usually Left", "No Preference", "Usually Right", and "Always Right". Scores range from -10 to 10, with higher scores indicating stronger preference for right handedness. Because of the effects of handedness on frontal alpha asymmetry (Fleck et al., 2018), only participants who scored a 70 or higher on the handedness inventory were retained for analysis.

BIS/BAS Motivation Scales (Carver & White, 1994)

The BIS/BAS Motivation Scale is a 20-item scale that measures an individual's level of approach or avoidance motivation. Behavioral inhibition systems (BIS) describe an individual's proneness to avoid unpleasant stimuli (Gray, 1987). This system inhibits behavior that may lead to punishment or painful outcomes. Therefore, an individual high in BIS has inhibition of movement towards goals. Behavioral activating/approach systems (BAS) describe an individual's proneness to move towards positive stimuli (Gray, 1987). Individuals high in BAS are more prone to approach motivating stimuli (Gray, 1987). The scale asked participants to answer on a scale of 1 (very true for me) to 4 (very false for me) for a series of statements such as, "I go out of my way to get things I want", "I'm always willing to try something new if I think it will be fun", "When I get something I want, I feel excited and energized", and "Criticism or scolding hurts me quite a bit." The scale is divided into four sub measurements: BAS Drive (persistent pursuit of motivating goals), BAS Fun Seeking (motivation to pursue new rewards and spontaneous reward-seeking), BAS Reward Responsiveness (response to pleasant rewards), and BIS (reaction to expectation of punishment). All items were reverse scored except for 1 and 18. Scores for each subscale were averaged across the total number of items in each subscale. BAS Drive contained 4 items, BAS Fun Seeking contained 4 items, BAS Reward Responsiveness contained 5 items, and BIS contained 7 items. The range of scores for each subscale was 1 to 4, with higher scores indicating a stronger presence of the corresponding subscale.

Beck Depression Inventory II (BDI-II; Beck et al., 1996)

The Beck Depression Inventory II (Beck et al., 1996) was used to assess participants' baseline depression levels. The BDI-II is the updated version of the BDI that corresponds with criteria for depression outlined in the DSM-IV. The assessment consists of 21 items, where participants are asked to pick the statement for each item that best corresponds to how they have been feeling during the past two weeks. For example, for item 1 (Sadness), participants must pick from the following statements: "I do not feel sad", "I feel sad much of the time", "I am sad all the time", or "I am so sad or unhappy that I can't stand it". Each statement is assigned a numerical value from 0 to 3. Scores are summed across the 21 items to determine total depression symptomology, which range from 0 to 63, subcategorized into minimal (0-13), mild (14-19), moderate (20-28), and severe (29-63) symptoms.

EEG

EEG data were recorded using a HydroCel Geodesic Sensor Net, with Cz reference (Electrical Geodesics, Inc., 2020). Sensor impedance levels were below 50 KΩ, appropriate for use with the Net Amps 400 high-impedance amplifier. Data were sampled at 500 Hz and filtered using an analog .1 – 100 Hz bandpass filter. Three minutes of eyes-open data followed by three minutes of eyes-closed data was recorded from each participant using Net Station 5.4 software (Electrical Geodesics, Inc., 2020) for the pre and post recordings.

EEG data was processed offline using EEGLAB 2022.1 (Delorme & Makeig, 2004), supplemented by MATLAB scripts, run using Matlab 2021a (Mathworks, Natick, MA, USA). The data were filtered in EEGLAB using a band-pass filter (0.2 - 50 Hz) and then segmented into 2-second epochs. Files were visually inspected to remove bad channels and epochs containing gross artifacts. Files were then subject to independent component analysis and the resulting components were processed for artifact using IC Label (Pion-Tonachini et al., 2019), a plug-in available for use on the EEGLAB platform. Components identified as artifact were removed from the data and the files were visually inspected a second time to ensure no artifact remains.

After final visual review, missing channels were interpolated from neighboring channels and the data were re-referenced to average reference before undergoing baseline correction. Absolute power for the remaining epochs was estimated using MATLAB's Fast Fourier Transformation function. Power spectra were estimated for each epoch separately, and spectra from epochs within the same block were averaged before mean power estimates are calculated for the 19 electrodes in the Standard 10-20 System for the following frequency bands: delta (1.00 – 4.00 Hz), theta (4.00 – 7.50 Hz), alpha 1 (8.00 – 10.50 Hz), alpha 2 (10.50 – 13.00), beta (13.00 – 30.00 Hz), and gamma (30.00 – 45.00 Hz). All power values were log transformed to reduce the positive skew that is typically present in EEG data.

Procedure

After providing written informed consent, participants were asked to complete the demographics form that asks about age, sex, race, ethnicity, GPA, and college major. Participants were also asked to complete the Edinburgh Handedness Inventory. Next, participants were asked to complete the Growth Mindset Questionnaire, the Beck Depression Inventory II, and the BIS/BAS Motivation Scales. The administration of these three measures was counterbalanced.

Participants were taken into the experiment area where the EEG net was applied and configured. Participants were asked to complete a resting-state EEG recording, which consisted of 3 minutes of eyes-open recording, and 3 minutes of eyes-closed recording. After, participants kept the EEG net on and were assigned to one of two groups: group assignment was counterbalanced. Group one was the fixed mindset condition. In this condition, participants were asked to read the fixed mindset version of the Psychology Today article, arguing that “intelligence is a genetically determined attribute that changes very little over time”, as outlined in materials. Group two was the growth mindset condition. In this condition, participants were asked to read the growth mindset version of the Psychology Today article, arguing that “intelligence is an environmentally determined attribute that can be improved over time”, as outlined in materials. After completion of their assigned reading, participants were asked to answer three open-ended questions to increase persuasiveness and strength of manipulation.

After completion of the assigned reading and associated questions, participants participated in another resting state EEG recording, which consisted of 3 minutes of eyes-open recording, and 3 minutes of eyes-closed recording.

When the EEG recording was complete, participants were asked to complete the BIS/BAS Motivation Scales and the Growth Mindset Questionnaire. The administration of these measures was counterbalanced.

The EEG net was then removed. Participants were given a short feedback form explaining the experiment goals and were thanked for their participation. The entire session took approximately 1 hour to complete.

Results

Analysis Overview

All analyses were conducted using SPSS 28. Frontal alpha asymmetry (FAA) was defined as right frontal alpha power minus left frontal alpha power and was calculated using electrodes F4 (right frontal) and F3 (left frontal). The formula used to calculate FAA was (F4 alpha – F3 alpha)/(F4 alpha + F3 alpha). Participants who scored lower than 70 on the Edinburg Handedness Inventory, provided insufficient answers to post-manipulation reading questions, or were currently taking medication for the treatment of a mental health disorder were excluded from analysis. This is because of the effects of handedness (Fleck et al., 2018) and depression (Gotlib et al., 1998) on frontal alpha asymmetry. The final sample size for all analyses was 37 participants (17 for the fixed mindset condition, 20 for the growth mindset condition).

The change scores for all variables were calculated by subtracting pre measures from post measures. For example, change in growth mindset is equal to post growth mindset minus pre growth mindset. Because all analyses were exploratory, no alpha correction was performed for multiple comparisons.

Behavioral Results

To test the effectiveness of the manipulation, a one-way ANOVA was conducted comparing the mean change in growth mindset between fixed and growth mindset conditions. There was a significant difference in the change in growth mindset between the fixed mindset condition (*M* = - 0.90; *SD* = 0.75) and the growth mindset condition (*M* = 0.11; *SD* = .54), *F*(1,35) = 22.92, $p < .001$, η_p^2 = 0.40. Results are displayed in Table 2.

Paired samples t-tests were conducted to determine if there was a significant change in mindset from pre to post for each condition. Participants in the growth mindset condition did not show a significant difference in growth mindset from pre manipulation (M = 4.29; SD = 0.72) to post manipulation (*M* = 4.40; *SD* = 0.78), *t*(19) = - 0.94 , *p* = .36, *d* = 0.21. However, participants in the fixed mindset condition scored significantly lower in growth mindset after the manipulation (*M* = 3.99; *SD* = 1.09) than before the manipulation (*M* = 4.89; *SD* = 0.66), *t*(16) = 4.97, $p < .001$, *d* = 1.21. Results are displayed in Figure 1.

To test whether the manipulation influenced motivation as well as growth mindset, one-way ANOVAs were also performed to compare the mean change in BIS/BAS Motivation subscales between fixed and growth mindset conditions. There was a significant difference in change in BAS Drive between the fixed mindset condition (*M* = -0.13; *SD* =0.25) and growth mindset condition (*M* = 0.07; *SD* = 0.28), *F*(1,35) = 5.02, *p* = .03, η_p^2 = 0.13. A paired samples t-test was performed and found that in the fixed mindset condition, participants scored significantly lower on BAS Drive following the manipulation (*M* = 2.68; *SD* = 0.64) than before the manipulation (*M* = 2.81; *SD* = 0.52), *t*(16) = 2.17, *p* = .046, *d* = 0.53. Participants in the growth mindset condition did not show a significant difference in BAS Drive from pre manipulation (M = 2.74; SD = 0.68) to post manipulation (*M* = 2.80; *SD* = 0.80), *t*(19) = - 0.94 , *p* = .31, *d* = 0.24. Results are displayed in Figure 2. Additionally, there were no significant differences in the change in BAS Reward Responsiveness (*FMM* = -0.07, *SD* =0.22; *GMM* = 0.05, *SD* = 0.26; *F*(1,35) = 2.16, *p* = .15,

η_p^2 = 0.06), change in BAS Fun Seeking (*FMM* = 0.03, *SD* =0.23; *GMM* = 0.17, *SD* = 0.27; $F(1,35) = 2.82$, $p = .10$, η_p^2 = 0.07), or change in BIS (*FMM* = 0.00, *SD* =0.14; *GMM* = - 0.08, *SD* = 0.22; $F(1,35) = 1.55$, $p = .22$, η_p^2 = 0.04) between the fixed and growth mindset conditions. Results are displayed in Table 2.

To further delineate the relationship between growth mindset and motivation, Pearson's correlations were conducted between change in growth mindset and change in motivation, using the subscales of the BIS/BAS Motivation Scales. Subscales included BAS Drive, BAS Reward Responsiveness, BAS Fun Seeking, and BIS. There were no significant correlations observed between change in growth mindset and change in BAS Drive (r (35) = 0.25, p = .14), change in BAS Reward Responsiveness (r (35) = 0.02, p = .92), change in BAS Fun Seeking (r (35) = 0.07, p = .68), or change in BIS (r (35) = -0.18, p = .32). Results are displayed in Table 3.

In order to explore patterns in the dataset between trait growth mindset, depression level, and motivation levels, Pearson's correlations were conducted among all pre measures. There was a significant correlation observed between pre growth mindset mean and pre BAS Drive (r (35) = 0.38, p = .03, R^2 = 0.13). The correlation between pre growth mindset and BDI depression score, although not significant, approached significance (r (35) = -0.32, p = 0.053, R^2 = 0.10). No significant correlations were found between change in growth mindset and Pre BAS Drive (r (35) = 0.09, p = .58), Pre BAS Reward Responsiveness (r (35) = - 0.06, p = 72), Pre BAS Fun Seeking (r (35) = 0.16, p = .36), Pre BIS (r (35) = - 0.09, p = .09), BDI Sum (r (35) = 0.16, p = .34), or Pre Growth Mindset (r (35) = -0.28, p = .10). Results are displayed in Table 4.

Neural Results

Change in Frontal Alpha Asymmetry

For neural results, overall alpha power (8-13 Hz) was used for calculations. Eyes-closed recordings were used to determine asymmetry changes. As noted above, alpha asymmetry was calculated as (F4-F3) (Right-Left)/(F4+F3) to correct the model for variance. Therefore, positive FAA values reflect greater left frontal relative to right frontal activity, whereas negative FAA values reflect greater right frontal relative to left frontal activity.

To test the effectiveness of the manipulation in changing frontal alpha asymmetry, a one-way ANOVA was conducted comparing the change in frontal alpha asymmetry between fixed and growth mindset conditions. There was a significant difference in the change in frontal alpha asymmetry between the fixed (*M* = - 0.08; *SD* = 0.12) and growth (*M* = - 0.01; *SD* = 0.04) mindset conditions, *F*(1, 35) = 7.70, *p* = .01 η_p^2 =0.18.

Paired samples t-tests conducted by condition revealed that for participants in the fixed mindset condition, frontal alpha asymmetry decreased significantly from pre (*M* = 0.02; *SD* = 0.12) to post (*M* = - 0.07; *SD* = 0.13), *t*(16) = 2.94, *p* = .01, *d* =0.71. There was no significant change in pre (*M* = - 0.05; *SD* = 0.13) to post (*M* = - 0.06; *SD* = 0.14) frontal alpha asymmetry observed in the growth mindset condition, *t*(19) = 0.82, *p* = .43, *d* = 0.18. Results are displayed in Figure 3.

Patterns between Pre Resting- State Brain Activity and Self-report Measures

Pearson's correlation analyses were conducted to explore the relationships between pre FAA and the pre growth mindset, motivation, and depression measures. Participants were collapsed across mindset conditions for these analyses. No significant relationships were found between pre FAA and BDI (*r* (35) = 0.05, *p* = .78), pre growth mindset mean (*r* (35) = 0.22, *p* = .19), pre BAS drive (*r* (35) = -0.03, *p* = .84), pre BAS fun seeking (*r* (35) = - 0.001, *p* = .997), pre BAS reward responsiveness (*r* (35) = 0.06, *p* = .73), and pre BIS (*r* (35) = 0.03, *p* = .86). Although not significant, the positive correlation between pre frontal alpha asymmetry and growth mindset is stronger than the other correlations. Of these correlations mentioned, the p-value for the correlation between pre frontal alpha asymmetry and pre growth mindset is also the closest to significance. Results are displayed in Table 5.

Additionally, the relationships between alpha power at left and right electrode locations for the pre resting-state recording and pre growth mindset and motivation measures showed significant negative correlations between growth mindset and left hemisphere alpha power at electrodes Fp1 (r (35) = - 0.37, p = .02, R^2 = 0.14) and F3 (r (35) = - 0.35, p = .04, R^2 = 0.12). No significant correlations were observed for the other pre measurements. Regarding the right hemisphere electrodes (Fp2, F4, and F8), no significant correlations were observed between pre measures and pre right hemisphere alpha power at any electrodes. Results are displayed in Table 5.

Discussion

The purpose of the present research was two-fold. First, we sought to explore whether mindsets can immediately be induced after a manipulation. Second, we sought to explore whether that mindset induction was associated with changes in neural patterns, specifically a change in frontal alpha asymmetry. Our results generally showed that mindset was able to be induced and that the change in mindset was accompanied by a corresponding frontal alpha asymmetry change. These findings are discussed in detail below in conjunction with the project hypotheses and prior research in the field.

The project results supported the hypothesis that the manipulation would result in a significant change in growth or fixed mindset from pre to post, depending on the condition assigned. The manipulation was successful in inducing the corresponding mindset from pre to post, such that there was a significant difference in the change in mindsets between conditions. Upon further analysis, it was revealed that this significant difference was driven by the fixed mindset condition, as participants in the fixed mindset condition significantly decreased in growth mindset views from pre to post, whereas there was no significant change in the growth mindset condition. The significance of these results is further compounded by the very large effect size found for the decrease in growth mindset from pre to post in the fixed mindset condition, which clearly illustrates the magnitude of the change. The lack of a significant change in the growth mindset condition could be due to the trend that participants in both conditions started high in growth mindset, making an increase in growth mindset harder to achieve for individuals who were assigned to the growth mindset condition.

Additionally, the results showed that the manipulation was successful at inducing a significant change in BAS drive, which again was also driven by participants in the fixed mindset condition, such that participants had significantly lower BAS Drive scores (i.e., a decrease in persistent pursuit of motivating goals) after being exposed to the fixed mindset manipulation reading than at pre measurement. This supports our hypothesis that growth mindset and motivation are related and is in line with work from Daly et al. (2019) and Degol et al. (2017), who found that growth mindset and motivation are related in completion of math problems. This hypothesis was also supported by the positive correlation observed between pre growth mindset and pre BAS Drive, which confirms that participants higher in growth mindset at pre also had higher BAS Drive at pre. However, no correlations were found between the change in growth mindset and change in any of the motivation subscales. This provides support that, although related to some extent, motivation and growth mindset are different constructs.

It is interesting to note that growth mindset and BAS Drive were both found to be significantly correlated at pre and significantly affected by our manipulation, driven by changes in the fixed mindset condition. Since no correlation was reported between BAS Drive change and Growth Mindset change, it could be that our manipulation was more effective at inducing a change in mindset than inducing a change in BAS Drive, which is further supported by the greater effect size for the change in growth mindset analysis, when compared to change in BAS Drive.

Although not predicted, our results showed that the correlation between BDI depression scores and pre growth mindset approached significance. This means that a trend was present where participants who were high in depression were low in growth mindset (high in fixed mindset). This relationship was not observed on a neural level—BDI scores were not correlated with frontal alpha asymmetry and did not approach significance. This is not in line with previous work by Gotlib et al. (1998), who found that left frontal hypoactivation was associated with a vulnerability to depression.

In support of the hypothesis that changes in FAA would accompany changes in mindset, our results showed many changes in frontal alpha asymmetry between growth and fixed mindset conditions. First, there was a significant difference in the change in frontal alpha asymmetry between the fixed and growth mindset conditions. This difference seemed to be driven by the fixed mindset condition, who showed a significant decrease in frontal alpha asymmetry (i.e. a decrease in relative left frontal brain activation) from pre to post. This change was also accompanied by a large effect size, further illustrating the strength of these findings. These findings are in line with the behavioral results that also confirmed that the significant difference in change in growth mindset was driven by the fixed mindset condition.

The analyses of pre FAA and the pre measures to capture trait relationships further offered some support for a relationship between FAA and growth mindset. Although no positive correlations between pre frontal alpha asymmetry and pre measures were observed, the correlation between pre frontal alpha asymmetry and growth mindset was the strongest correlation of the pre measures with an R^2 of 0.05. This correlation also has the closest p-value to significance. Therefore, this implies that with a larger sample size, a significant correlation between these two variables may occur, supporting the trend that an increase in growth mindset is associated with an increase in frontal alpha asymmetry (i.e., an increase in left frontal brain activation). Additionally, the link between frontal activity and growth mindset level is further supported by the negative correlations present between frontal alpha power at Fp1 and F3 and pre growth mindset, which support that an increase in growth mindset is correlated to a decrease in alpha power (increase in brain activity) in the left frontal region of the brain.

Together, these results are in line with previous literature on frontal alpha asymmetry and left frontal activation. Previous literature has shown that left frontal hemisphere activation was related to positive approach-related behaviors (Coan & Allen, 2003; Davidson, 1984; De Pascalis et al., 2013), with some work supporting the potential relationship between frontal alpha asymmetry and growth mindset (Daly et al., 2019). The results of the present research support and extend these findings.

Conclusion

The results of this study confirm the relationship between growth mindset and frontal alpha asymmetry, while also confirming that a change in growth mindset can be induced both on a behavioral level and on a neural level. An increase in growth mindset is related to increased activation in the left frontal lobe —a region associated with positive approach-related behaviors.

Limitations

It must be noted that our sample size was small, which accounted for some of the correlations only approaching significance and for the lack of a significant change in growth mindset from pre to post for the growth mindset condition. Our sample was also composed of undergraduate university students. This could explain why our sample scored so high on pre growth mindset mean (4.5 out of 6), as growth mindset is related to greater academic success (Blackwell et al., 2007). Future research is needed on a more diverse sample with a greater variation in pre growth mindset beliefs. A greater variation in pre growth mindset beliefs would allow for a more observable and distinctive change in growth mindset and associated frontal alpha asymmetry to occur after the manipulation.

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Tables

Table 1

Gender and Age Demographics by Condition

		Fixed Mindset		Growth Mindset	
		M	*SD*	*M*	*SD*
Age		22.06	7.34	23.35	6.92
		n	%	*n*	%
Gender					
	Male	4	23.53	4	20.00
	Female	13	76.47	16	80.00

Table 2

Comparison of Change Variables Between Conditions Using One Way ANOVA

Variable	Fixed Mindset		Growth Mindset		*F (1,35)*	n_p^2
	M	*SD*	*M*	*SD*		
Change in BAS Drive	-0.13	0.25	0.07	0.28	5.02*	0.13
Change in BAS Reward Responsiveness	-0.07	0.22	0.05	0.26	2.16	0.06
Change in BAS Fun Seeking	0.03	0.23	0.17	0.27	2.82	0.07
Change in BIS	0.00	0.14	-0.08	0.22	1.55	0.04
Change in Growth Mindset	-0.90	0.75	0.11	0.54	22.92**	0.40

*p < .05. **p < .01. ***p < .001.

Table 3

Correlation Coefficients Between Change in Growth Mindset and Change in Motivation Subscales

Variable	Change in Growth Mindset	Change in BAS Drive	Change in BAS Reward Responsiveness	Change in BAS Fun Seeking	Change in BIS
Change in Growth Mindset	—				
Change in BAS Drive	0.25	—			
Change in BAS Reward Responsiveness	0.02	0.04	—		
Change in BAS Fun Seeking	0.07	0.17	0.18	—	
Change in BIS	-0.17	0.07	0.24	0.11	—

*p < .05. **p < .01. ***p < .001.

Table 4

Correlation Coefficients Between Change in Growth Mindset and Pre Manipulation Measures

Variable	Pre Growth Mindset Mean	BDI Sum	Pre BAS Drive	Pre BAS Fun Seeking	Pre BAS Reward Responsiveness	Pre BIS	Change in Growth Mindset
Pre Growth Mindset	—						
BDI	-0.32	—					
Pre BAS Drive	0.37*	-0.36*	—				
Pre BAS Fun Seeking	0.03	0.25	0.38*	—			
Pre BAS Reward Responsiveness	0.17	-0.15	0.36*	0.43**	—		
Pre BIS	0.27	0.08	-0.28	-0.05	0.17	—	
Change in Growth Mindset	-0.28	0.16	0.09	0.15	0.06	-0.22	—

*p < .05. **p < .01. ***p < .001.

Table 5

Correlation Coefficients Between Resting-State Brain Activity and Pre Manipulation Measures

Variable	BDI Sum	Pre Growth Mindset	Pre BAS Drive	Pre BAS Fun Seeking	Pre BAS Reward Responsiveness	Pre BIS	Pre FAA	Pre Fp1	Pre F3	Pre F7
BDI Sum	—									
Pre Growth Mindset	- 0.32	—								
Pre BAS Drive	- 0.36*	0.37	—							
Pre BAS Fun Seeking	0.25	0.03	0.38*	—						
Pre BAS Reward Responsiveness	-0.15	0.17	0.36*	0.43**	—					
Pre BIS	0.09	0.27	-0.28	-0.05	0.17	—				
Pre FAA	0.05	0.22	-0.03	-0.001	0.06	0.03	—			
Pre Fp1	0.20	-0.37*	-0.27	-0.11	-0.27	-0.05	0.13	—		
Pre F3	0.21	-0.35*	-0.23	-0.07	-0.19	-0.03	0.10	0.98**	—	
Pre F7	0.21	-0.26	-0.28	-0.08	-0.18	-0.17	0.24	0.83**	0.86**	—

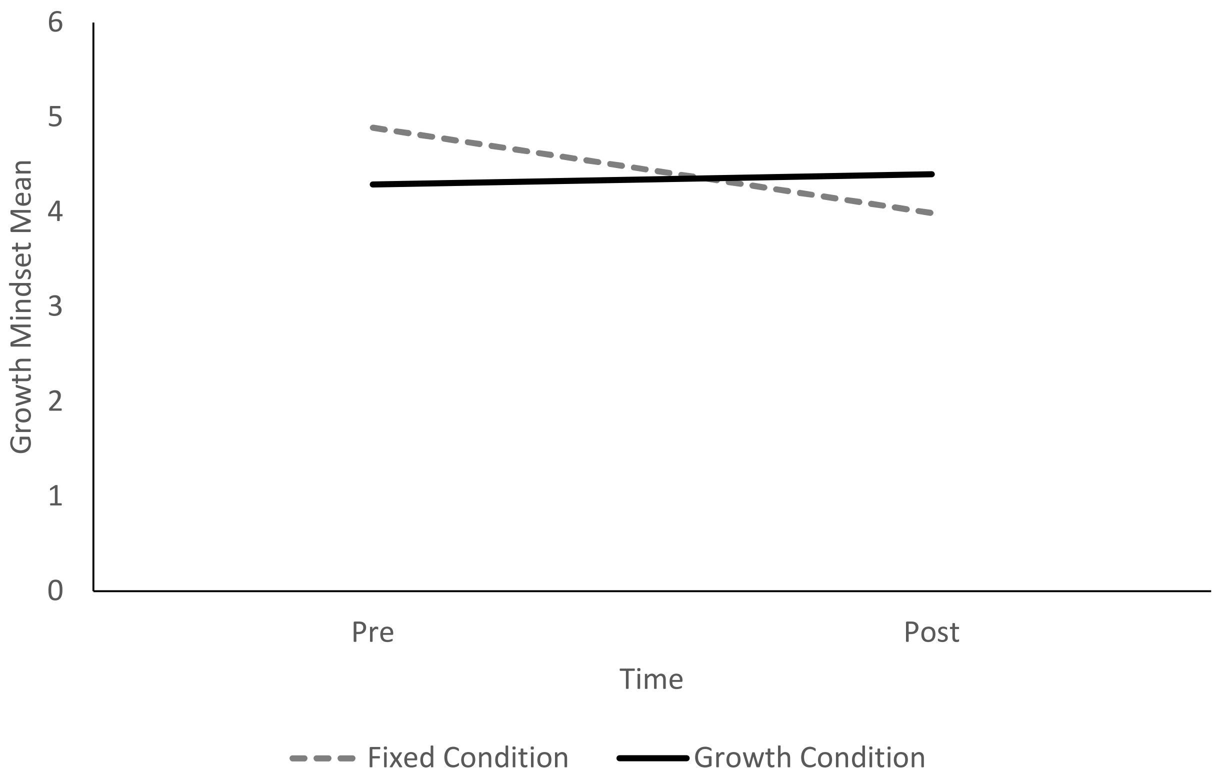
Note. Frontal alpha asymmetry is abbreviated as FAA. Pre Fp1, F3, and F7 refer to pre alpha power at indicated electrodes.

*p < .05. **p < .01. ***p < .001.

Figures

Figure 1

Change in Mean Growth Mindset as a Function of Time

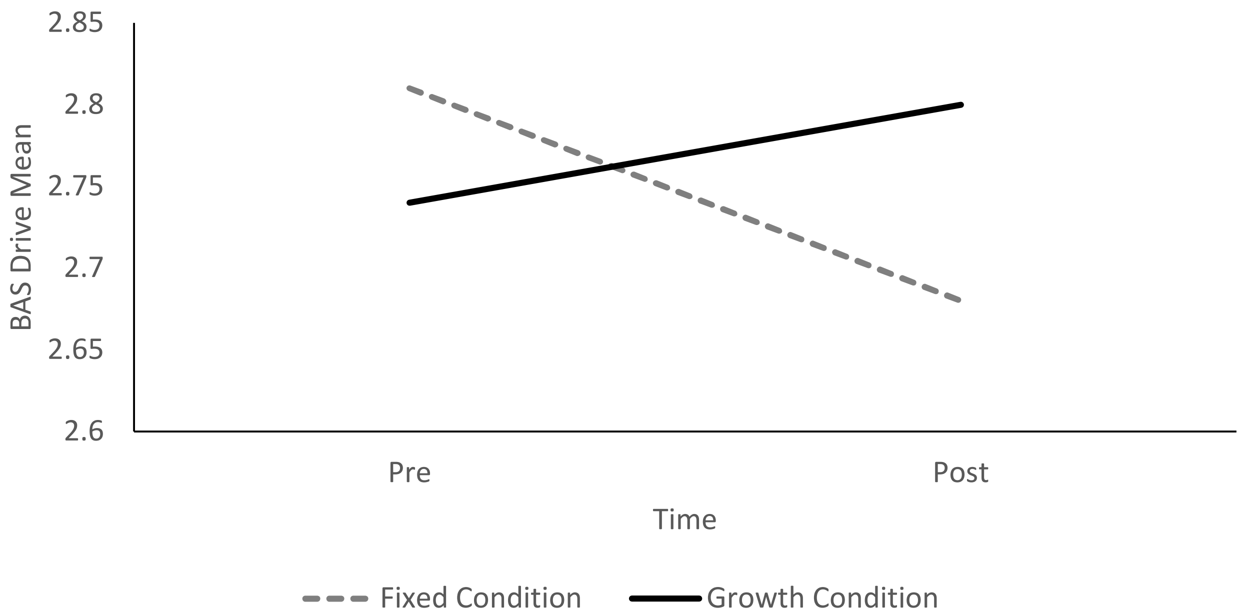


Note. Change in mean growth mindset by condition from pre to post manipulation.

*The change in growth mindset from pre to post manipulation is significant in the fixed mindset condition.

Figure 2

Change in Mean BAS Drive as a Function of Time

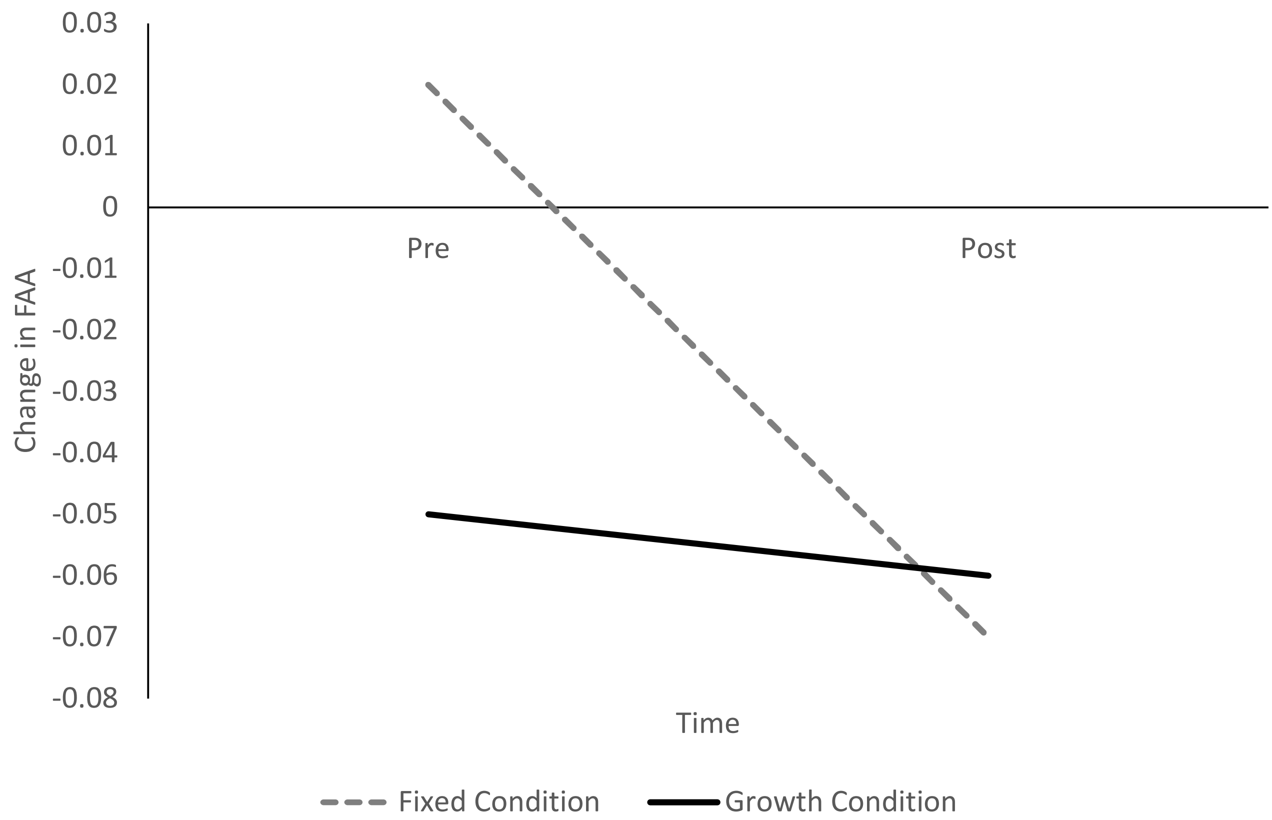


Note. Change in mean BAS Drive by condition from pre to post manipulation.

*The change in BAS drive from pre to post manipulation is significant in the fixed mindset condition.

Figure 3

Change in Mean FAA as a Function of Time



Note. Change in frontal alpha asymmetry by condition from pre to post manipulation. Frontal alpha asymmetry is abbreviated as FAA.

*The change in FAA from pre to post manipulation is significant in the fixed mindset condition.

Appendix A

Growth Mindset Manipulation Reading

CROSSTALK

THE BRAIN

The Origins of Intelligence:

Is the Nature-Nurture Controversy Resolved?

BY JEROME BERGLUND

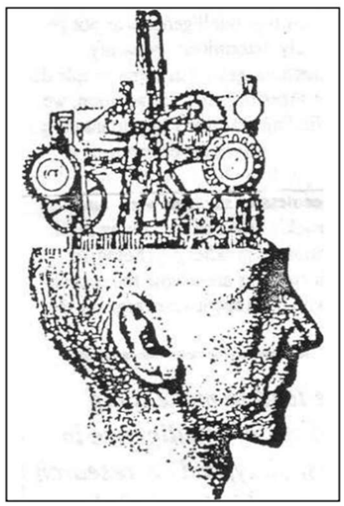
Adam Steagal is gifted. Although he is just eighteen months old, he can understand over 2000 words, has a speaking vocabulary of 500 words, and is even able to identify five different species of birds. Early in his life, Adam's parents had a hunch that he was unusual.

At the age of 8 months he was crawling and investigating everything in the Steagal household. All babies are curious, but Adam's curiosity led him to heights of baby creativity. He was not simply banging on pots and pans; Adam had learned to dismantle a toy camera and put it back together again. He had the coordination to handle small objects, the ability to remember how parts fit together, and could concentrate on the camera for almost an hour. Most children can't do what Adam was doing until they are at least three or four.

When he was ten months old, Adam's parents brought him to University of Michigan's Unit for Intelligence Research (UIR). Paula Rescorla, the director of UIR, found that Adam had an IQ of 185. Experts consider an IQ of 130 "very superior." Adam's IQ is so extreme that only one person in a million has an IQ that even comes close. Researchers like Rescorla are keenly interested in what made Adam so smart.

The traditional "is it heredity or is it environment?" question is batted around the halls of UIR on a daily basis. But, people who take the side that intelligence is genetically determined are going to be believed less and less. Current research shows that intelligence can be increased substantially by environmental factors.

In the past decade, a number of comprehensive studies have been published in the United States and in Europe. These studies provide the clearest answers so far in the ongoing debate. The most significant of these studies will be published this fall in Psychological Review, a prestigious



psychological journal published in the United States.

John Knowles, the author of the article and a professor at Harvard, concludes that, "intelligence seems to

"The brilliance of Leonardo da Vinci and Albert Einstein was probably due to a challenging environment. Their genius had little to do with their genetic structure."

have a minimal genetic component. People may be born with a given level of intelligence, but we see increases in IQs up to 50 points when people enter stimulating environments."

Knowles spent the last decade tracing identical twins who were raised apart. In a relentless search through Latin America, Africa, and North America, he was able to locate 83 pairs of twins who were raised separately. These twins ranged in age from 7 to 51 and came from all economic levels.

Knowles had an ideal sample to study the nature-nurture question. The twins in his study were often reared in different cities by parents of different social classes. The various pairs of twins came from different countries, spoke different languages, were different ages, and he followed them for ten years. Knowles tested the subjects individually with the best "culture-fair" intelligence tests available.

Culture-fair tests measure intelligence by having people identify relationships between shapes and objects. Because the tests use only shapes and objects—not words—to measure intelligence, cultural factors don't influence people's scores. Consequently, they provide a much more accurate measure of intelligence than most other intelligence tests. In addition, culture-fair tests don't discriminate against any ethnic groups. Because Knowles used these sophisticated measures of intelligence, he was able to make stronger conclusions than have been possible in the past.

He found that twins raised in different environments had very different levels of intelligence. According to his results, up to 88 percent of a person's intelligence is due to environmental factors. In his study, if twins were raised in stimulating environments with motivated parents, they tended to have high IQs. Twins raised in unstimulating environments tended to have lower IQs. In an extreme case, a young girl adopted by a college professor and his wife had an IQ of 138. The genetically identical twin was raised by the real mother who was a prostitute. This girl had an IQ of only 85.

Although this evidence is very strong,

CROSSTALK

Knowles has even more evidence which may convince skeptics. He found that people in challenging environments showed substantial increases in their intelligence during the ten year study. Children and adults who were in stimulating environments had increases in IQ ranging from 15 to 48 points. People who were in unstimulating environments showed slight drops in their IQ.

According to Knowles, his results suggest that "the brilliance of Leonardo da Vinci and Albert Einstein was probably due to a challenging environment. Their genius had little to do with their genetic structure. These men are truly admirable because they were challenged and worked to overcome obstacles."

Other researchers are finding similar results. Hans Eysenck recently published an article supporting Knowles research. Eysenck's studies show that a person's level of motivation can have a profound effect on intelligence. He found that bright children placed in "dull" environments tended to become less intelligent unless they were motivated to learn. Relatively dull children placed in stimulating environments seemed to get much smarter, especially if they were rewarded for learning new things.

Needless to say, Knowles' and Eysenck's research is drawing much attention from other psychologists. Their findings are widely praised by researchers who have been trying for years to prove that intelligence is not genetically determined.

Leo Kamin of Princeton University is one such researcher. In the 1960s and '70s, he argued strongly that there was no good evidence to show the link between intelligence and genetics. He helped prove that Sir Cyril Burt, a now infamous researcher, faked his data to show that intelligence was inherited. When Burt was alive, the Queen of England knighted him for his "brilliant" research. When Kamin examined Bun's results, he discovered serious flaws that could only have resulted by faking the data.

This has led Kamin to be a bit careful before accepting any intelligence findings as the "truth." Consequently, he carefully examined Knowles' study. He found "no flaws in [Knowles'] methods or his analysis. Finally, the best available research shows what I have been arguing for for 25 years. Knowles' research is simply the best, and it shows that intelligence can be increased by stimulating environments."

Paula Rescorla at University of Michigan's UIR is also excited about Eysenck's and Knowles' results. "I think something crucial has come out of these studies – we now know that intelligence is something that motivated people can acquire. I think this idea will definitely revolutionize education in the twenty-first century. We can help motivated children find environments that will help them increase their intellectual abilities."

"I think something crucial has come out of these studies – we now know that intelligence is something that motivated people can acquire. I think these ideas will definitely revolutionize education in the twenty-first century. We can help motivated children find environments that will help them increase their intellectual abilities.

The eighteen month-old genius Adam Steagal seems to be in an ideal environment right now. His young brilliance is being challenged by fascinating toys and games. But apparently, whether or not he will be brilliant when he grows up is largely his choice. □

Jerome Berglund is a free-lance writer from Ann Arbor, Michigan. He is a frequent contributor to Psychology Today.

Appendix B

Fixed Mindset Manipulation Reading

CROSSTALK

THE BRAIN

The Origins of Intelligence:

Is the Nature-Nurture Controversy Resolved?

BY JEROME BERGLUND

Adam Steagal is gifted. Although he is just eighteen months old, he can understand over 2000 words, has a speaking vocabulary of 500 words, and is even able to identify five different species of birds. Early in his life, Adam's parents had a hunch that he was unusual.

At the age of 8 months he was crawling and investigating everything in the Steagal household. All babies are curious, but Adam's curiosity led him to heights of baby creativity. He was not simply banging on pots and pans; Adam had learned to dismantle a toy camera and put it back together again. He had the coordination to handle small objects, the ability to remember how parts fit together, and could concentrate on the camera for almost an hour. Most children can't do what Adam was doing until they are at least three or four.

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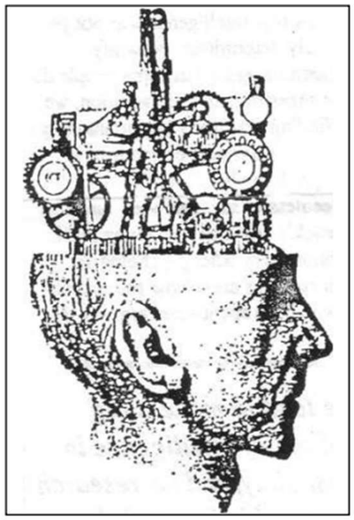
The traditional "is it heredity or is it environment?" question is batted around the halls of UIR on a daily basis. However, the answer is becoming increasingly clear. Current research shows that almost all of a person's intelligence is either inherited or determined at a very young age.

In the past decade, a number of comprehensive studies have been published in the United States and in Europe. These studies provide the clearest answers so far in the ongoing debate. The most significant of these studies will be published this fall in Psychological Review, a prestigious



psychological journal published in the United States

John Knowles, the author of the article and a professor at Harvard, concludes that "Intelligence seems to have a very

"The brilliance of Mozart and Einstein was mostly built into them at birth. Their genius was probably the result of their DNA."

strong genetic component. In addition, the environment seems to play a somewhat important role during the first three years of life. After the age of three, though, environmental factors (barring brain damage) seem to have almost no influence on intelligence."

Knowles spent the last decade tracing identical twins who were raised apart. In a relentless search through Latin America, Africa, and North America, he was able to locate 83 pairs of twins who were raised separately. These twins ranged in age from 7 to 51 and came from all economic levels.

Knowles had an ideal sample to study the nature-nurture question. The twins in his study were often reared in different cities by parents of different social classes. The various pairs of twins came from different countries, spoke different languages, were different ages, and he followed them for ten years. Knowles tested the subjects individually with the best "culture-fair" intelligence tests available.

Culture-fair tests measure intelligence by having people identify relationships between shapes and objects. Because the tests use only shapes and objects—not words—to measure intelligence, cultural factors don't influence people's scores. Consequently, they provide a much more accurate measure of intelligence than most other intelligence tests. In addition, culture-fair tests don't discriminate against any ethnic groups. Because Knowles used these sophisticated measures of intelligence, he was able to make stronger conclusions than have been possible in the past.

He found that twins raised apart had very similar levels of intelligence. Twins separated at birth sometimes had small differences in intelligence, ten to fifteen points. Almost all of the twins in his study that were separated after the age of three, though, had essentially identical IQs. If one twin was bright, the other was almost always equally bright. If one twin was not-so-bright, the other twin was probably not-so-bright

According to Knowles' results, up to eighty-eight percent of a person's intelligence is due to genetic factors.

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CROSSTALK

About ten percent of intelligence seems to be determined during the first three years of life. This means that intelligence may be increased or decreased by only about two percent during most of a person's life. To support this claim, Knowles can show that people's intelligence did not change much in ten years. Many things in their environment shifted in that time, but their intelligence stayed constant

According to Knowles, his results suggest that "the brilliance of Mozart and Einstein was mostly built into them at birth. Their genius was probably the result of their DNA, not their schooling, not the amount of attention their parents gave them, not their own efforts to advance themselves. These great men were probably born, not made."

Other researchers are finding similar results. Hans Eysenck recently published an article supporting Knowles research. Eysenck's studies show that a person's environment does not alter his or her intelligence. He found that bright children placed in "dull" environments did not become less intelligent. Instead, they tended to take advantage of the less-gifted people around them. Relatively dull children placed in stimulating environments did not seem to get any smarter.

Needless to say, Knowles' and Eysenck's research is drawing much attention from other psychologists. Their findings are a blow to researchers who have spent years arguing that intelligence is due to environmental factors.

Leo Kamin of Princeton University is one such researcher. In the 1960s and '70s, he argued strongly that there was no good evidence to show the link between intelligence and genetics. He helped to prove that Sir Cyril Burt, a now infamous intelligence researcher, faked his data to show that intelligence was inherited. When Burt was alive, he was knighted in England for his research. When Kamin examined Burt's results, he discovered serious flaws that could only have resulted by faking the data.

This experience has made him highly skeptical of any research that establishes a relationship between intelligence and a person's genes. Because of this, he carefully examined Knowles study. He says he found "no flaws in [Knowles'] methods or his analysis. For me, these results are a little like finding out that the earth is round when you've spent 25 years trying to show it's flat. But I am a scientist first and foremost. If the best research shows that intelligence is mostly genetically determined, I will accept that fact. Knowles' research is simply the best."

Paula Rescorla at University of Michigan's UIR is excited about Eysenck's and Knowles' results. "It is about time we realize that intelligence is a genetically-determined ability. Knowing that intelligence is genetically controlled is something that can help society. We can learn to identify quickly those

"Knowing that intelligence is genetically controlled is something that can help society... By having young geniuses get the kind of training that challenges them, we will be helping them live up to their abilities. Then they can help society."

who can really benefit from specialized training. By having young geniuses get the kind of training that challenges them, we will be helping them live up to their abilities. Then they can help society. In addition, we can help less bright people find environments that won't frustrate them. We can put them into non-threatening environments that match their skills."

The eighteen month-old genius Adam Steagal seems to be in the ideal environment Rescorla described. His young brilliance is being challenged by fascinating toys and games. He is in the company of other intellectual babies. If what the researchers say is true, there is a good chance that Steagal is destined to be a leader in about the year 2040. □

Jerome Berglund is a free-lance writer from Ann Arbor, Michigan. He is a frequent contributor to Psychology Today.