A Thesis

entitled

Handedness Differences in Hindsight Bias: Insight into Mechanisms and Theory of a Common Decision Bias

by

Chandrima Bhattacharya

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the Master of Arts Degree in Psychology

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The University of Toledo

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An Abstract of

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In research dealing with hindsight bias, there are still controversies regarding why hindsight bias occurs. This could be partly because the hindsight bias that a person experiences, might differ depending on what method has been used to assess it. In some situations, for example, if we use what has been called the hypothetical design, we find greater hindsight bias than if we use a memory design to assess hindsight bias. One way to understand to explain why one design shows more bias than the other in some situations is to use individual difference variables such as strength of handedness. Previous studies show that mixed (or inconsistent) handers show more anchoring than strong (or consistent) handers and that mixed handers have a better episodic memory as compared to strong handers. Interestingly, these differences related to the underlying processes of the two different hindsight bias designs. Our results show that for the hypothetical design, where participants do not have a previous response with which to compare, participants tend to anchor to the given feedback when feedback is available. In the memory design, where participants have to compare their present response with their past response, episodic memory plays a major role in such situations. In the present study
we found that in hypothetical design mixed handers showed greater hindsight bias as compared to strong handers, whereas in memory design strong handers showed greater bias as compared to mixed handers. Thus our present study concludes that underlying mechanism of hindsight bias differs depending on what design has been used. Strength of handedness helps to understand the underlying mechanisms for occurrence of such differences and it could be a useful tool to predict in what situations the memory design would exhibit greater hindsight bias and in what situation the hypothetical design would show greater hindsight bias
I would like to dedicate this thesis Project to my Dearest Dad who has always encouraged me to study further and helped understand my goal in life. I greatly feel his absence in my life and I hope wherever he is, he is proud of me.
I am heartily thankful to my supervisor Dr J. D Jasper, whose encouragement, guidance and support from the initial to the final level enabled me to finally complete this project. I am also very grateful to all my committee members, Dr Stephen Christman and Dr Jason Rose for their valuable feedback and suggestions that served as valuable guidelines during various stages of my project. I would also like to show my gratitude to Ryan Corser and Undergraduate Students of our Decision Making lab who gave their valuable time and effort and helped me with data collection. Lastly, I offer my regards and blessings to all of those who supported me in any respect during the completion of the project.
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Preface

We often find our parents and friends exaggerating after an event, that they knew all along about what the outcome of an uncertain event would be. This gives an impression that all of us are either clairvoyants or equivocators. A vast amount of research on this phenomenon popularly known as hindsight bias, has been done starting in 1975 by Fischoff. A simple example could be the myths circulated about the Year 2000 problem (also known as the Y2K problem, the millennium bug). It was a notable problem for both digital (computer-related) and non-digital documentation and data storage situations which resulted from the programmer practice of abbreviating a four-digit year to two digits. When asked about what could be the possible outcomes of the Y2K problem, 126 out of 136 pre-Y2k (subjects interviewed before the year 2000) students at Kansas State University predicted negative outcome possibilities in the year 1999 on a scale of 0 to 100. In January 2000, that is, after the onset of the year 2000, the same participants were asked about what their prediction was before the onset of the year 2000. Most of them responded that they predicted it to be much less negative on a 0 to 100 scale than they actually did in 1999. (Pease, McCabe, Branon & Tagler 2003). Undoubtedly, their predictions were biased with the information about the actual outcome of Y2K. There are many other day to day instances when such hindsight biases occur.
Chapter One

1. Handedness Differences in Hindsight Bias

Generally, hindsight bias is said to exist whenever responses made after the fact lie closer to the correct answer than those made in foresight. Thus, when a measure captures this difference, and it is significantly larger in the experimental group than for a control group we could presume that hindsight bias exists for that event. Hindsight bias is important partly because the phenomenon has been observed in domains as diverse as general knowledge (Fischoff, 1977), scientific findings (Davies, 1987), sports results (Leary, 1981), election outcomes (Blank & Fishcher, 2000) and the location of cities on a map (Pohl & Einhauer, 1995). It is a critical issue in situations such as jury decision making and eyewitness testimony. Yet, despite all the research, there are still some questions intrinsically related to this issue that have not been properly and adequately addressed, and thus require more research.

1.1 Memory and Hypothetical Designs

One area of importance that has resulted in recent review and meta-analysis on hindsight bias centers around the notion that there could be intrinsic differences in hindsight biases depending on the nature of the study and instructions used. In other words, it was evident from these reviews that many of these studies used what is referred to as a memory design whereas others used a hypothetical design. Though these two designs may use
similar types of questions, they differ in their operational definition of hindsight bias instruction used for the study, use of feedback, as well as possibly the underlying cognitive mechanisms that account for the occurrence of these hindsight biases.

In the memory design (Table 1), individuals first give an (unbiased) response, then receive the correct answer, and are finally (after a period of time) asked to recall the correct answer. As a control, other people are asked for their response without giving them the correct answer beforehand. In memory design measures subjects are compared within group on their pre and post test outcome estimates with respect to their distance to the solution.

Table 1

*Schematic Representation of Instruction Used in Memory Design of Hindsight Bias*

<table>
<thead>
<tr>
<th>Memory Design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental condition</strong></td>
</tr>
<tr>
<td><strong>Control condition</strong></td>
</tr>
</tbody>
</table>
Here if responses in the experimental condition are significantly closer to the feedback than responses in the control condition, it is said that hindsight bias exists.

In the hypothetical design (Table 2), subjects are given the problem, and then immediately given a feedback solution to the problem. Following the feedback, they are asked what they would have predicted the answer to be had they not known the outcome. In the control condition they are given a problem with no feedback and are asked to guess the answer.

Table 2

*Schematic Representation of the Hypothetical Design of Hindsight Bias*

<table>
<thead>
<tr>
<th>Hypothetical Design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental</strong></td>
</tr>
<tr>
<td>condition</td>
</tr>
<tr>
<td>Some questions/task are given along with feedback (answer)</td>
</tr>
<tr>
<td><strong>Control</strong></td>
</tr>
<tr>
<td>condition</td>
</tr>
<tr>
<td>Some questions/task are given without any feedback (answer)</td>
</tr>
</tbody>
</table>

Here, as well, if responses in the experimental condition are significantly closer to the feedback than responses in the control condition, hindsight bias is said to exist.
Both memory and hypothetical designs use a variety of tasks including two-alternative forced choice tasks, both with respect to choices and to one’s confidence in their correctness, numerical questions predicting outcomes of survey questions on a percentile scale, item wherein one rates the likelihood of possible developments of a given scenario and questions wherein one answers on closed rating scales. The memory design, however, requires an additional dependent variable, the proportion of correct recollection (Horace & Pohl, 2003). In other words, in a hypothetical design, participants only respond once, specifically, after the outcome feedback has been given. In a memory design, participants respond twice and researchers might get three measures from it, first their answers immediately after the problem has been given, second the recollection of their previous answer after they receive the outcome feedback and lastly, the difference in distance between pre feedback response and post feedback which can be calculated from the first two measures.

1.2 Theories of Hindsight Bias

There are two lines of theories that can be applied to explain the underlying processes of hindsight bias in the memory design: memory impairment and biased reconstruction. Memory impairment explanations emphasize storage or retrieval difficulties as the root cause of hindsight bias. Most of these explanations argue that outcome information causes retroactive inhibition and impairs memory of previous judgment by either altering or erasing existing memory traces, or rendering them less accessible (Schwarz & Stahlberg 2003). Hell, Gigernzer, Gauggel, Mall and Muller
(1988), in their dual traces model, proposed two separate memory traces: one for the original prediction, and one for the outcome information. They argue hindsight bias should depend on how accessible the two memory traces are. Accessibility is determined by two different features: the depth and recency of information encoding. The authors claim that hindsight bias is due to the fact that the outcome information is encoded more recently than the original prediction in hindsight situations. Thus, the outcome information should be more accessible than the original prediction and should therefore play a more important role when a judgment is made in hindsight. On the other hand, the deeper the memory trace for the original prediction, the smaller the distorting influence of the outcome information should be. Consequently, hindsight bias should be strong if the outcome information is encoded more deeply than the original prediction. In a series of experiments, Hell et al (1988) were able to show that the depth of encoding for the original prediction (or the outcome information) and the time of presentation for the outcome information influenced the strength of the hindsight bias.

According to the biased reconstruction theory, such as Fischoff’s immediate assimilation hypothesis, the outcome information is automatically integrated into the existing knowledge structure, and these results in an inevitable and permanent modification of a person’s prior representation of the event. Thus according to this theory as opposed to the memory impairment theory, forgetting is not necessary for hindsight bias to occur in the memory design as it is more of an automatic process.
A more recent theory that encompasses both of these theories and offers a more comprehensive explanation is RAFT (Reconstruction After Feedback with Take the Best). The RAFT model (Hertwig, Fanselow, & Hoffrage, 2003; Hoffrage et al., 2000) explains hindsight bias using paired comparisons of objects in terms of a quantitative criterion (e.g., "Which city is larger: Hamburg or Heidelberg?"). Specifically, Hindsight bias is explained in RAFT as a byproduct of adaptive learning; (Blank and Nestler 2007; Hawkins & Hastie 1990). The assumption is that feedback about the true state of affairs (Hamburg is larger than Heidelberg) leads to automatic updating of the knowledge base. Specifically, by unconscious associative inference, some of the unknown cue values or cue values pointing in the wrong direction (i.e., suggesting that Heidelberg is larger) are probabilistically replaced with "fitting" values. This adaptation of the knowledge base to the feedback then leads to hindsight bias if individuals are unable to directly retrieve their initial judgment but instead try to reconstruct it by repeating the original judgment process, this time, however, on the basis of the updated knowledge base. This applies to memory for both the original choice and the original confidence.

For the hypothetical design, hindsight bias is said to occur due to anchoring to the given feedback. The magnitude and direction of the hindsight bias depends on people’s subjective assumption about their predictive ability. Since people are generally overly optimistic about their predictive abilities (Greenwald 1980), in the majority of cases they will locate their presumed prior estimate closer to the real outcome (given anchor) than it originally was, producing a hindsight bias. But, if they have reason to believe that the
outcome was unpredictable (e.g., if they doubt their predictive abilities in a certain field of expertise), the hindsight bias might be reduced, non-existent, or even reversed (Mazursky, 1997; Stahlberg & Schwarz, 1999).

Hindsight distortions have generally been reported to emerge more forcefully in the hypothetical (explained by biased reconstruction) than in the memory design (explained by both memory impairment and biased reconstruction) (Campbell & Tesser 1983; Davies 1992; Fischoff, 1977; Wood, 1978). From the above explanation, it is clear that the hypothetical design decision is solely influenced by anchoring and availability, whereas in the memory design, not only is anchoring involved but subjects also need to lose the original memory trace of their predictive outcome in order to anchor to the given outcome information. Obviously, subjects do not forget or lose all of their memory traces in a memory design situation. Thus, they will anchor less in the memory than in the hypothetical design. This explains why hindsight bias is more evident in the hypothetical design.

1.3 Individual Difference, Hindsight Bias and the Current Study

Despite these debates about what could be the underlying processes that account for hindsight bias in these designs, there are very few studies that directly compare the hindsight bias in a memory design and a hypothetical design and even fewer studies look at the effect of individual differences on hindsight bias. Campbell & Tesser (1983) and Musch (2003) used an individual differences approach in terms of motivational and personality differences to account for differences in memory and hypothetical designs.
and was able to come up with a plausible explanation of how these two designs differ and why hindsight bias is more evident in the hypothetical design. For example, Musch (2003) tested ten personality correlates of hindsight bias by having 75 participants answer almanac type knowledge questions. Participants showed hindsight bias when hindsight estimates were compared to foresight estimates in the memory condition, when hindsight estimates were compared to foresight estimates of other participants in the hypothetical condition (between subjects), and when hindsight estimates were compared to foresight estimates in response to equally difficult control items (within subject hypothetical condition). The magnitude of hindsight bias in both hypothetical conditions was found to be positively associated with participants’ field dependence and his or her tendency for favorable self presentation as measured by social desirability and impression management. In addition between-subjects hypothetical hindsight was associated with participant’s conscientiousness and need for predictability and control.

The present study assesses the effect of another individual difference factor namely strength of handedness, on different types of hindsight bias designs. Strength of handedness is an individual difference variable related to functional dissimilarity in the two hemispheres of the brain. In strong handed people (who mostly use either their left or right hand for all tasks) have less interaction between their left and right hemispheres as compared to mixed handed people (those who use their non-dominant hand for at least some tasks)? It is argued that this individual difference is related to inherent size of the
corpus callosum or the type of connection made by the corpus callosum between the two hemispheres (Witelson & Goldsmith 1991).

The argument in the present study is that strength of handedness may be related in interesting ways to the two different designs of hindsight bias and this may predict the site of the bias. Specifically, strong and mixed handers have been found to utilize anchoring to different degrees. Anchoring (or focalism) is a cognitive bias that describes the common human tendency to rely too heavily, or "anchor," on one trait or piece of information when making decisions. In this case, the outcome information in the hindsight bias studies acts as an anchor that aids the subjects to reconstruct their predicted outcome based on the anchor. Agans and Shaffer (1994) showed that hindsight information activates the use of availability heuristics on people. Sedelmeir and Jeager (2007) in their study on hindsight bias showed that post-event information is being used as anchors. All these studies suggest that people who anchor more to the feedback will show greater hindsight bias. Mixed handers have been found from previous studies to update their belief more readily based on available information (Christman, Henning, Geers, Propper and Niebauer; Jasper, Prothero, Christman 2009), and they more strongly anchor to the given feedback (Jasper & Christman, 2005) but only if they find the information relevant. It would seem reasonable then that mixed-handers would show more hindsight bias if the information was found relevant and the situation was conducive to anchoring. Given that the hypothetical design appears to be driven
solely by anchoring, the prediction may apply more to the hypothetical than the memory design.

In the memory design, one must lose the original memory trace before anchoring can operate. Interestingly enough there are differences in memory between mixed and strong handers. Propper, Christman and Phanaeuf (2005), for example, found that mixed handed people have a better episodic memory for real life events due to their greater interhemispheric connection than strong handed people. Thus, one might argue that mixed handers are more likely to remember the original responses better than strong handers. Theoretically, individuals should show strong hindsight bias in only those questions that they have forgotten but will not show any hindsight bias in those questions for which they remember. Summing the two, amount of hindsight bias in the memory design should not be as high as in the hypothetical design as individuals oftentimes remember their original responses. Given that mixed handers have better episodic memory, they will have to anchor to fewer new feedbacks and thus should show less hindsight bias than strong handed individuals.

In sum hindsight bias is a common, everyday decision phenomenon. When and why it occurs seems to depend on the situation and whether anchoring and/or memory reconstruction processes are involved. Finding an individual difference factor that relates to memory and anchoring (particularly in opposite ways) would seem to be critical to studying hindsight bias and its mechanisms. Strength of handedness seems to meet those criteria.
This study’s predictions are threefold. In the hypothetical design, mixed handers will show more hindsight bias and that the difference in hindsight bias between mixed handers and strong handers will be larger as compared to the memory design. In the memory design strong handers should show more hindsight bias.
Chapter Two

2. Method

2.1 Participants

One hundred and sixty volunteers from University of Toledo introductory psychology classes participated in the study. Experimental sessions lasted 45 minutes to 1 hour. Each participant was tested individually.

2.2 Experimental Materials

The stimulus materials consisted of 64 almanac-type assertions (32 true and 32 false) taken from the studies of Campbell and Tesser (1983), and Hasher, Goldstein, and Toppino (1977). The assertions dealt with facts from history, politics, biology, medicine, current affairs, geography and social customs, among others. These items were chosen such that participants probably did not possess the specific knowledge to answer correctly, but should have had some pre-experimental knowledge to form a general basis for their estimates. Two examples were “Earth is the only planet in the solar system that has one moon” (True) and “The Danube is the longest river in Europe” (False). For each statement, participants were asked to indicate the degree to which they thought it was true. This was done by responding on a 21-point line scale anchored by “certainly false” and “certainly true”.
To construct the test booklets, the 64 items were randomly divided into two sets of 32 items each (Set A and Set B); see Table 3. Half of the items in each set were true and half were false. The first section of each test booklet consisted of 32 items without feedback information. Half of the booklets contained Set A items. In the second section of the booklet, participants were asked to answer other research questionnaire items that were unrelated to the present study. These filler items took about 20 minutes. After the filler task was completed, participants were provided with feedback for the almanac questions. The third section contained answers (feedback) to 16 of 32 items in the first section of the booklet. For example, for the question “The Danube was the longest river in Europe” participants read “Answer: False- Volga (Russia) was the longest river in Europe”. In the fourth section, participants responded to all 64 items of both Set A (memory design) and Set B (hypothetical design).

Thirty two of these items (Set A) were the same ones the subjects responded to in the first section of the booklet, and were accompanied by memory instructions. Specifically, subjects were asked to “Recall as accurately as possible the response you gave earlier to this statement”. The remaining 32 items were new items for which hypothetical instructions were given (16 of these questions had feedback: (experimental condition) and 16 had no feedback (control condition).). The hypothetical instructions for Set B read as follows: “try to estimate as accurately as you can the answer you believe you would have given to the statement if we had not told you the correct answer”. The order of item sets and associated instruction type (i.e., memory versus hypothetical) were
### Table 3

*Procedure for Memory Design and Hypothetical Design*

Memory design (Set A) : Experimental Condition

<table>
<thead>
<tr>
<th>Step 1:</th>
<th>Step 2:</th>
<th>Step 3:</th>
<th>Step 4:</th>
</tr>
</thead>
<tbody>
<tr>
<td>almanac general knowledge questions were provided.</td>
<td>Completion of filler task</td>
<td>Feedback comprises of answers for half of the questions.</td>
<td>They were asked to recall Their previous responses without considering the feedback that has been given to them.</td>
</tr>
</tbody>
</table>

Control Condition

| Step 1: almanac general knowledge questions were provided. Participants responded by saying which answers they think were true and which they found to be false on a 21 point scale | Step 2: Same filler task were given as in experiment | Step 3: No feedback was provided for rest of the question | Step 4: Participants were asked to recall their answers |
Hypothetical Design (Set B) : Experimental Condition

<table>
<thead>
<tr>
<th>Step 1: Almanac general knowledge questions were provided along with feedback</th>
<th>Step 2: They were asked to respond without considering the feedback that has been given to them by saying which answers they think were true and which they found to be false on a 21 point scale.</th>
</tr>
</thead>
</table>

Control Condition

<table>
<thead>
<tr>
<th>Step 1: Almanac general knowledge questions were provided. (with no feedback)</th>
<th>Step 2 Participants were asked to respond by saying which answers they think were true and which they found to be false on a 21 point scale</th>
</tr>
</thead>
</table>

counterbalanced across test booklets. Because two different forms of instructions were used, this resulted in eight different forms of test booklets (Order of the two item sets $\times$ true versus false items $\times$ feedback versus no feedback).

At the end of each booklet, participants were asked to answer a few questions about themselves. For the demographic questionnaire, they were asked a variety of
questions including their age, sex and ethnic background. They were then given the Edinburgh Handedness inventory (EHI; Oldfield, 1971). In the EHI, they were asked how often they use each hand (from always left to always right) for 10 daily activities that involve hand use, such as combing, brushing teeth etc).

2.3 Procedure

Each experimental session was started by providing the participant with a randomly selected test booklet. Participants answered the first 32 questions of the booklet. Next, they completed a filler task that took approximately 20 minutes. After reading the solutions to the memory items in the third section of the test booklet, participants answered the memory and hypothetical questions in the fourth section. Then they completed the demographic questionnaires and the Edinburgh Handedness Inventory (EHI; Oldfield, 1971). Finally, participants were debriefed and thanked for their participation.

2.4 Dependent measures

All participants responded to 32 items with memory instructions (in a within-subject design) and 32 items with hypothetical instructions. Within each set, the correct answers were “true” for half of the items and “false” for the remaining items. For the memory design the magnitude of the hindsight bias effect was computed as the increase in one’s confidence given feedback as compared to one’s original confidence prior to feedback. For example suppose for the question “Earth was the only planet in the solar system that has one moon” a participant responded 2 on a 21 point scale where
indicates “completely false” and 10 indicates “completely true”. Below is an example of how hindsight bias was calculated.

<table>
<thead>
<tr>
<th>Memory design</th>
<th>Total hindsight bias</th>
<th>Total experimental (for 16 questions) – total control (for 16 questions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pre</td>
<td>post</td>
</tr>
<tr>
<td>Bias</td>
<td>true</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>false</td>
<td>2</td>
</tr>
<tr>
<td>Revere</td>
<td>true</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>false</td>
<td>-8</td>
</tr>
<tr>
<td>No bias</td>
<td>true</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>false</td>
<td>-2</td>
</tr>
</tbody>
</table>

In this particular example when the post response is greater than pre response (which is indicated by the post-pre score that equals a positive number greater than 0,) we could say hindsight bias exists. This would be the case if our participant, after perceiving feedback (the correct answer), responded with an 8, resulting in Post-pre score of 6. A basis is also demonstrated if the post-pre scores are negative. When the pre response is equal to post response the post-pre score becomes 0, meaning no hindsight bias. When the pre response is greater than post response and the post –pre score is a negative
number (for true items) or a positive number (for false items) a reverse hindsight bias is present.

In the hypothetical design, participants were asked to estimate how they would have answered had they not been given the correct answer. For hypothetical instructions, the hindsight score was calculated in the same way as described by Campbell and Tesser (1983). In the computation of this between-subjects (BS) theoretical hindsight bias index, the difference between those participants’ response and the true answer with feedback and the average difference score of response from the true answer of other subjects responding to the same items without feedback were calculated. These differences were scored as positive if it was in the direction of the feedback and negative if it was not. The indexes were calculated by averaging all the scores of the participants. For example, for the question “Aladdin of Arabian Nights was Chinese”. (which was a true statement), suppose the average of all the participants who responded (without feedback) was 5.6. The answer of a participant who was been given feedback that it was a true statement was then compared. In the within subject hypothetical design the participants total score in control condition was subtracted from the participants total score in experimental condition to calculate their hindsight bias. Hindsight bias is calculated by subtracting the control index (average group response) from the response score. When this difference score is greater than 0 it indicates hindsight bias exists. When the difference score is equal to 0 (and the item was true) it
indicates no hindsight bias. When the difference score is less than 0 it indicates reverse hindsight bias.

Repeated measures ANOVA was used as there were 2 within group variables (pre feedback and post feedback versus no feedback control) and (true vs. false questions) and one between group’s variables (handedness with two levels: mixed versus strong handers).

Table 5:

*Example for Hindsight bias calculation for Hypothetical Design*

<table>
<thead>
<tr>
<th>Hypothetical Design (between subject)</th>
<th>Total hindsight bias</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>response</td>
</tr>
<tr>
<td>bias</td>
<td>true</td>
</tr>
<tr>
<td></td>
<td>false</td>
</tr>
<tr>
<td>Reverse bias</td>
<td>true</td>
</tr>
<tr>
<td></td>
<td>false</td>
</tr>
<tr>
<td>No bias</td>
<td>true</td>
</tr>
<tr>
<td></td>
<td>false</td>
</tr>
</tbody>
</table>
Chapter Three

3. Results

As described in the method, Amount of hindsight bias was established using different general knowledge questions in both the memory and hypothetical designs. Each general knowledge statement presented to participants was either true or false. Participants were asked to determine which of the questions were true and which were false on a 21 point scale where 10 meant they thought it was completely true and -10 meant they thought it was completely false. Feedback was provided in the experimental condition for both memory and hypothetical designs, and no feedback was provided for the control condition. Hindsight bias was calculated by comparing the experimental and control conditions. A paired sample t test was conducted to see which design (hypothetical vs. memory) shows greater hindsight bias. A paired sample t test was computed to assess whether strong and mixed handers differed significantly in their magnitude of hindsight bias in the memory design. An independent sample t test was computed to assess if strong and mixed handers differ in their degree of hindsight bias in hypothetical design. Finally, a repeated measures ANOVA was run to compare both the designs, using standardized scores.

A paired sample t test showed that the participants in experimental condition of hypothetical design ($M=6.14$ showed greater hindsight bias as compared to experimental condition of memory design ($M=2.13$) $t (144) =6.895 \ p <0.01$. 

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Hypothetical Design

For the hypothetical design, hindsight bias was calculated and compared statistically for the feedback and no feedback conditions. The hindsight score in the feedback condition \((M=6.15)\) was significantly greater than the hindsight bias score in the no feedback condition \((M=1.3)\). The results of the independent sample t test showed that mixed handers exhibited significantly more hindsight bias \((M=7.63)\) than strong handers in the experimental condition \((M=3.95), t (156) =4.546, p<0.001\). The difference between mixed and strong handers on hindsight bias was not significant for control condition.

Memory Design

According to Pohl (1999), exact recollections are confounded with the amount of hindsight bias. So, in order to avoid such confound one should disregard all perfectly recalled estimates while calculating hindsight bias. Thus in the present study we analyzed hindsight bias in the memory design after omitting the perfect recall scores which represented 9% of all data. Data were then submitted to paired sample t test. Results indicated that the mean hindsight bias in experimental condition \((M=2.13)\) (post-pre score) was significantly different from that of the control condition \((M = -0.53)\) (post-pre score), \(t (144) =5.346, p<0.001\). In addition, it was found with a between group ANOVA that strong handers \((M=3.69)\) show significantly more hindsight bias as compared to mixed handers \((M=1.05)\), in the experimental condition of the memory design \(F (1,143) =13.1, p<0.01\)
Interaction Effects and Simple Effects

Since the procedure for computing hindsight bias score in the memory and hypothetical designs were slightly different scores were converted to z-scores for comparing the two designs. (A raw score can be converted to z score by subtracting mean score from raw score and then dividing it by standard deviations) A z score of 0 indicates the mean, any score above 0 indicates relatively greater hindsight bias compared to mean and any score below zero indicates relatively smaller hindsight bias compared to the mean.

A repeated measures ANOVA was conducted to analyze the interaction effect of the type of hindsight bias design of hindsight bias (memory vs. hypothetical) with strength of handedness (strong vs. mixed handers). It was found that there was a significant interaction between design and strength of handedness (see Fig 1 & Fig 2), Wilk’s Lamda=0.895 \textit{F}=(1,145)=18.53, p<0.001, such that mixed handers (M=7.48, z score=0.265) (score in experimental condition-control index score) showed greater hindsight bias than strong handers (M=4.20, Z score=-0.350) in hypothetical design but strong handers’ (M=3.69, Z score=0.349) showed greater hindsight bias than mixed handers (M=1.05, Z score=-0.239) in the memory design.
Figure 1: Hindsight bias score as a function of strength of handiness and design.
Figure 2: Relative Hindsight bias score (z score) as a function of strength of handiness and design.

The results repeated measures ANOVA for Simple effects analyses (Fig 3) showed that strong handers did not differ significantly between hypothetical and mixed design. Wilk’s Lamda=0.966, F (1,66)=2.37, p=0.13, whereas, mixed handers showed significantly greater bias in hypothetical design as compared to the memory design, Wilk’s Lamda=0.797, F (1,92)=23.42, p=0.01
Fig 3 Mean Hindsight Bias Scores for Strong handers in Hypothetical and Mixed designs and Mean Hindsight Bias Scores for Mixed Haners in Hypothetical and Memory Designs.
Chapter Four

4. Discussion

Hindsight bias is operationally defined as a type of decision making error where after an event occurs people tend to believe that they already knew or predicted that an event was the most likely to occur out of all possible events. As discussed earlier in the introduction, there are different ways to elicit hindsight bias, the most popular of which are the memory design and the hypothetical design. In the hypothetical design participants tend to overestimate how much they would have known (if they had not been given the answer) whereas in the memory design participants tend to overestimate how much they knew about the chances of an event occurring before it occurred. These two designs differ in at least two distinct ways. First, the method used in the designs differs. In the memory design participants are expected to remember their previous responses and hindsight bias occurs only when participant’s present responses seem to be closer to a given feedback than their previous responses. If their current response is the same as their previous response then there is no bias. In the hypothetical design, there is no need to remember a previous response, so participants are provided feedback (the correct answer) along with the question and then they are asked what their answer would have been had they not known the answer relayed via feedback. In this situation again people’s responses are closer to the feedback as compared to a control condition when no feedback is provided when they exhibit hindsight bias.
The second way in which the designs differ is the proposed underlying mechanisms as to why the hindsight bias occurs, owing to the nature of the instruction. According to the reconstruction model (in the memory design of hindsight bias,) since the original response is unavailable from memory updated knowledge (provided by feedback) replaces the original response (as well as confidence) thus creating hindsight bias. The notion is that hindsight bias only occurs when the original responses are forgotten. In the hypothetical design, where there are no original responses that need to be recalled, feedback about the true state of affairs leads to automatic updating of the knowledge base. Hindsight is more likely to occur in those who more readily update their representations.

The goal of the present study was to confirm that different underlying mechanisms cause hindsight bias in the two designs by using the individual difference variable strength of handedness which has been shown to relate to both mechanisms—memory and belief updating. The first hypothesis was that individuals would show more hindsight bias in hypothetical design than for memory design. The second hypothesis has that strong handers would show more hindsight bias in the memory design because they have worse memory and mixed handers would show more hindsight bias in the hypothetical design because they more readily update their beliefs.

The results of the present study support both hypotheses. We found that participants showed significantly more bias in the hypothetical design as compared to the memory design. Similar finding have been reported by Fischhoff (1977), Campbell and
Tesser (1983), Davies (1992) and Musch (2005). Possible reasons as to why hindsight bias is significantly lower for memory instructions are that people generally have a good memory for their previous responses, and they feel accountable to recall their previous ratings once they have given a rating (Fischhoff 1977, Campbell and Tesser 1983). For the hypothetical design, since there is no previous answer with which to compare, people are less accountable for their answers and may show greater hindsight bias due to that reason. The present study also supported our second hypothesis. We found that there was a significant interaction effect between type of design used and strength of handedness. Specifically, for hypothetical instructions, mixed handers showed greater hindsight bias as compared to strong handers. For the memory instructions strong handers showed greater hindsight bias as compared to mixed handers.

We can directly relate these findings to the underlying mechanism of hindsight bias. One explanation for the underlying mechanisms as to why hindsight bias occurs in the hypothetical design suggests that people tend to unconsciously reconstruct the responses using the given feedback to provide answers to questions for which they do not have a certain answer. In the present study mixed handers showed significantly greater hindsight bias than the strong handers in the hypothetical design. Interestingly mixed handers tend to anchor more to information (Jasper & Christman, 2005). If they find that information relevant they also update their beliefs more readily (Christman, in press; Christman, Bentle, & Niebauer, 2007; Niebauer, Aselage, & Schutte, 2002). The
argument here was that they would also be more prone to committing hindsight bias, but only in the hypothetical designs.

For the memory design, descriptively we found that strong handers showed greater hindsight bias as compared to mixed handers. Propper, Christman and Phanaef (2005), found that mixed handed individuals have better episodic memory for real life events due to their greater interhemispheric connection than strong handed people. Thus, one might argue that in the memory design mixed handers are more likely to remember their original responses than strong handers. Thus they should exhibit significantly less hindsight bias as compared to the strong handers. For those items for which they did not remember their previous responses both strong handers and mixed handers consciously used the given feedback information to generate a response. Since strong handers remembered fewer responses overall they used it more often than mixed handers.

There are a few theoretical and practical implications of this study. One implication of this study is that in studying hindsight bias, researchers should be aware of what design they are using. Of course, this depends on the aim of one’s study, but one needs to remember that whether hindsight bias is exhibited depends on how the questions are asked. Another implication of the study is that experimenters should be aware of their sample. For example, if they are using a hypothetical design and most of the people in the sample are mixed handers they will find very high hindsight bias scores. However, if most of the people are strong handers they may find much less hindsight bias. Thus it might not be generalizable. Finally, it should be noted that even if researchers are not
interested in looking at differences in strength of handedness for predicting hindsight bias they can still keep handedness in their statistical model to partial out its effects to reduce noise in the data.

As with most studies the present research raises additional unanswered questions. One of those is in reference to mechanism. With this study we cannot clearly show that hindsight bias is caused by conscious or unconscious processes. Future studies could be conducted to find out what processes are involved and how they operate. We could look at recall and recognition memory for memory design in hindsight bias. Recognition memory is not affected as much by memory impairment as recall because the target responses are already present in the target list. We could create a task where participants have to generate numbers as responses to questions. For half the questions, correct answers in terms of feedback could be given, and for the other half there would be no feedback. Then one could have 3 different between subject conditions of retrieval 1) participant who are asked to recognize their own responses as well as the given feedback from a list of answers 2) participants who are asked to recall their previous responses as well as the given feedback for each question for which feedback was given and 3) participants who are asked to recall their previous responses ignoring the feedback that is given.

The prediction is that for Condition 1 - where participants have to recognize both previous responses and feedback - there will be no difference between mixed and strong handers, since here mixed handers would not have a memory advantage. For Condition 2
where participants will have to recall their previous answer and feedback - we predict that mixed handers will produce more correct answers for their own answer as well as feedback. This is because here mixed handers will have a memory advantage, and moreover, it is easier for them to hold multiple representations of their own response and the feedback at the same time. For Condition 3, we predict that strong handers (similar to the present study) will show more hindsight bias as compared to mixed handers. This is because now mixed handers likely will recall previous responses and will not anchor to the feedback as much as strong handers.

In conclusion, the goal of the present study was to see if we could find and explain differences in the underlying mechanisms of the hypothetical and memory design with the help of the individual difference variable strength of handedness. From the present study we do find indications that the mechanisms underlying hindsight biases differ. It could be because the instructions are asking slightly different questions. As a result the focus of one’s response is different in the two designs which draws upon different processes which seem to be predicted by the handedness differences. Mixed handers showed more bias in the hypothetical design where as strong handers ( at least descriptively ) showed more bias in the memory design.
References


Christman SD, Henning BR, Geers AL, Propper RE and Niebauer CL (2008). Mixed-handed persons are more easily persuaded and are more gullible: Interhemispheric interaction and belief updating. *Laterality, 13*(5), 403-426


Appendix A

Questionnaire with Feedback for the study

1. The Aurora Borealis appears in the Southern Hemisphere.
   Answer: False: The Aurora Borealis appears in the Northern Hemisphere.
2. Chicago, Illinois is North of Rome, Italy.
   Answer: False: Chicago and Rome are in the same latitude.
3. The Obie awards are given for Chess Championship.
   Answer: False: The Obie awards are given for excellence in off-Broadway theatre.
4. High doses of Vitamin A can produce blurring of vision and dizziness.
   Answer: True.
5. The Japanese Parliament is called Diet.
   Answer: True.
6. Electron was discovered by Sir J J Thomson.
   Answer: True.
7. The famous statement, "Genius is 1% inspiration and 99% perspiration." Was made by Albert Einstein.
   Answer: False: The famous statement, "Genius is 1% inspiration and 99% perspiration," was made by Thomas Alva Edison.
8. The Panama Canal is about 70 miles long.
   Answer: False: The Panama Canal is about 48 miles long.
9. Lithium is the lightest of all metals.
   Answer: True.
10. The equatorial radius of Mars is approximately equal to that of earth.
    Answer: False: Radius of Mars is approximately half the radius of earth.
11. The second closest star to our solar system is known as Barnard's star.
    Answer: True.
12. The well known play "The Glass Menagerie" was written by Eugene O'Neill.
    Answer: False: The Glass Menagerie was written by Tennessee Williams.
13. The largest Dome in the world is Louisiana Super-Dome in New Orleans.
    Answer: True.
14. Ernest Hemingway received a Pulitzer Prize for The Old Man and the Sea.
   Answer: True

15. University of Florida has the largest library of any American university.
   Answer: False: Yale of Florida has the largest library of any American university.

16. Coffee got its name from the Ethiopian province of Kaffa.
   Answer: True

17. The Dutch are the tallest race in the world on average.
   Answer: False: The tallest race in the world is Tutsis (a tribe in Africa)

18. The holy book of Parsi religion is known as the Koran
   Answer: False: The holy book of Parsi religion is known as the Zend Avesta.

19. An element that has the highest boiling point is Stanium
   Answer: False: An element that has the highest boiling point is Tantalum

20. Florida is the flattest state in terms of elevation.
    Answer: True

21. Football sent the most 5-24 year old in the emergency room in 2008
    Answer: False: Basketball sent the most 5-24 year old in the emergency room in 2008

22. Mexico has the largest population of any Latin American country.
    Answer: True

23. Laughing sickness can be a fatal disease.
    Answer: True

24. The study of earthquakes is called Oligochaetology
    Answer: False: The study of earthquakes is called Seismology

25. The first Country to use paper was Egypt
    Answer: False: The first Country to use paper was China

26. One knot is equivalent to 1.84 K.M/hr
    Answer: True

27. In our solar system the planet that has the longest day is Neptune
    Answer: False: In our solar system the planet that has the longest day is Venus.

28. Wisconsin was the first state to abolish capital punishment.
    Answer: True

29. The People's Republic of China was founded in 1957.
    Answer: True

30. Babe Ruth has the highest lifetime batting; average in professional baseball.
    Answer: False: Ty Cobb has the highest lifetime batting; average in professional baseball.

31. The largest religious building in the world is Ang Kor Wat in Cambodia.
    Answer: True

32. Floyd Patterson was the youngest man to win the world heavy weight boxing championship.
33. George Washington delivered the shortest presidential inaugural address.  
   Answer: True
34. Marlon Brando has won the Academy Award for the best actor three times.  
   Answer False: Marlon Brando has won the Academy Award for the best actor two times
35. Earth is the only planet in this solar system that has one noon.  
   Answer: True
36. There are more single men in Alaska than in any other state.  
   Answer: True
37. The largest dam in the world is in Pakistan.  
   Answer False: the largest dam in the world is in China
38. Dr. David Livingston was opposed to the slave trade in Africa.  
   Answer: True
39. Originally fortune cookies contained Bible passages.  
   Answer: True
40. United States is the world's leading producer of silver.  
   Answer False: Peru is the world's leading producer of silver
41. The inner core of the earth is composed largely of liquid metals.  
   Answer False: The inner core of the earth is composed largely of solid iron-nickel alloy.
42. The Indian Ocean is the smallest ocean on the earth.  
   Answer False: Arctic Ocean is the smallest ocean on the earth
43. Tin is the traditional gift associated with the 10th wedding Anniversary.  
   Answer: True
44. The first modern Olympic Games were held in Rome, Italy.  
   Answer: True
45. Aladdin from One Thousand and One Arabian Nights was Chinese  
   Answer False: Aladdin from One Thousand and One Arabian Nights was Persian
46. The name of Socrates' most famous student is Aristotle  
   Answer: True.
47. A dime has 118 ridges around the edge.  
   Answer: True.
48. Both the centigrade and Fahrenheit Scale show the same reading at 33 degrees  
   Answer False: Both the centigrade and Fahrenheit Scale show the same reading at -40 degrees
49. At temperatures close to absolute zero the' magnetic' properties of many substances undergo changes  
   Answer: True
50. Michael Angelo did a famous painting called "Still life with apples"
   Answer False: Michael Angelo did a famous painting called Fruit on a stone
51. George Blanda is the national Football League's all-time leading scorer.
   False: Morten Anderson is the national Football League's all-time leading scorer
52. The movie "Casablanca" won the Academy Award for best picture in 1943.
   Answer: True
53. The largest museum in the world is the Louvre in Paris.
   Answer: True
54. Andrew Jackson was the only president to also serve as speaker of the house.
   Answer: True
55. The green part of a sprouting potato is poisonous.
   Answer: True
56. Peli has scored more goals than any other professional soccer players.
   Answer: True
57. A rock more than 10 inches in diameter is called a boulder.
   Answer: True
58. The Atlantic Ocean is deeper on the average than the Pacific.
   Answer False: The Pacific Ocean is deeper on the average than the Atlantic
59. The maximum duration of a solar eclipse is 17 minutes.
   Answer False: The maximum duration of a solar eclipse is 12 minutes 24 seconds
60. Aladdin from One Thousand and One Arabian Nights was Persian.
   Answer False: Aladdin from One Thousand and One Arabian Nights was Chinese.
61. The name of Socrates' most famous student is Aristotle
   Answer: True
62. Introduced by the British army, India's national sport is Cricket.
   Answer False: India's national sport is Field Hockey.
63. The largest living Invertebrate in the world is Octopus.
   Answer False: The largest living Invertebrate in the world is Colossal Squid
64. A sport wherein you use a "sand iron" is Polo.
   Answer False: A sport wherein you use a "sand iron" is Golf