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### Title

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### Authors

Bhardwaj,, Ayushi

Eloy Couto Correia, Luiza

Kaur Dharni, Noor

et al.

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**Replicating and Extending Upon “Hindsight Bias in Depression”**

Aaron Kermani, Ayushi Bhardwaj, Luiza Eloy Couto Correia, Noor Kaur Dharni

Cognitive Science and Psychology Undergraduate Laboratory @ Berkeley

Undergraduate Mentor: Hannah Jeong

Graduate Mentor: Joseph Ocampo

University of California, Berkeley

### **Abstract**

Hindsight bias is the tendency to perceive past events to be more foreseeable and inevitable than it actually was. This phenomenon has been assumed to be related to depression, but explicit empirical evidence is lacking in current literature. Groß et al.'s "Hindsight Bias in Depression" (2017) addresses the gaps in the literature by measuring participants' foreseeability, inevitability, responsibility, affect, and other related factors after they listen to various scenarios with either positive or negative outcomes. Our statistical replications align with the conclusions of the initial research, indicating that individuals exhibiting elevated depressive symptoms are inclined to perceive negative outcomes, rather than positive ones, as more foreseeable and inevitable in hindsight. Furthermore, we extended upon their data, finding those with more depressive symptoms to rate higher responsibility for negative outcomes, and not positive outcomes. Our findings concur with the consensus across literature that depressed individuals tend to take on more responsibility over negative events that they experience, and therefore lead to greater negative affect.

## Introduction

### Background Information

To understand the intricacies of this study and its respective extension, it is necessary to establish a definition of keywords and concepts. The premise under which this paper is written, “Depression”, is a common mental health disorder characterized by persistent feelings of sadness, hopelessness, and a lack of interest or pleasure in daily activities. Approximately 280 million people in the world have Depression, across all ages, races, and socioeconomic backgrounds (World Health Organization). It affects a person's thoughts, feelings, and behavior, and can lead to a variety of emotional and physical problems. The consequence is heavy; more than 700,00 people die due to suicide every year (World Health Organization).

Depression is often manifested in intangible and tangible ways, and can accumulate over time, particularly in frameworks like one's approach to life and general mentality. For example, those who have Depression tend to overgeneralize, generalizing specific negative events or experiences to a broader, more pervasive belief that everything in their life is negative. Furthermore, they often practice Selective Abstraction, focusing exclusively on negative aspects of a situation while ignoring positive elements - another common cognitive distortion. “Hindsight Bias” integrates these concepts, and is commonly referred to as the *"I-knew-it-all-along"* phenomenon. It is the tendency to perceive events as having been predictable or expected after they have already occurred. Hindsight Bias can influence the way people remember their own earlier predictions or beliefs about an event. They may unconsciously adjust their recollections to align with the actual outcome. In this paper, the relationship between Depression and Hindsight Bias is explored, on a statistical axis.

When looking at Hindsight Bias and its correlation with Depression (Groß et al., 2017), it is important to consider the broader contexts of this research. Understanding this relationship can inform clinical practices in Therapy and Cognitive-behavioral interventions. Understanding how individuals retrospectively interpret events can shed light on the cognitive mechanisms that may contribute to the development and persistence of depressive symptoms and be used by professionals to address depressive patients better. Life-review approaches are one example of targeting negative biases and helping individuals work to change these. Other literature emphasizes the link between counterfactual inhibition and retroactive pessimism (Tykocinski & Steinberg 2005), as well as the link between negative affect and hindsight bias (Haslim, Jayasinghe 1995), but is limited in knowledge about depression specifically, making this study necessary to address the holes in our current understanding of hindsight bias.

When looking at the existing study, there are several limitations. Firstly, the validity of the affect ratings that followed each scenario is limited because of the hypothetical nature of the scenarios. Furthermore, there cannot be a proven causal relationship between hindsight bias and affective responding due to the correlational design of the research. Moreover, the study can only be generalized to a population of University students, and a different study would have to be conducted to make conclusions to generalize results to the general population. These potential limitations are important to acknowledge through our replication and extension, which will be conducted through statistical analysis using R and RStudio.

## **Original Methods**

### **Participants**

In Experiment 1, Groß et al. (2017) gathered participants with consideration for depressive symptoms. Depression was measured using the Beck Depression Inventory-II (BDI-II) (German version) and depression levels were measured via participants' self-report. Participants included students at the Heinrich Heine University in Düsseldorf. In total, 245 students were screened for depression and participants were asked to join the study depending on BDI-II scores in addition to their desire to be contacted. According to Beck et al. (1996), BDI-II scores greater than 13 align with depressive symptoms that are considered at least mild. Thus, Groß et al. collected a participant group that reflected BDI-II scores both above and below this designation. The researchers also strived to equally reflect participants in the different groups in respect to gender and age. Ultimately, 60 participants joined the study and all participants were either native-born German speakers or had lived in Germany since before the age of 7. Participants were compensated by either receiving €8 or academic course credit.

### ***Design***

Multiple variables were used to understand the mechanisms and interactions at play within this study. The outcome valence of different scenarios (either positive or negative) served as a categorical variable and “manipulated within participants.” As mentioned earlier, depression was measured using the BDI-II inventory and stood as a continuous variable. Responsibility, affective relations, and hindsight cognitions (foreseeability vs inevitability) were all measured continuously as well.

### **Materials and Measures**

All participants were presented with materials in German. Researchers created 16 scenarios with descriptions that ranged from 47 to 147 words. Descriptions detailed situations about everyday life, ranging from work, to family, social interactions, romance, and more. Each scenario had two versions: one with a positive outcome and one with a negative outcome.

Researchers offered the following example to display this variation:

- i. “Imagine that after the past stressful weeks you have now finally arrived at your vacation destination in Southern France. Via the internet, you have booked a room in a small hotel at the seaside.
- ii. Arriving at the hotel, you realize that the room looks even better than what you saw on the internet. You have a balcony with ocean view, and the staff has equipped your room with a basket full of fresh fruit. (positive outcome)
- iii. Arriving at the hotel, you realize that the room does not look at all like what you saw on the internet. It is small, shabby, and lacks the ocean view that you had expected. (negative outcome).” (Groß et al., 2017, 775)

Each of the 16 scenarios was separated into two different sets of 8 (Set 1 and Set 2). From these mixtures, two versions of the sets were also created (Version 1 and Version 2). In Version 1, the positive scenarios were compiled into Set 1 while negative scenarios were compiled into Set 2. These compilations are reversed in Version 2. Of the 60 participants that took part in this study, half of them received Version 1 while the other half received Version 2. Depression scores (BDI-II) were similar between the groups (Version 1:  $M = 11.1$ ,  $SD = 9.4$ ; Version 2:  $M = 12.2$ ,  $SD = 8.4$ ).

Groß et al. (2017) calculated inevitability and foreseeability using existing items from Blank et al. (2008) and Blank and Peters (2010). Two items were used to determine inevitability

“Under the given circumstances the outcome of the situation was essentially determined” and “Because of the many factors that could influence the outcome of the situation, the outcome was still open” [reverse coded]). Three items were used to measure foreseeability (“I knew all along how the situation would turn out,” “I had a clear vision of how the situation would turn out,” and “It was difficult to predict how the situation would turn out” [reverse coded]). Additionally, the researchers formulated one item to measure responsibility (“If I was in the described situation, I’d feel responsible for the described outcome”), one item to measure imaginability (“I can clearly imagine myself in the situation”), and four items that measured affect. Two of these affect items measured positive emotions (joy and pride) while the other two focused on negative emotions (regret and disappointment). All items were measured with participants rating their personal agreement on items ranging from 0 (I fully disagree) to 100 (I fully agree).

### **Procedure**

Participant groups ranged from individuals to groups of 5. In order to conduct the experiment, participants sat in booths in which their informed consent was gained. They were asked to complete the BDI-II questionnaire, from which their BDI-II scores were derived. Participants did not read the 16 scenarios, but rather they listened to them with headphones in a randomized order that varied between participants. After hearing each outcome, they were asked to rate the imaginability of the scenario, hindsight, responsibility, and affect. Participants finished by submitting demographic health information, after which they were debriefed and compensated for their time and participation.



## Replication

### Methods

The current replication endeavor aimed to faithfully duplicate the methodologies and results of the original study, adopting a mixed-effects model framework using the accompanying open data set shared by the original researchers. The investigation revolved around 16 scenarios, categorized by valence (positive/negative), and examined key dependent variables (DV), including Foreseeability, Inevitability, and Affect. Design variables encompassed valence, Beck Depression Inventory-II (BDI-II) scores, and their interaction (Beck et al., 1996). Incorporating random effects, the model entailed random intercepts for subjects and scenarios, complemented by random slopes for continuous variables within both subjects and scenarios.

Preliminary analyses involved the computation of Imaginability and Responsibility scores. These scores were scrutinized through models integrating BDI, valence, and their interaction (Beck et al., 1996). Experiment 1 delved into Hindsight Cognitions, dissecting Foreseeability and Inevitability independently and decomposing them to elucidate the impacts of BDI and valence (Beck et al., 1996). In Figure 1, it explores the negative affect after negative outcomes, unraveling the interaction through subset analyses stratified by BDI levels. Similar scrutiny was applied to disappointment, positive affect after positive outcomes, and pride. (Beck et al., 1996).

### Results

In replicating foreseeability as a function of BDI and valence of Experiment 1, there was a main effect in BDI-II score and foreseeability scores in negative scenarios with a  $b = 0.82$  ( $p = .001$ ), while the original study found a similar positive effect with a  $b = 0.74$  ( $p = .001$ ).

Compared to the original study, our replication found a stronger correlation between BDI-II scores and post-outcome foreseeability, but nonetheless both significantly positive. Both the original study and the replication scores revealed a main interaction of scenario valences and BDI-II (original:  $b = -0.68$ ,  $p = .005$ ; replication:  $b = -0.63$ ,  $p = 0.005$ ) and further decomposition analysis showed that there was a significant increase in foreseeability ratings for negative scenario valences, but not positive ones, especially for those with higher depressive scores. Decomposition of the interaction further revealed that foreseeability scores increased with higher BDI, but only for negative valence scenarios, and not positive valences (original study:  $b = 0.74$ ; replication:  $b = 0.642$ ).

Similar hindsight bias interactions were evident for inevitability as well, finding a main effect of BDI of  $b = 0.77$ , and interaction of BDI and valence  $b = -0.7129$ . Decomposition of inevitability effects showed similar effects to foreseeability where scores increased with higher BDI, but only for negative valence scenarios, and not positive valences.

Overall, the replication found similar conclusions about foreseeability and inevitability in relation to depression and valence outcomes, but slight discrepancies within b-values were noted. We assume these slight discrepancies are due to possible differences in the optimizer and/or package version. We used the linear mixed effects model R's lme4 package to perform multilevel modeled statistical analysis as stated in the original study (Bates et al., 2015). However, in the original study, it was not specified which control optimizer or version of the package was used. Therefore, we decided to use the "bobyqa" optimizer with lme4 package version 1.1-35.1.

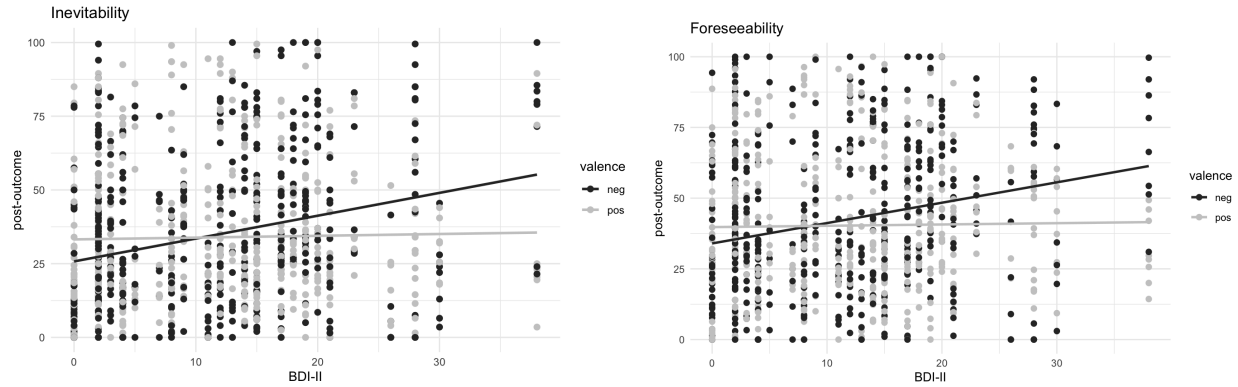


Figure 1 and 2: Replication of the original paper’s figure 1. Inevitability (fig.1) and foreseeability (fig. 2) ratings (Experiment 1, post-outcome) as a function of BDI-II score and valence of scenario outcome. The individual dots represent every scenario each participant read.

## Extension

### Methods

#### *Participants*

We used the open data set provided by “Hindsight Bias in Depression” (Groß et al., 2017). The original study screened students from Heinrich-Heine-Universität Düsseldorf, Germany as participants. More participant recruitment information can be found in the original Groß and colleagues’ (2017) methods section of the study. We looked at the participant’s responsibility rating, BDI-II scores, and the valence of scenarios from both Experiment 1 and 2. It totaled to 135 unique participants.

#### *Materials and measures*

**BDI-II.** We chose to focus on participants who scored above a 20 on the BDI-II, which signifies moderate to severe ranges of depressive symptoms according to Beck et al. (1996). Of the 135 total participants, there were 22 participants who had a BDI that fell under this range.

**Scenarios.** Each participant listened to 16 scenarios: 8 with positive outcome valences, and 8 with negative outcome valences. After they listened to the 16 scenarios, each participant rated their responsibility levels (“If I was in the described situation, I’d feel responsible for the described outcome”).

Within experiments 1 and 2, BDI-II measures, scenarios, and responsibility rating were measured the same. However, in experiment 2, foreseeability and inevitability items were measured both before and after reading each scenario outcome contrary to experiment 1’s post-outcome measure. Experiment 2 participants’ CTI (Pössel, 2009), a short version of the DAS (DAS-18A; Rojas, Geissner, & Hautzinger, 2015), and the CEQ (Pössel, 2008) were additionally measured. All materials and measures were in German per the original study.

The main effects and interactions of responsibility ratings, BDI-II scores, and valence of each scenario outcome were analyzed using General Linear Models in R.

## Results

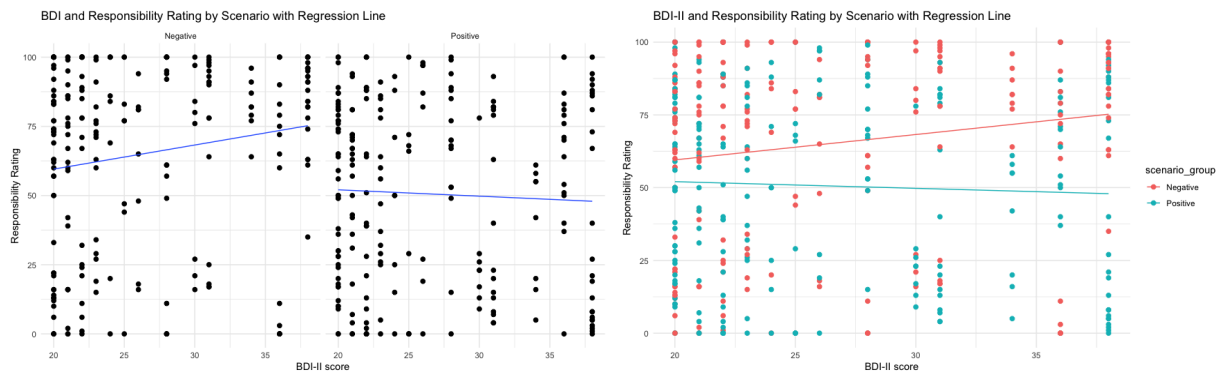
In this analysis, a total of 135 participants with BDI-II scores ranging from 20 to 53 were selected for further investigation. In a correlation analysis, it was revealed a significant positive correlation between BDI scores and responsibility ratings ( $r = 0.060$ ,  $p < 0.05$ ). This suggests that higher BDI scores are associated with higher perceived responsibility.

Aggregate analysis of BDI scores across different scenarios showed slight variations in mean BDI scores across scenarios. However, no significant differences were observed between scenarios (Figure 3). Participants with higher BDI scores tended to have higher responsibility

ratings in negative scenarios, whereas those with slightly lower BDI scores showed higher responsibility ratings in positive scenarios (Figure 4). Notably, this pattern was consistent across both positive and negative scenarios.

Multiple linear regression analysis revealed that both BDI scores and responsibility ratings significantly predicted scenario valence ( $p < 0.05$ ). These findings suggest that depressive symptoms and perceived responsibility play crucial roles in shaping scenario outcomes. T-tests comparing responsibility ratings between moderate and severe groups indicated significant differences in responsibility ratings for both positive ( $p = 0.0127$ ) and negative ( $p = 0.027$ ) scenarios.

These figures depict the relationships between BDI scores, responsibility ratings, and scenario outcomes, highlighting the nuanced interplay between depressive symptoms and perceived responsibility across different scenario types.



Figures 3 and 4: BDI-II score plotted against the responsibility ratings of the respective scenario valences. For negative outcome scenarios, people with higher depression symptoms rated their responsibility rates higher.

### **Discussion/Analysis**

Our replication study indicates a clear correlation between Beck Depression Inventory (BDI) scores, responsibility ratings, and scenario outcomes. In our initial analysis, we found the correlation between BDI scores and responsibility ratings to be  $r = 0.060$ , signifying a weak but positive relationship between the two variables. This leads us to conclude that individuals with higher levels of depression are generally more inclined to assume greater responsibility for scenarios beyond their control.

Moreover, we observe the influence of scenario outcomes on responsibility. As depicted in Figure 3, among scenarios with negative outcomes, individuals with higher depression levels tend to exhibit increased responsibility-taking. Conversely, when only positive outcomes are considered, the correlation is negative and less distinct. Depressed individuals are notably less inclined to take responsibility for positive outcomes. Figure 4 contrasts the correlation between responsibility ratings and BDI-II scores across the two scenario groups, highlighting their marked differences.

Additionally, variations in responsibility based on depression severity are evident. A comparison between moderately and severely depressed groups reveals a significant disparity in assuming responsibility for scenarios with negative outcomes. This is supported by a T-test value of  $p = 0.027$ , which is below the widely recognized significance threshold of  $p = 0.05$ .

Overall, looking at our data, we can conclude that more depressed individuals are much more likely to take responsibility for a scenario with a negative outcome compared to less depressed individuals and/or a scenario with a positive outcome. Using this information as well as the conclusions drawn from the original paper, we can work to refine therapies that address depressed individuals as well as educate mental health-care providers.

Compared to the results of our original study, we find a compelling level of parallel. It is evident that depression triggers certain mentality patterns that emphasize negative circumstances. There is an overall emphasis on negative outcomes and the establishment of a personal connection to negative phenomena. Themes like inevitability, hindsight, responsibility, and pessimism surface.

There are powerful implications of this exploration. For one, clinical practice and research and development can be inspired by such research in many critical ways. Medicine can be designed to address related areas of the brain associated with negative emphasis. Even more, cognitive behavioral therapy to address depression can be heavily influenced by this research; aiding those with depression through a perspective of empathy and science-backed understanding is instrumental.

Educational and preventative initiatives can also be developed with this research in mind. Teaching children from an early age to not ruminate on the negative, and learn to strike a balance between positive and negative in life can truly change lives. To add, general awareness in society creates a safer environment for those with depression, allowing for stronger and more informed support systems. Moreover, preventive interventions targeting cognitive biases early in the course of depression could potentially reduce the severity and duration of depressive episodes.

### **Conclusion**

In review of this extension, the proposed research offers insight into associations between depression/BDI-II and responsibility. As outlined earlier, the general trend between depression and responsibility correlates positively, although scenario outcomes (i.e., positive or negative) moderates this relationship, creating starker discrepancies between these variables. This development opens the door to greater conversations on perceived situational outcomes as they

serve to impact people with depression. More specifically, these results suggest that people with greater depressive symptoms may feel greater responsibility for negative outcomes, with the opposite being plausible for positive outcomes.

This discussion, however, requires greater investigation. The suggestive results derived from this extension highlight a need for greater work on the matter as the literature on responsibility and depression is limited. Even within this project, the original researchers failed to explicate this dynamic in their analysis, possibly suggesting that an endeavor between these two variables may offer extensive results.

To reiterate, future directions point towards extending the literature on responsibility and depression. More specifically, researchers may want to orient this inquiry towards groups beyond the original sample to possibly identify cultural differences within this phenomenon. Additionally, these initiatives may attempt to uncover potential underlying mechanisms among depressive symptoms that may mediate these relationships. Expanding our knowledge on the dynamic between depression and responsibility harbors potential both in alleviating sociocultural stigmas surrounding depression and through clinical work that may support individuals facing these symptoms. Our project here underscores the need for this work as psychopathologies often pose complex etiologies. Thus, equally comprehensive and diverse opinions on topics such as depression are welcome and necessary into the future.



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