CAUSES OF INDIVIDUAL DIFFERENCES IN MENTAL IMAGERY

by

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Abstract

Previous work has shown that the degree to which individuals can recruit mental imagery in a variety of tasks varies widely. These differences in self-reported mental imagery can be the result of an innate or training-based skillset. The MAE (Motion After Effect), a tool for implicitly measuring mental imagery, was used to assess whether repeated dynamic imagery training can strengthen mental imagery ability. Participants' MAE magnitude from mental imagery was calculated before and after a 3-day imagery training program. The MAE from language was also measured in all participants after training. Participants were randomly assigned to an imagery training condition in which they either had to maintain the speed (a property related to motion) or contrast (a property unrelated to motion) of a set of moving stripes over a delay. The type of imagery training had no significant effect on an individual's mental imagery ability, however there was a trend in the predicted direction. Practice imagining information related to motion increased the size of the MAE from mental imagery, whereas practice imagining information unrelated to motion decreased the size of the MAE from imagery. These trends did not extend to the MAE from language comprehension. These findings suggest that mental imagery may be a trainable ability, but more research is needed to better understand this important human ability.

Causes of Individual Differences in Mental Imagery

Mental imagery is a unique ability that allows individuals to create seemingly perceptual experiences in absence of perceptual stimuli. To experience this phenomenon, take a moment to imagine the face of a close friend or relative, someone who you frequently see. Create as detailed of a mental image as possible. Consider the picture that comes before your mind's eye. How vivid is this image to you? How similar was it to their actual face? Were you able to replicate specific and unique details? If you were to ask a group of people to complete the task above and report the vividness of their visual recall, chances are the responses would vary quite a bit. Some individuals may report a greater sense of vividness when imagining these scenes while others report lower levels of vividness.

Why might it matter whether people differ in the vividness of mental imagery? Researchers have speculated that greater mental imagery vividness is an asset in a number of cognitive tasks requiring the persistence of visualizations in the mind's eye over a period of time. Therefore, the ability to create vivid mental images might help in a variety of creative and cognitive tasks involving reading comprehension. This could prove to be important in a variety of testing scenarios like the SAT's and GRES. The goal of the present study is to explore the differences in mental imagery ability between individuals and provide insight into the causes and consequences of these differences. This thesis will focus on the causes of individual differences in mental imagery, and my partner's thesis will focus on the consequences of individual differences in mental imagery.

Self-reports have been used to reliably show individual differences in the vividness of mental imagery. However, there is quite a bit of variability in the degree to which individuals report being able to vividly create mental images (Marks, 1973). The Vividness of Visual

Imagery Questionnaire is composed of 16 questions, focusing on generating mental images of common visual experiences and reporting the vividness of these mental images. Participants in this study were asked to think of a country scene involving trees, mountains and a lake and to consider both the vividness and clarity of the picture that came into their mind's eye. Participants were then asked to rate this visual experience and compare how similar it was to the actual experience of viewing this type of scene. Each part of the questionnaire was rated on a scale from 1-5, with 1 meaning “Perfectly clear and as vivid as normal vision” and 5 meaning “No image at all, you only “know” that you are thinking of an object”. The results of this study showed that there is indeed a great amount of variability in self-reported mental imagery ability between individuals. These stable differences in self-reports of mental imagery vividness might represent differences in how people consciously describe their own experiences, or they may suggest that there are real differences in mental imagery ability between individuals.

A challenge associated with any experiment gauging the strength of mental imagery would be the inherently subjective nature of the personal experience. Self-reporting the strength of such an illusory quality presents its own unique set of limitations when making comparisons between individuals. For example, this methodological approach to accessing one's mental imagery ability relies heavily on the accuracy of one's own insight into the strength of their mental imagery. While the results of this study provide evidence for variations in individuals mental imagery ability, it is difficult to conclude that these self-reported differences do not originate from the nature of self-reporting itself. It is possible that these differences in self-reports of mental imagery vividness can be explained by differences in an individual's own self-perception.

While it can be argued that self-reported measures of illusory quality may are problematic, research has shown that the results of VVIQ questionnaires do carry validity when comparing one's judgment of their own mental imagery ability to their actual visual memory of a stimulus. In a study by Marks (1973), male and female participants rated their level of mental imagery vividness using the VVIQ test. Participants were then presented with a set of color photographs that they were later asked to visually recall. Across three experiments, responses to the VVIQ questionnaire were found to be reliable predictors of accuracy in the visual recall of photographs. Participants who rated their mental imagery vividness as 'poor' had lower visual recall scores than did participants who rated their mental imagery ability as 'good'. These results show that one's own perception of mental imagery vividness can be a reasonably reliable indicator of actual mental imagery strength (measured in terms of visual recall accuracy). The correlation between self-reported mental imagery vividness on the VVIQ questionnaire and accuracy of visual recall shows that self-reported measures of mental imagery ability are more accurate than past researchers have concluded. While the implications of these results seem promising, the effectiveness of self-reported responses to VVIQ questionnaires and their predictive insight into people's mental imagery abilities are controversial.

In a study by Berger, G. H., and Gaunitz (1976), the accuracy of VVIQ self-reports of mental imagery vividness previously found in Marks research was disconfirmed. It was suspected that such subjective measures of an illusory quality were unreliable indications of actual mental imagery ability. Participants were given a VVIQ questionnaire to measure their perception of their own mental imagery ability. A simple image recall test was later given, participants were asked to match pictures and identify whether they were identical or not. It was found that an individual's explicit rating of their own mental imagery ability was not a reliable indicator of real mental imagery ability or in this case visual recall accuracy.

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Self-report measures are not the only way to assess individual differences in mental imagery ability. More implicit measures of mental imagery ability across individuals can provide researchers with a more objective measure of mental imagery ability. Previous studies on mental imagery have made use of a visual illusion, called the motion after aftereffect (MAE) (Winawer, Huk, & Boroditsky, 2008). This perceptual illusion can be reliably observed by focusing attention on a moving stimulus for a prolonged period of time and then shifting focus to a non-moving (or ambiguously moving) stimulus. Once the stimulus stops moving, the image will appear to be moving in the opposite direction. This illusion is generated by the activity of direction selective neurons in visual cortex used in the perception of actual motion. Because of its well-understood basis in the visual cortex, the MAE can be used to measure how intensely the visual system is activated by a moving stimulus. Winawer et al. tested whether intentional mental imagery of motion in a direction would recruit direction-selective neurons tuned to the same direction as perceptual motion, producing a motion aftereffect illusion. Subjects were exposed to a static grating on a screen with an arrow superimposed on top. After focusing on the grating, subjects were prompted to imagine motion in the direction of the arrow for 60 seconds. After this period of mental imagery, participants were shown a field of moving dots. The motion that they had imagined during that 60 second period distorted participant's visual perception of the dots, creating a motion aftereffect in which the dots appeared to move in the direction opposite to which they had imagined. The results of this study showed that simply imagining motion for a period of time can create a motion aftereffect similar to one created by an actual moving stimulus. The presence of a MAE from mental imagery shows that mental motion imagery and actual motion perception have common neural circuits.

The data collected from participants in this study also showed varying levels of MAE intensity. While some participants in this study showed a very powerful motion after effect, others experienced a MAE magnitude that was much weaker. Still others experienced a priming effect, where the dots appeared to move in the same direction as the imagined motion. The results of the VVIQ questionnaires completed by participants did not correlate with their measured MAE magnitudes from imagined motion. This data shows that mental imagery ability does in fact vary between individuals and cannot simply be explained by differences in self-reporting. That said, there is evidence that these individual differences as measured by the MAE are stable and consistent across different forms of internally-generated visual motion. Dils and Boroditsky (2010) tested for aftereffects from mental imagery and linguistic descriptions of motion in the same individuals. They found that the stronger the motion aftereffect from mental imagery, the stronger the motion aftereffect from language.

The research presented thus far has shown that stable individual differences in mental imagery ability exist, and that we have a methodology for assessing these levels implicitly. What causes these individual differences in the first place? Individual differences in vividness of mental imagery can be the result of training and experience, or they might result from differences in an innate ability. People with occupations that require regular use of mental imagery, such as choreographers, air traffic controllers, and playwrights, may possess stronger mental imagery abilities because of their routine engagement in tasks that train their mental imagery. In this scenario, the act of completing tasks that engage and train mental imagery would allow these individuals to better activate perceptual representations in the absence of a perceptual stimulus. In the case of air traffic controllers, for example, routinely having to project the location of planes in the air could over time improve motion imagery skills. However, it could also be reasoned that these individuals were born with strong mental imagery abilities and have a propensity to select careers that require this ability.

A preliminary study on mental imagery differences between playwriting and screenwriting majors (mental imagery experts) and visual arts majors (mental imagery novices) showed a marginally stronger MAE in mental imagery experts (Gagliardi & Dils, 2017). Although this study had a limited subject pool, the results showed a trend in the predicted direction, suggesting that those who are involved in majors requiring mental imagery of motion have a larger motion aftereffect from mental imagery and language comprehension than do those involved in majors that do not require mental imagery of motion. It can be argued that those within majors that require mental imagery possess an innate ability to imagine vividly and are therefore self-selecting into these majors. However, it can also be reasoned that these individuals developed their mental imagery ability as a result of routine training through their education. Those who routinely engage in tasks that engage and train their mental imagery may be better able to activate perceptual representations in the absence of a perceptual stimulus.

One way to test whether experience can lead to individual differences in mental imagery ability is to randomly assign people to different mental imagery training conditions and test whether that can improve mental imagery ability. The present study was designed to test whether practice imagining visual motion (compared to imagining visual features that are not related to motion), can strengthen the motion aftereffect illusion from imagery. Furthermore, the present study also tested whether any benefits of training extend to the motion aftereffect illusion from language comprehension. If language comprehension requires imagining what you hear, then training mental imagery of motion should also improve the vividness of imagery during language comprehension, resulting in an increase in the motion aftereffect from language. The findings of this study will help us to better understand how specific types of experience with mental imagery might lead to individual differences in this cognitive ability.

Methods

Participants

A subject pool of 24 participants from the Purchase College psychology participant pool and from the broader campus community were used in this study. Participants were compensated with either class credit or a payment of $10 per hour. Of the total participants, 16 were male and 21 were female. The majority of participants were Psychology majors, however there were a few participants majoring in visual arts like Cinema Studies, Photography and Playwriting/ Screenwriting. Of the total participants, 11 were freshman, 10 were sophomores, 13 juniors and 3 seniors. Participants' described themselves as White (33.33%), Hispanic/Latino/a (47.62%), Black or African American (9.52%%), Asian/ Pacific Islander (4.76%) and Other (4.76%).

Overview

Before participating in the study, a consent form was given to the participants and explained by the researchers. To establish a baseline for each participant, a motion aftereffect pretest was given to test the magnitude of their motion aftereffect from imagined motion. Each participant was randomly assigned to either the static mental imagery training or the dynamic mental imagery training condition. Each participant completed three training sessions for approximately 30 minutes each over three days. The first meeting consisted of the participants completing a pre-test followed by their first assigned mental imagery training task. The second meeting consisted of only their assigned training task. The third and final session consisted of both their training task, a posttest and a surprise memory task. This task asked participants to recall stories they had heard in the posttest and was analyzed by my partner to assess any consequences of individual differences in mental imagery ability.

Design

This study used a mixed design to compare the effectiveness of both dynamic mental imagery and static mental imagery training tasks on mental imagery ability. The independent variables within this study included both the test and training materials used within the control and experimental participant groups. The dependent variables used in this study were the magnitude of the motion aftereffect elicited by both language and mental imagery as well as participants scores on training exercises. Recall for stories in the linguistic MAE task was used by my partner to measure comprehension.

Materials

Training task materials. Animations were generated consisting of black and white stripes (sine gratings) that drifted either upward or downward. Across the set of animations, the contrast, speed, direction, and thickness of the gratings varied.

Linguistic adaptation materials. A set of stories was adapted from Dils and Boroditsky (2010). A total of 12 unique stories were used with literal motion language suggesting upward and downward motion, resulting in 24 stories. This literal motion language condition used motion language that described the movement of physical objects (e.g., squirrels, ping pong balls). These stories were broken up and given in four installments: a long initial installment for 40 seconds, and three subsequent installments for 8 seconds each. Participants either heard the upward or downward version of each story, but not both.

Mental imagery adaptation materials. Participants were presented with striped sinusoidal gratings drifting either upward or downward and then asked to imagine these animations within their minds eye. These gratings were presented similarly to the manner in which the language installments were presented. The first long installment lasted 40 seconds, and three subsequent installments lasted 8 seconds each.

Adaptation test materials. The test materials consisted of a visual field filled with random dots that have net motion coherence either upward or downward. Participants were asked to judge the direction of the dot motion. The proportion of dots that moved coherently varied across trials. The degree of motion coherence was utilized to quantify the size of the motion aftereffect.

Procedure

This study consisted of three total meetings. In the first meeting, participants were given a pretest for the magnitude of their motion after effect after imagining motion. This pretest utilized a procedure based on the motion aftereffect task used in Dils and Boroditsky (2010). Participants imagined visual motion in a downward or upward direction for a short period of time and were then shown an ambiguously moving dot stimulus. Participants had to indicate the direction in which the dots appear to move. The magnitude of their motion aftereffect was calculated based on the degree to which they reported the dots as moving in the opposite direction of the motion they imagined.

Following the pretest, participants were randomly assigned to one of two training conditions and completed their first training exercise on day 1. Those assigned to the dynamic mental imagery training condition were shown two drifting gratings in succession, with a 5 second blank screen between the two. The participant had to discern whether the two gratings shown were drifting at the same speed (experimental condition: motion-related imagery) or whether they had the same contrast level (control condition: motion-unrelated imagery). Participants needed to maintain a dynamic mental image of the initial grating in their working memory over the five second delay to get the right answer in the dynamic training condition, but there was no need to remember anything about the motion itself to make a judgment about the contrast level. For each trial audio feedback was provided after participant input. A high frequency beep indicated a correct response while a low frequency beep indicated an incorrect response. Participants in both training conditions completed this 30-minute exercise three times over the course of a week. Each training session ended with viewing their final score for that day as well as their score to beat for their next training session. Those being compensated for their participation monetarily were offered a cash bonus if they improved their score by 10% in the next training session.

Following the final training exercise on day 3, a post-test was administered for each participant, which was used to assess the magnitude of the motion after effect. The post-test for mental imagery was identical to the pretest for mental imagery. There was also a post test for size of the MAE from linguistic descriptions of motion on this day. This was adapted from Dils and Boroditsky (2010) and matched the structure of the task measuring the MAE from mental imagery. Participants listened to a story with strong upward or downward motion language then were asked to judge the direction of motion for an ambiguously moving dot stimuli. The present study took approximately three hours for each participant, spread over 3 days.

Results

Twenty participants completed the full three-day training and testing protocol. Data from those participants were analyzed. I subtracted the proportion of upward responses following upward motion from the proportion of upward responses following downward motion, to get a single number representing MAE for each participant. This was done for both the mental imagery pre- and posttests, as well as for the aftereffect from language. For the training tasks, the proportion of correct responses was computed across all trials for each of the three training sessions to get a single number for each participant per session.

To test whether performance was similar across two training conditions, I conducted a 2(condition: experimental vs. control) x 3(training day: 1 vs. 2 vs. 3) mixed designs ANOVA with condition as a between subject's variable and training day as a within subject's variable. The dependent variable was the percentage of correct responses. There were no main effects or interactions in this analysis (all p's > .05; see Figure 1 for means and confidence intervals).

To test whether performance on the MAE measure depended on which training condition participants were assigned to, I conducted a 2(training condition) x 2(time of test) mixed designs ANOVA with condition as the between subject's variable and time of test as the within subject's variable. The dependent variable was the MAE magnitude, in which positive numbers reflect a motion aftereffect and negative numbers reflect a priming effect. There was no significant main effect of condition, $F(1,19) = 0.43$, $p = .520$. There was no main effect of time of test, $F(1,19) = 0.33$, $p = .571$. There was a marginal interaction between time of test and condition, $F(1,19) = 2.58$, $p = .125$. The size of the MAE increased from day 1 ($M = 0.05$, $SD = 0.10$) to day 3 ($M = 0.10$, $SD = 0.22$) for participants in the experimental condition but decreased from day 1 ($M = 0.09$, $SD = 0.25$) to day 3 ($M = -0.02$, $SD = 0.13$) in the control condition (see Figure 2)

To test whether there was an effect of training on the size of MAE from language, I conducted a one-way ANOVA comparing performance on the task between the experimental ($M = -0.17$, $SD = 0.29$) and the control condition ($M = -0.15$, $SD = 0.19$). There was no significant effect of condition, $F(1,18) = 0.041$, $p = .843$ (see Figure 3). However, there was an overall priming effect in this test ($M = -0.16$, $SD = 0.23$; $t(19) = -3.08$, $p = .006$).

Discussion

The goal of the present study was to assess the causes of individual differences in mental imagery vividness for visual motion. To test this, two training conditions were created. The experimental training condition consisted of a motion-related imagery task while the control training condition had a motion-unrelated imagery task. It was hypothesized that the size of the motion aftereffect would increase following speed mental imagery training (experimental condition) and not contrast mental imagery training (control condition). The benefit of dynamic mental imagery training was expected to extend to language as well, increasing the MAE from linguistic descriptions of motion in the experimental condition relative to the control condition. Trends in the data suggested that the MAE from mental imagery changed according to these predictions, but the effects were not significant in this small sample. People consistently showed a priming effect from language comprehension, not an aftereffect. The priming effect did not depend on training condition, which was inconsistent with the predictions. Therefore, any effects of mental imagery training might not transfer to other types of tasks, like language comprehension (at least not after only three days of training). Marginal increases to the magnitude of an individual's MAE through dynamic training are promising for the idea that individual differences in mental imagery ability can come from experience and are not necessarily due entirely to innate differences in ability. However further research would be needed to confirm the role of training in improving mental imagery. Even with evidence for the improvement of mental imagery ability through training, it could still be that there are innate differences in mental imagery ability to begin with, but that people are not entirely limited by the ability they were born with.

Although we did not find reliable evidence of mental imagery improvement, it is possible that refinement of our methodology and the use of a larger subject pool would result in an increase in the MAE after training. The trends we did observe were promising and suggest the need for further research. Future directions for this study may include revisions to the training procedure to improve effectiveness. Such revisions may include increasing the frequency of training or increasing the total number of training sessions.

Routine engagement in activities requiring mental imagery, even unconsciously, could explain why some might possess greater imagery abilities than others. Better understanding the causes of individual differences in mental imagery ability may open new doors for interventions and therapies that will allow people to improve not just their imagery performance, but also their performance on other tasks that might rely on mental imagery. The use of mental imagery has been shown to be beneficial in a variety of fields, including clinical applications for physical therapy and training for sports (Warner L & McNeill ME, 1988). Mental imagery also has potential to improve performance on language comprehension tasks such as word problems and story recall (Boerma et al. 2016). Finding an effective methodology for training to improve mental imagery could have a positive impact on countless individuals.

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Figures

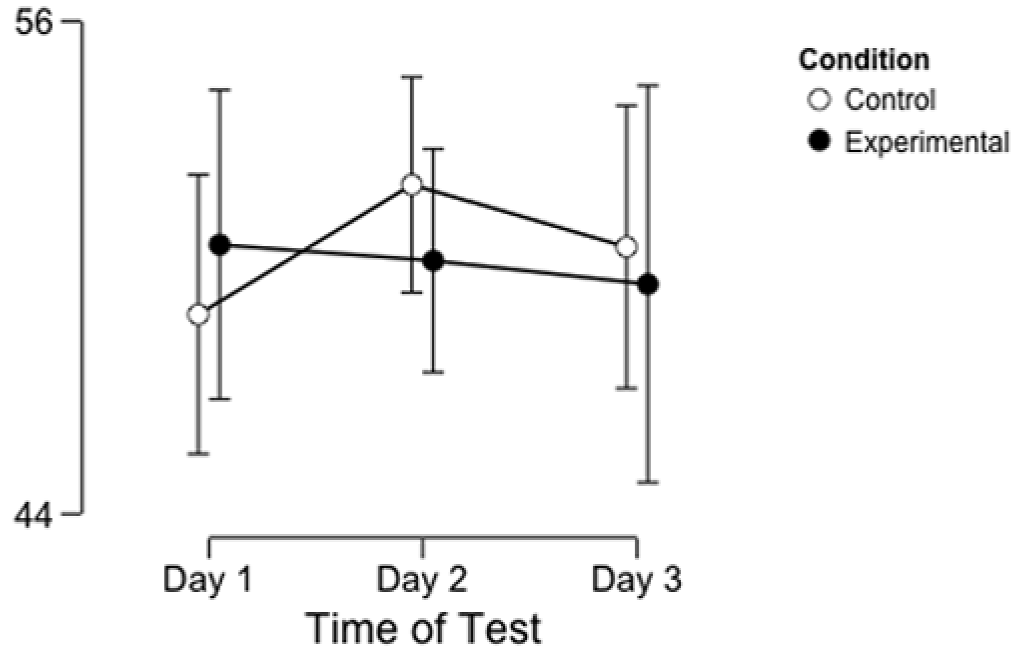

Figure 1. Average score on the training exercise for each day of training across both the control and experimental group. Error bars represent confidence intervals.

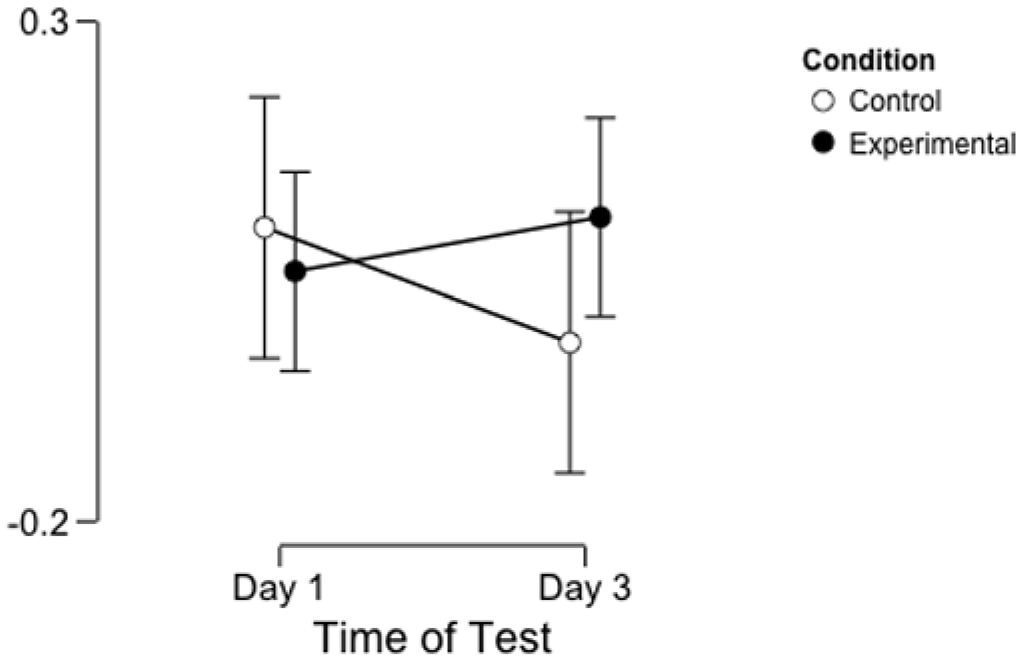

Figure 2. Average magnitude of all the motion aftereffect from mental imagery by time of test and training condition. Positive numbers reflect adaptation, and negative numbers reflect priming. Error bars represent confidence intervals.

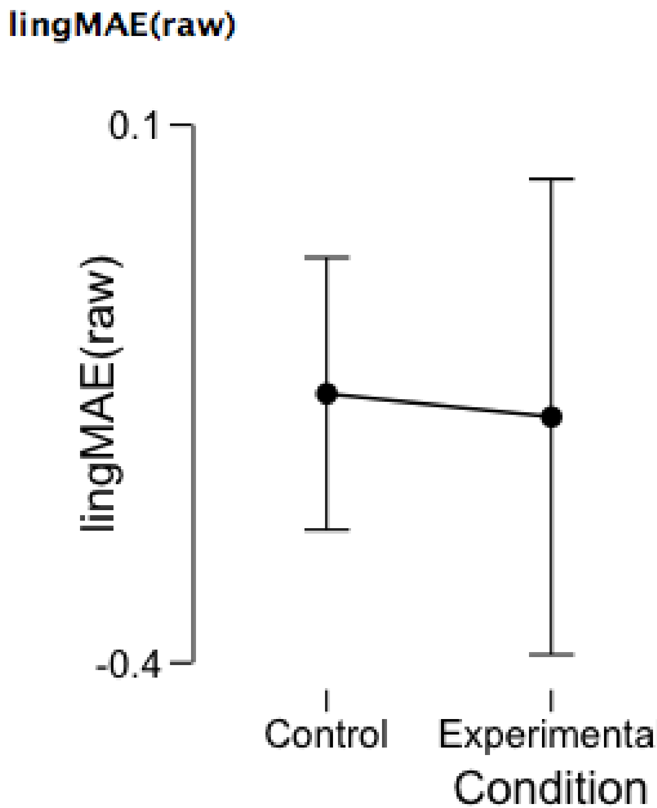

Figure 3. Average magnitude of all the motion aftereffect from language by training condition. Positive numbers reflect adaptation, and negative numbers reflect priming. Error bars represent confidence intervals.