Mental Addition Versus Subtraction in Counterfactual Reasoning: 
On Assessing the Impact of Personal Actions and Life Events

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Assessing the consequences of actions and events often requires comparing a mental simulation of the world in which the action is present to one in which the action is absent. We propose that people perceive more impact when asked to assess whether an action would increase the likelihood or degree of a potential outcome (mental addition) than when asked whether it would reduce the probability or extent of a potential consequence (mental subtraction). This judgmental asymmetry occurs because people (a) give more weight to features of the particular mental simulation (the action or its absence) serving as the subject of comparison and (b) give more weight to factors that produce as opposed to inhibit the relevant outcome. In 4 studies, Ss assessed the impact of personal actions (e.g., studying for an exam). Ss perceived more impact when the assessment was placed in an additive frame (e.g., "how many more questions will you get right if you study?"), as opposed to a subtractive one (e.g., "how many fewer will you get right if you do not study?"). This effect was not influenced by the hedonic value of the event or by whether the S had actually experienced it. Discussion centers on the relevance of these results for the undoing of scenarios and causal attribution.

Whether one engages in an action depends to an important degree on one's assessment of its potential benefits and costs. People will start a fitness program, for example, only if they believe it will likely improve their health without too much effort, pain, or threat of injury. They will endorse a political candidate's pledge for a federal jobs program only if they believe it will greatly increase employment and not spur a damaging rise in inflation. Likewise, people's emotional reactions to personal actions and life events are driven by perceptions of their consequences. A person will derive satisfaction from a decision to enter graduate school, to take a job, or to buy a house only if he or she believes that action will produce a number of pleasures while not creating an undue variety of difficulties.

In the social psychological literature, there has been to date little theory or research devoted to how people assess the impact of personal actions and life events. Clearly, the correct way to determine the impact of an action would be to conduct a rigorously controlled experiment in which data were collected from the "world" in which the action occurs and from the world in which the action is absent. Everyday life, however, largely precludes such experiments. A person can have, for example, only one hometown, one first love, and one set of parents. Assessing the consequences of an action or event is thus often a counterfactual reasoning task in which one compares the event experienced, or some notion of what one will experience, to some alternative, imagined possible world.

This article is devoted to how people complete the construction and comparison of these worlds when rendering assessments of impact. Specifically, drawing on recent work on the mental simulation (Kahneman & Tversky, 1982) and judgment of similarity (Tversky, 1977; Tversky & Gati, 1978), we trace through the steps that people follow when assessing impact. From that analysis, we then test and explore a specific implication: That people perceive greater impact when their assessments are framed in terms of mental addition as opposed to mental subtraction. By mental addition, we mean assessments in which people must determine whether a causal agent will produce an outcome to a greater degree or with greater probability (e.g., "How many more questions will I get right on the test if I study tonight?" "How much more of a quality education will I get at High Quality University as opposed to Mediocre State?"). By mental subtraction, we mean assessments in which people must determine whether an outcome will occur to a lesser extent or with reduced probability (e.g., "How many fewer questions will I get right if I skip studying?" "How much less of a quality education will I get at Mediocre State as opposed to High Quality University?").

As can be seen in these examples, any assessment concerning
the impact of an event can be placed either in terms of addition or subtraction. In the studies that follow, we examine whether the same personal action or event will be assigned more impact when its assessment is placed in an additive as opposed to a subtractive frame. For example, if a prospective student or concerned parent is worried about the differences between two universities, High Quality University (HQU) and Mediocre State (MS), we propose that the individual will perceive a greater contrast between the two schools when focused on the advantages conferred by HQU (e.g., “How much better education does HQU offer as opposed to MS?”) than when concentrating on the potential disadvantages associated with MS (e.g., “How much less does MS offer as opposed to HQU?”)

A Model and an Example of Impact Assessment

Perhaps an example better illustrates what we mean by mental addition versus subtraction, as well as explains why people might be more likely to perceive greater impact when performing mental addition. Consider the high school senior who is contemplating attending two different universities: High Quality University and Mediocre State. Clearly, HQU is the better choice, but the question here is how much more quality education can be obtained at HQU, and, conversely, how much less of a quality education can be received at MS.

It seems likely that the student will rely on some form of the simulation heuristic (Kahneman & Tversky, 1982) when called on to make an assessment of this sort. That is, the student will set up mental models of the events or worlds in question (e.g., HQU and MS) and then run “simulations” to see whether each model suggests any paths leading to the particular outcome of interest (e.g., quality education). Links between model and outcome are likely to be of two types. First, the individual can note whether any instances of the relevant outcome come to mind (perhaps thinking of a student’s testimonial). Second, the individual might generate causal theories that would link the event to the outcome (for example, the individual might decide that because HQU has rich alumni, the institution might be more able to lure quality faculty). To the extent that the available features of one model (HQU) more plausibly suggest the relevant outcome than do those of the other (MS), the more impact will be perceived. Table 1 displays a list of features that the student might generate in the simulation and comparison of HQU and MS. Of key interest is that in judgments of this type, people will predominantly focus on features that would produce or facilitate the relevant outcome, such as quality education, people will give more weight to features that would produce or facilitate the relevant outcome as opposed to those that would reduce or inhibit it. For example, when considering the degree to which a college can provide a good education, people will predominantly generate and give weight to advantages that each university possesses (e.g., a prestigious faculty and an emphasis on undergraduate education). People could predominantly focus on features that would detract from a quality education (e.g., introductory classes are taught by teaching assistants), but are not likely to do so unless under special circumstances.

With these two tendencies in hand, the rationale for the asymmetry between mental addition and subtraction becomes clear. Consider the additive frame (e.g., “How much more at HQU?”) Confronted with this frame, people will tend to focus on the advantages present at HQU that would produce a quality education. They will, conversely, give little weight to features at MS that could potentially produce the same outcome (see top section of Table 1). Under this frame, people will thus see a marked contrast between the two colleges. Now consider the subtractive frame (e.g., “How much less at MS?”) When the assessment is placed in these terms, the advantages of HQU will become less salient and the features of MS that would produce a good education will receive more attention (see bottom section of Table 1). Under this frame, people will perceive less difference between the two schools.

In sum, in additive assessments people focus on the advantages present in the “superior” world (the one more likely producing the outcome) and, as a result, perceive the action as possessing much impact. In the subtractive frame, the advantages of the superior world become less salient, and people are more likely to focus on any compensatory advantages contained in the “inferior” world, decreasing any perceived difference between superior and inferior worlds.

Table 1

<table>
<thead>
<tr>
<th>Schematic of Judgments Under Additive and Subtractive Frames for Example Comparison of High Quality University (HQU) and Mediocre State (MS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factors associated with</strong></td>
</tr>
<tr>
<td><strong>High Quality University</strong></td>
</tr>
<tr>
<td>Weight given to factors under additive frame, i.e., “How much more quality education would I get at HQU than at MS?”</td>
</tr>
<tr>
<td>Students have high SATs</td>
</tr>
<tr>
<td>Foreign campuses</td>
</tr>
<tr>
<td>Rich alumni</td>
</tr>
<tr>
<td>Weight given to factors under subtractive frame, i.e., “How much less quality education would I get at MS than at HQU?”</td>
</tr>
<tr>
<td>Students have high SATs</td>
</tr>
<tr>
<td>Foreign campuses</td>
</tr>
<tr>
<td>Rich alumni</td>
</tr>
</tbody>
</table>

Note. Features in boldface are given more weight than those that are not.
It is Tversky’s (1977; Tversky & Gati, 1978) work on the contrast model of similarity judgments that has documented the first judgmental tendency assumed here, that the features in the subject of the comparison receive the bulk of the attention in judgments of similarity and contrast. Consider a comparison, for example, between an object that contains many features (e.g., China) and one that contains just a few (e.g., North Korea). When the unique aspects of the many-featured object are made salient by making it the subject of the comparison (e.g., “How similar is China to North Korea?”), people perceive more contrast than when the alternative is made the subject (e.g., “How similar is North Korea to China?”) This asymmetry in similarity judgments has been observed in a wide variety of domains. Indeed, it has been observed for judgments in the social realm as well (e.g., “How similar are you to your neighbor?” vs. “How similar is your neighbor to you?”; Holyoak & Gordon, 1983; Read, 1987; Srull & Gaelick, 1983).

Evidence for the tendency to give weight to facilitatory over inhibitory factors in judgment comes from research in causal attribution. In that work, researchers have long noted that people prefer to think about factors that would facilitate an outcome over those that would inhibit it (cf. Hansen, 1980, 1985; Jones & Davis, 1965; Nisbett & Ross, 1980; L. Ross, 1977; Shaver, 1981). In perhaps the clearest demonstration, Hansen and Hall (1983) presented college students with the results of various competitions, such as football games or tug-of-war contests. When subjects were presented with games that produced wide margins of victory, they were more likely to attribute the result to the strength of the winner (an obvious facilitator) than to any weakness in the loser (a clear inhibitor). Newtonson (1974) also found that people were more affected in their causal reasoning by the introduction of facilitators than inhibitors. Specifically, when he asked subjects to assess the reasons why hypothetical college students chose one action over another (e.g., choosing to babysit for a professor over working at the university library), he found that causal reasoning was influenced more by the introduction of factors that would promote the relevant choice (e.g., ingratiating oneself with the professor) than by the introduction of considerations that would inhibit it (e.g., the library is noisy). The goal in this research was to determine whether the tendency to focus on the subject of the comparison, coupled with the bias toward reasoning in terms of facilitators, would lead to asymmetries in counterfactual reasoning. More to the point, we wanted to see whether people’s perceptions of the impact of a particular causal factor would be greater when the assessment was placed in additive terms as opposed to subtractive terms. Toward that aim, we conducted four experiments. The 1st two were designed as simple tests of our notions about the mental operation required (addition or subtraction) and perceptions of impact. The final two studies explored, and ultimately ruled out, many alternative explanations for the phenomena we found.

Study 1: Assessing the Impact of a Hypothetical Action

In this study, college students were presented with a hypothetical scenario in which they were about to take a midterm examination. Subjects were asked to assess the impact of a personal action, studying for 3 hr, on their performance. The specific queries that students faced were framed in either an additive or subtractive fashion.

Method

Subjects. Subjects were 50 introductory psychology students at Stanford University. Their participation fulfilled a course research requirement.

Procedure. Subjects were approached at the end of experimental sessions involving irrelevant studies. All subjects read the following short scenario:

Imagine you’re in a psychology class and the midterm exam is scheduled for tomorrow. Obviously, it’s time to study for the midterm. You’ve been told that the exam is a 60 multiple-choice exam, with half the questions coming from the lectures and half from the textbook. You’ve studied your lecture notes, but up until now you haven’t had a chance to read, let alone study, the book. Tonight, though, you set aside three hours to read and review the book.

For 25 subjects in the additive condition, the scenario continued, “And, indeed, nobody interrupts you and you spend those three hours studying the text. The next day, you take the test.” These subjects were then asked, “On the 60-item test, how many more questions on the midterm did you get right because you studied the book for three hours?”

There were 25 students in the subtractive condition. Their continuation of the scenario read, “But something important comes up and you do not get to spend those three hours studying the text. The next day, you take the test.” These subjects were then asked, “On the 60-item test, how many fewer questions on the midterm did you get right because you didn’t get to study the book for three hours?”

A few additional exploratory questions were asked of subjects in both conditions. Specifically, after responding to the queries we have described, subjects were next asked (a) how many total exam questions they would have gotten right if they had studied, (b) how many they would have gotten right if they had not studied, and (c) how many hours they typically studied the textbook for a test of this type.

Results and Discussion

Responses of subjects confronting an additive or subtractive frame are presented in Table 2. As expected, when presented with an additive frame, subjects’ estimates of the study session’s impact were greater ($M = 18.4$ questions) than when they were faced with a subtractive frame ($M = -14.3$ questions). The absolute value of these estimates between the two groups is significantly different, $t(48) = 2.39, p < .05$, supporting the hypothesis under study.

Recall that we also asked students in both conditions to estimate their total exam score after studying and after not studying. We made no predictions about group differences on these queries, but as can be seen in Table 2, the two groups did differ in these estimates. When asked to estimate the number of total points they would have received after studying, subtractive subjects gave marginally higher estimates of their total exam score than did additive participants ($M_s = 50.7$ and 52.8 for additive and subtractive groups, respectively), $t(48) = 1.67, p < .10$. The groups differed dramatically when considering the situation in which they did not study ($M_s = 32.4$ and 40.0 for additive and
Table 2

<table>
<thead>
<tr>
<th>Measure</th>
<th>Additive</th>
<th>Subtractive</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived impact of study</td>
<td>18.4</td>
<td>14.3</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Session (absolute value of change)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total exam score if studied</td>
<td>50.7</td>
<td>52.8</td>
<td>&lt;.10</td>
</tr>
<tr>
<td>Total exam score if did not study</td>
<td>32.4</td>
<td>40.0</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Typical number of hours spent</td>
<td>5.1</td>
<td>4.6</td>
<td>ns</td>
</tr>
<tr>
<td>studying</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>25</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

In all, subjects responded to 21 different queries. Fifteen questions involved subjective dimensions, that is, factors that are not easily quantified. Subjects responded to these queries on 19-point Likert scales that ranged from -9 (much less) to 0 (the same at both colleges) to 9 (much more). The remaining 6 questions involved objective estimates, involving quantities that could at least in theory be verified with data. For example, subjects were asked to estimate the impact of coming to Stanford on the number of people (out of 100) who would esteem their college education, the average SAT score of the students they knew, the number of hours they had to study a week, the number of nights they went "out on the town," their score on any future GRE/LSAT test, and the likelihood (in percentage terms) that they would obtain their first-choice job on graduation.

Results and Discussion

Subjects’ responses are presented in Table 3. Once again, subjects perceived greater impact when confronting an additive as opposed to a subtractive frame. This asymmetry was most present when subjects considered the subjective dimensions, multF(15, 51) = 2.37, p < .05; however, it appears that the effect occurs, although much more weakly, even when subjects are asked to provide exact numerical or objective estimates, multF(6, 60) = 1.94, p < .10. As can be seen in Table 3, the additive frame produced significantly larger perceptions of impact when subjects considered the subjective dimensions of quality of education, interest in classes, challenge in classes, knowledge of subject matter, ability to think clearly, likelihood that people would be impressed, preparation for career, ease at getting a first job, pressure, and time spent studying. When asked to offer objective estimates, subjects confronting the additive frame produced more extreme responses when considering number of hours spent studying in a week and the likelihood that they would obtain their first-choice job on graduation.

It should be noted that the assessment frame even influenced whether subjects perceived that Stanford had any influence at all in their education, social life, and future opportunities. For each query and for each group, we determined the percentage of subjects who said that coming to Stanford had had an influence on their lives (whether positive or negative and of whatever magnitude), and the percentage who said Stanford had had no impact of their lives (i.e., they stated that the colleges were the

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1 The careful reader will note a few discrepancies in Table 1. Recall that subjects estimated the impact, in terms of questions correct, of studying versus not studying. Estimates of impact can also be derived by taking subjects’ estimates of total exam score after studying and subtracting their estimates of total score after not studying. As can be seen in Table 1, estimates of impact using this derived measure do not equal subjects’ direct estimates of impact. This occurred because a few subjects in each condition provided total exam score estimates whose difference did not equal their direct reports of perceived impact.
Mental Addition Versus Subtraction

Table 3
Perceived Impact of Coming to Stanford Over Second-Choice College Under Additive Versus Subtractive Frame

<table>
<thead>
<tr>
<th>Measures</th>
<th>Additive</th>
<th>Subtractive</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of education</td>
<td>4.4</td>
<td>1.7</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Interest in classes</td>
<td>2.7</td>
<td>0.6</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Challenge in classes</td>
<td>2.7</td>
<td>0.1</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Knowledge of subject matter</td>
<td>2.5</td>
<td>1.0</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Ability to think clearly</td>
<td>1.2</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Efficiency of work</td>
<td>0.4</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Impression on other people</td>
<td>5.3</td>
<td>2.8</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Preparation for career</td>
<td>3.4</td>
<td>1.6</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Ease at obtaining job</td>
<td>3.2</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>What “got out” of classes</td>
<td>0.9</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Enjoyment of college</td>
<td>2.7</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
<td>2.6</td>
<td>0.0</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Study time</td>
<td>2.3</td>
<td>−0.5</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Social time</td>
<td>1.3</td>
<td>−0.3</td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of nights out per week</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Points on [GRE, GMAT, LSAT]</td>
<td>3.1</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Likelihood will obtain job (%)</td>
<td>7.7</td>
<td>3.3</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

n = 33, 34

* Positive numbers indicate an increase due to coming to Stanford; negative numbers indicate a decrease. b Positive numbers indicate a decrease if a subject had attended a second-choice college; negative numbers indicate an increase.

Discussion: Studies 1 and 2

Studies 1 and 2 provided evidence that assessments of causal impact are labile. When asked to assess the impact of a hypothetical action (i.e., studying for an exam) or of actual life occurrences (i.e., attending a particular college), subjects perceived more influence when the assessment was cast in an additive as opposed to a subtractive frame. Indeed, in Study 2 we obtained evidence that question-framing could influence whether subjects saw any impact whatsoever. When faced with a subtractive frame, subjects were much more likely to say that their college choice had no effect on their life and livelihood whatsoever.

These demonstrations, however, do not point conclusively to the exact factor responsible for these asymmetries in causal reasoning. Our guiding explanation centers on the mental operation (addition vs. subtraction) that subjects were asked to perform. These results, however, could have been produced via other mechanisms, both cognitive and motivational.

One such alternative account for our results is based on the distinction between common and unusual events. There is evidence that people tend to make attributions to any unusual or abnormal conditions present in the situation (Hilton & Slugoski, 1986; Kahneman & Tversky, 1982). Perhaps in these studies, people were focused on an unusual event in the additive frame and more common ones in the subtractive. This explanation for our results, however, seems problematic. Specifically, in Study 2, in which subjects compared coming to their chosen college with attending another particular college, it is difficult to decide which event is “normal” and which is unusual. Study 1, in addition, provides direct evidence against this interpretation of our findings. Judging from reports about how much the subjects studied for examinations (typically 4–6 hr), it appears that studying is the status quo event and that not studying is the unusual occurrence. Subjects, however, perceived more impact when they considered studying relative to not studying.

Study 3: Does the Hedonic Value of the Event Make a Difference?

One other plausible explanation for the results of the 1st two studies focuses on the hedonic value, or the pleasantness, of the event under consideration. Specifically, in the two previous studies, the additive or subtractive nature of the assessment was confounded with the pleasure associated with the event of focus. When asked to “add” effects, subjects generally focused on events (i.e., studying) that conferred pleasurable consequences (e.g., obtaining a higher score on an exam). When asked to “subtract,” subjects were impelled to concentrate on events that conferred unpleasant results. Perhaps people find it easier to think about pleasant events and so assign to them more impact than to unpleasurable alternatives. There is much experimental evidence showing that people learn, process, and remember pleasurable stimuli much better than negative ones (cf. Boucher & Osgood, 1969; Matlin & Stang, 1978; Wagenaar, 1986), making this alternative explanation plausible.

We should note that this explanation does not explain all the results we obtained in Study 2. For example, it fails to explain perceptions of the impact of college choice on time spent studying. Subjects reported that coming to Stanford caused them to study more. When focused on the other college, subjects also reported (somewhat incoherently) that they would also have studied more there! This result is quite explicable if we assume that people find adding consequences easier than subtracting.
them. This result runs contrary to the hedonic value hypothesis, which would predict that students would wish to report studying less at both institutions.

The hedonic value explanation, however, deserves an explicit test. That was the aim of Study 3, in which we strove to pit the hedonic value explanation against our own notions of mental addition versus subtraction. In this study, we presented a new set of subjects with the materials used in the first study, in which subjects compared the impact of studying (or not studying) on their performance on a midterm examination. In the present study, we closely compared responses to an event with measurable consequences (studying) to one with unfortunate consequences (not studying) in either an additive or subtractive framework. For example, some subjects considered studying and assessed its impact additively (i.e., how many more questions will you get right). Others assessed the same event under a subtractive frame (i.e., how many fewer will you get right). Some subjects assessed the impact of not studying by adding (e.g., how many more will you get wrong); others by subtracting (e.g., how many fewer will you get right). If the mental operation people must perform (i.e., adding or subtracting) is responsible for the causal asymmetries we have observed, then people should perceive more impact when considering how many more as opposed to how many fewer. If the hedonic value of the event is crucial, then people should perceive more impact when dealing with the event of studying relative to that of not studying.

It should be noted that the design of this study (as well as that of the study that follows) also allowed us to examine another potential confound. Namely, in the 1st two studies, our subjects always focused on the effects of implementing an action (e.g., studying) in the additive frame, whereas in the subtractive frame they concentrated on the impact of foregoing the action. Perhaps the causal asymmetry occurred because people deal with action and inaction differently. In past research, people have been shown to possess different emotional reactions to consequences that result from action as opposed to inaction. For example, if a person buys stock and loses $10,000, that individual feels more regret than if he or she failed to sell a previously owned stock that subsequently lost the same amount (Landman, 1987).

Method

Subjects. Subjects were 193 Stanford undergraduates enrolled in an introductory psychology course. Participation partially fulfilled a course research requirement.

Procedure. Subjects were presented with the midterm scenario (used in Study 1) during a session in which they completed a series of questionnaires. The scenario was altered in only one detail: The exam was presented as a 100-item test, half of which came from the course textbook (as opposed to the 60-item test described in Study 1).

In all, subjects assessed the impact of studying under four different frames. Approximately half of the subjects considered the act of studying. Under the additive-study frame, subjects were asked “How many more questions did you get right because you studied?” Under the subtractive-study frame, students reported “How many fewer did you get right because you studied?” The remaining subjects considered the act of not studying, roughly half under an additive frame (“how many more did you get wrong?”) and half under a subtractive frame (“how many fewer did you get right?”)

Results and Discussion

In essence, our design was 2 (mental operation: addition vs. subtraction) × 2 (event: studying vs. not studying), pitting the two competing explanations against each other. If the mental operation explanation were correct, we would expect a main effect for addition versus subtraction. As can be seen in the top section of Table 4, the mental operation that subjects had to perform did have a significant effect on perceptions of causal impact. Subjects perceived a greater impact when required to add (M = 27.5) than when compelled to subtract (M = 22.4), F(1, 189) = 7.07, p < .01. The hedonic value of the event had virtually no effect on assessments of impact, F(1, 189) = 1.80, ns. These results are consistent with our notions of mental addition versus subtraction, but not with the competing speculations focusing on the pleasantness of the event in question or on whether people concentrated on actions taken versus actions foregone.

The influence of addition versus subtraction on assessments of impact, however, was mediated by an unexpected but statistically significant Mental Operation × Event interaction, F(1, 189) = 5.82, p < .01. As can be seen in the top section of Table 4, the asymmetry between addition and subtraction was observed only when subjects considered the act of studying, t(189) = 3.71, p < .001. The asymmetry was barely evident for subjects confronting the no-study scenario.

This interaction is open to a number of interpretations. One interpretation would be that the mental operation people are asked to perform influences judgments only when considering actions taken as opposed to actions foregone. Another interpretation is presented in the bottom section of Table 4, and begins with the observation that our subjects perceived more impact when considering how many more or fewer questions they would get right (M = 27.2) as opposed to questions they would get wrong (M = 23.0). Why would our subjects perceive more impact when considering questions right than when assessing questions wrong? One explanation, admittedly post hoc and requiring further study, rests on notions of the “psychophysics of

<table>
<thead>
<tr>
<th>Event focus</th>
<th>Condition</th>
<th>Additive</th>
<th>Subtractive</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studying</td>
<td>28.9</td>
<td>20.0</td>
<td>27.5</td>
<td>22.4</td>
</tr>
<tr>
<td>Not studying</td>
<td>26.1</td>
<td>25.7</td>
<td>27.5</td>
<td>22.4</td>
</tr>
<tr>
<td>Overall</td>
<td>27.5</td>
<td>22.4</td>
<td>27.5</td>
<td>22.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit of measurement</th>
<th>Number of questions right</th>
<th>Number of questions wrong</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additive</td>
<td>28.9</td>
<td>25.7</td>
<td>27.3</td>
</tr>
<tr>
<td>Subtractive</td>
<td>26.1</td>
<td>20.0</td>
<td>23.1</td>
</tr>
<tr>
<td>Overall</td>
<td>27.5</td>
<td>22.4</td>
<td></td>
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</tbody>
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numbers.” It seems intuitive that changes seem larger when close to zero. For example, a move from 1 unit to 11 units seems larger than a swing from 81 units to 91. Our subjects, when reporting what score they expected to achieve on the hypothetical examination, typically stated that they would obtain roughly 10–30 points wrong, or 70–90 points right. Thus, subjects may have been more likely to report smaller swings when thinking about questions wrong relative to questions right because they were dealing with numbers that were close to 0. Thus, each unit change may have seemed more impressive. When considering questions right, on the other hand, they were considering numbers far away from zero, and so a greater swing in points may have been necessary to make the change seem equally impressive. This reasoning is consistent with past research focusing exclusively on perceptions of numbers (Holyoak, 1978; Shepard, Kilpatrick, & Cunningham, 1975), in which it has been shown that people perceive small numbers (e.g., 1 or 2) to be more dissimilar than larger numbers (e.g., 8 or 9).

Study 4: Does Experiencing the Event Make a Difference?

Study 4 was designed to investigate another plausible alternative mechanism that could underlie the results we obtained: whether the subjects experienced the event they were focused on under a particular frame. In Study 2, we asked subjects to consider actual events (i.e., coming to college). It could be argued that we observed causal asymmetries because when we asked subjects to add the benefits of coming to their chosen college relative to going elsewhere, we were focusing their attention on an event they had experienced as opposed to a hypothetical alternative. When focused on an event they had experienced, subjects drew on vivid and salient memories. In the subtractive frame, people may have been forced to focus on less vivid and certain construction of an alternative world. As we have discussed, there is much indirect empirical support for this “experience” hypothesis. Recall earlier that when people consider two objects and one contains many more features than the other, people perceive more contrast between the two when focused on the many-featured object (cf. Tversky, 1977; Tversky & Gati, 1978).

Study 4 was designed to provide a clear test of whether our mental addition phenomenon is an experience effect in disguise. Students at Cornell University were asked to consider in either an additive or subtractive format the impact of coming to Cornell (the experienced event) or of going to their second-choice college.

Method

Subjects. Subjects were 92 Cornell University student volunteers enrolled in an upper-division psychology course.

Procedure. Subjects completed the questionnaire as part of a class demonstration on research methods. The questionnaire was a shortened version of that used in Study 3. Subjects were asked to name the college they would have attended if they had not been accepted by Cornell.

That college was termed “the other college.” Students were then asked to assess the impact that coming to Cornell had had on their education and personal lives and would have on their future. In all, subjects were asked to consider the interest (or dullness) of their classes, the amount of challenge (or ease) that their classes presented, the expected ease (or difficulty) in obtaining their first-choice job on graduation, and the likelihood that they would obtain (or be rejected for) that first-choice job.

Subjects in this study confronted one of four different frames. Some subjects were presented with the additive–Cornell frame (e.g., “How much more challenging are your classes at Cornell than they would have been at the other college?”) Some subjects faced the additive–other college frame (e.g., “How much more easy would your classes have been at the other college than they are at Cornell?”) Others were presented with a subtractive–Cornell frame (e.g., “How much less easy are your classes at Cornell than they would have been at the other college?”) Finally, some confronted a subtractive–other college frame (e.g., “How less challenging would your classes have been at the other college than they are at Cornell?”) Subjects responded to these questions on 19-point scales ranging from −9 (much less) to 0 (the same) to 9 (much more), except when estimating the likelihood of obtaining their first-choice job. That scale ranged from −30% to 30%.

After answering these questions, subjects were asked to compare Cornell to the other college in terms of overall academics (i.e., “How much better or worse is Cornell academically than the other college?”) Responses could range from −9 (Cornell much worse) to 9 (Cornell much better). All subjects rated Cornell as better than the other school in this regard, an important result.

Results and Discussion

The design of Study 4 was 2 (mental operation: addition vs. subtraction) × 2 (event: Cornell vs. other college). The responses of subjects to the individual questions are presented in Table 5, along with an overall index consisting of the average standardized scores of all items.

As expected, subjects perceived more impact when asked to add (overall standard M = 1.20) than when required to subtract (standard M = .72), multF(4, 85) = 2.69, p < .05. This effect was significant for two of the four individual items (interest–dullness, likelihood of obtaining–being rejected for first job) and marginally significant for the other two (challenge–ease, ease–difficulty of obtaining first job).

Further analyses failed to support the experience hypothesis.
Specifically, when subjects focused on Cornell, they did perceive more impact (overall standard $M = 1.13$) than when they focused on the other college (overall $M = 0.79$), but this difference failed to reach statistical significance, multF(4, 85) = 1.45, $p > .20$. This effect, however, was marginally significant for two of the individual items that subjects considered (interest—dullness, ease—difficulty of obtaining first job). There was no evidence for any interaction between the mental operation required and the event considered ($F < 1$).

In sum, Study 4 was designed to determine whether the causal asymmetries we had uncovered previously were caused by the mental operation that people were required to perform or the nature of the event serving as the subject of comparison. Study 4 indicates that the mental operation that people had to perform was the crucial factor: Subjects perceived more impact when asked to add rather than subtract, regardless of the event of focus.

**General Discussion**

We began this article by proposing that people assess the impact of events and actions by running mental simulations that introduce the feature into a model of the world and then assessing the consequences that plausibly follow. From this general point, we moved to a specific hypothesis: People would perceive more impact when those simulations were cast in terms of the consequences that might be added as opposed to the outcomes that might be removed. In four studies, in which we framed the same simulations of events in terms of addition versus subtraction, we found consistent support for this hypothesis. For example, when asked to assess the benefits of coming to their first-choice college, students perceived much more impact when asked to consider the benefits that that college provided than when asked to consider the benefits they would have foregone by attending their second-choice institution.

Along the way, we were able to identify and rule out various alternative explanations for the causal asymmetries that were observed. These results were not produced by whether subjects were asked to consider a frequent or an unusual event. These results were also not driven by the hedonic value, or pleasure, associated with each event. Moreover, these results did not depend on whether subjects had experienced the event in question. Also, the results were not influenced by whether subjects focused on an action taken or on an action foregone. In sum, these results suggest that causal reasoning is influenced by the mental operation that people must perform. All things being equal—indeed, including the causal agent under consideration—people will perceive more impact when asked whether an event will add consequences than when asked if it will subtract them.

Beyond documenting and exploring the mental addition versus subtraction effect, the results of Study 3 suggest that other factors may influence causal reasoning as well. In Study 3, when subjects considered the influence of studying on their subsequent academic performance, students unexpectedly perceived more impact when the unit of measurement was number of questions right as opposed to number of questions wrong. Our interpretation of these results rests on the idea of the “psychophysics of numbers.” That is, people treat numbers near zero differently than numbers that are far away. This notion, we feel, deserves more attention in the social psychological literature, for numerical estimates involving a percentage or percentile score can be framed in numbers close to or far away from zero.

**New Avenues for Research**

The research reported in this article suggests a number of immediate follow-up investigations. Do the differing assessments of contrast prompted by mental addition versus subtraction lead to differing emotional reactions on the part of the social perceiver? Specifically, does the perceiver experience more extreme emotions when making an additive assessment as opposed to a subtractive one? What about action? Do people perceive the potential benefits and costs as greater under an additive frame, and thus become more (and in some instances perhaps less) likely to pursue the behavior under scrutiny?

Future research might also focus on the specific process model we have proposed that people follow in their assessments of causal impact. Do people, as we have suggested, focus on factors that would produce the outcome in question at the expense of factors that would prevent it? Do people focus more on features in the subject of the comparison over those included in the referent? Each of these assertions is of interest not only for understanding the phenomenon uncovered in this article, but also because each has potential consequences for other types of social judgments.

In addition, empirical work on the processes underlying the mental addition versus subtraction asymmetry may shed light on the normative status of the assessments people are providing. For people to answer what is putatively the same causal question differently under divergent frames suggests that something, somewhere is “going wrong.” Are people chronically overestimating the impact of actions and events in the additive frame, or are they underestimating the impact in the subtractive one? Are they perhaps doing a little bit of both? At this time, it would be sheer speculation to decide which assessments, additive or subtractive, are faulty. Suffice it to say that the phenomenon shown here does carry some implications for the ability of people to render normatively adequate judgments of impact. At the very least, judgments of consequence should be consistent, that is, the person should give the same assessment no matter how the query is superficially framed. Here, assessments of impact were hardly consistent.

Finally, it should be noted that this research introduced a host of factors (the pleasantness of the event, whether it has actually been experienced, whether it is unusual or common, whether it is an action or an inaction) that might plausibly influence judgments of impact, even though they failed to do so here. Perhaps if we had focused on these factors more closely, they would also have been shown to influence judgments of impact.

A case in point is whether a person has experienced an event. In Study 4, we found that focusing on an experienced event as opposed to a hypothetical alternative had, if anything, only a slight influence on perceptions of impact. In subsequent research concentrating exclusively on this variable, however, we have found that people perceive more contrast between experienced life events and alternatives when the experienced event is
made the subject of the comparison (Dunning & Madey, 1989). It should be noted that this effect fits into the general notions about mental simulations and the comparison process presented in this article. That is, when focused on the experienced event, people draw on vividly remembered experiences that become less salient when the hypothetical alternative is made the subject of the comparison. In short, in these judgments of contrast, we again find that judgments of contrast are driven predominantly by the nature of the subject of the comparison.

Relation to Work on the Undoing of Scenarios

The research reported here on assessments of impact has an obvious relation to other recent work on counterfactual reasoning, such as norm theory (Kahneman & Miller, 1986; Miller & McFarland, 1986) and the undoing of scenarios (Kahneman & Tversky, 1982; Wells & Gavanski, 1989; Wells, Taylor, & Turtle, 1987). In that work, researchers presented subjects with an event (e.g., Mary was killed in an auto accident when she took a cab) and ask them how they would "undo" the outcome of that event. Researchers then explore the counterfactual or "default" world that subjects construct (e.g., if only she had taken the bus). Subjects in those studies, as in our research, must make judgments that involve an actual event, a counterfactual world, and the difference between them (i.e., the appearance of the outcome).

Research on the undoing of scenarios has one important implication for the research reported in this article. Specifically, that research presents an alternative theoretical account for the judgmental asymmetries we observed. Recall that our theoretical account emphasizes the weight subjects give to features associated with two worlds: one that is "superior" (it more likely produces the outcome) and one that is "inferior." Specifically, we propose that causal agents in the inferior world potentially producing the relevant outcome become more salient under a subtractive frame (e.g., people give more weight to the fact that Mediocre State, although an inferior college, still has assets that would provide a quality education). Work on undoing, however, suggests that less contrast is perceived in the subtractive frame because it simply evokes a different inferior world than does the additive frame. Consider as an example a college student who is assessing the impact of receiving a $5,000 scholarship. The appraisal can easily take on an additive form ("How much more money would I have with this scholarship than without?") or a subtractive one ("How much less money would I have without this scholarship than I would with?") In the additive frame, the assessment may well be that the scholarship provides $5,000 because the student simply compares having the award to the inferior world of having no money. In the subtractive frame, however, the inferior world in the comparison itself might change: The student, for instance, might construct a world in which he or she obtains a part-time job paying $3,000. In that case, the net loss is $2,000. In other words, the inferior event considered in the subtractive frame (the part-time job) is a different world from the one dealt with in the additive frame (simply having no money).

In a sense, this alternative account for the addition-subtraction asymmetry does not differ greatly from the account presented in the introduction, which was based on the weight given to features contained in superior and inferior worlds. Specifically, it is possible to consider the evocation of alternatives account as a special case of our theoretical perspective, one in which the features of the inferior world are given zero weight until placed in a subtractive frame. In the scholarship example, we could argue that the chance of obtaining a job is given no weight in the additive frame but $3,000 worth of weight in the subtractive frame. Although this analysis reveals that the two accounts are similar, it should be noted that the two accounts certainly differ in terms of subjects' phenomenology. Specifically, the evocation of alternatives viewpoint suggests that people mentally simulate the inferior world only when confronted with subtractive frames. Future work on the processes underlying the mental addition versus subtraction asymmetry is needed in order to gauge how much attention the inferior world receives under both framing conditions.

Research on the undoing of scenarios also presents an apparent contradiction with the research presented here. In studies of undoing, subjects tend to alter outcomes by providing "downhill changes," that is, they delete a feature present in the scenario. For example, when hearing that Mary was killed in an auto accident when she was in a cab, subjects undo the scene by wishing that Mary had never taken the cab. The preference for deletion revealed in undoing experiments, however, seems at odds with the preference for mental addition exhibited here. If people perceive more contrast when asked to add features, and if subjects in undoing experiments wish to alter the outcomes of the scenarios presented to them maximally, then it follows that people should prefer to undo scenarios by adding features.

There are many possible responses to this apparent paradox. In past research on undoing, the focus has been on how people remove or subtract unusual or unwanted outcomes (e.g., death in a car crash). The main focus of this research, and something yet to be addressed in research on undoing, is how people would alter scenarios in order to produce favorable or wanted outcomes (e.g., "how do I get Jane to do well in her courses?"). It seems likely that people would approach the production of outcomes by adding causal agents to the scenario in question (e.g., "I'll hire a tutor"). In short, it might be the case that when people focus on obtaining outcomes, they might show a preference for adding causal agents. The reason that previous work has shown a tendency for deletion is because it has focused exclusively on situations in which the individual wants the outcome to be removed.

Implications for Attributional Reasoning

This research also has implications for theory on how people reach attributional judgments.

First, this research shows the usefulness of thinking about attribution in a "backwards" manner. That is, in traditional attributional research, the event or outcome is presented to subjects and then researchers observe how subjects determine the crucial causal factor responsible for the event. In these studies, we presented subjects with the opposite task: We focused them...
on the causal factor and asked what outcomes were likely to occur. We feel this sort of causal reasoning task has been unduly ignored by social psychologists. As noted at the outset, assessments of impact guide our actions every day (e.g., “Will I fail behind on my work if I skip writing the discussion section today?”) They guide our affective reactions as well (e.g., “I’m so glad I got accepted to Cornell—it’ll provide the finest education!”). As our results indicate, assessments of impact are influenced by a variety of factors. There may be other factors (e.g., hedonic value of the event) that influence these appraisals as well. To this point, we know little about what those influences are.

This research reinforces the usefulness of recent reconceptualizations of the attribution process as well. As traditionally defined, attribution is a covariation detection task in which the individual seeks out consensus, distinctiveness, and consistency information (Kelley, 1967, 1973). Recently, many researchers have proposed that causal attribution is more accurately a counterfactual reasoning task in which the world is compared with alternative states or to one’s knowledge of likely worlds (Hilton & Slugoski, 1986; Kahneman & Miller, 1986; Kahneman & Tversky, 1982; Leddo, Abelson, & Gross, 1984; Wells & Gavanski, 1989; Wells et al., 1987). These types of reconceptions allow for the introduction of a host of factors, such as framing, that may importantly influence causal reasoning.

For example, the present research can lead us to speculate on how people treat facilitators and inhibitors in causal attribution. It has been proposed in the causal attribution literature that facilitators dominate causal attribution, although little research has been conducted to test that point directly (Hansen, 1980, 1985; Hansen & Hall, 1985; Jones & Davis, 1965; Newson, 1974; Nisbett & Ross, 1980; Nisbett & Wilson, 1977). Our research indirectly confirms that point: An action or event seems to have more impact when cast as a facilitator as opposed to an inhibitor. However, in causal attribution, would people tend to cite facilitators over inhibitors when explaining social events? Moreover, if people are biased to explain and predict events in terms of facilitators, are they unjustly neglecting inhibitors that would successfully explain and predict the same events?

In addition, consider the notion that people pay attention predominantly to features present in the subject of the comparison and its implications for causal attribution and theory building. It suggests that the attributions that people make depend on how the attributional question is framed, a point first articulated by Kahneman and Miller (1986). Consider the example of a football game in which Team X wins over Team Y. When asked to explain that event, if the question is framed as “Why did Team X win?”—and if people are prone to examine only one cell of the two (Team X and Team Y) included in this thought experiment—someone may answer this question by citing good coaching or a superlative game plan or teamwork. Frame the question differently, that is, by asking “Why did Team Y lose?” and people may base their explanations on other factors, such as penalties, turnovers, and injuries.

In a sense, this reasoning has appeared in the social psychological literature before. In an experiment on attribution, M. Ross and Sicoly (1979) asked basketball players why they won or lost. Players always cited their own actions as being crucial. M. Ross and Sicoly speculated that these attributions may have been quite different had they asked why the other team went on to win or lose. Consider as well how people, and also social scientists, come to explain social phenomena—such as the classic finding in the “minimal group” literature that people favor their ingroup and disfavor the out-group when arbitrarily separated into groups (cf. Brewer, 1979). Our intuitions concerning the mechanisms underlying this phenomenon may change if we frame this effect as a derogation of the out-group (e.g., people like to hate, remember only negative features of other groups) or as an enhancement of the ingroup (e.g., believing that ingroup members are similar to the always highly esteemed self).

In sum, it is clear that our research highlights, above all else, the potentially important role of mental simulation in social judgment. We believe that future research might fruitfully concentrate on the implications of mental simulations and framing for the judgments people are called on to make in their social world. We cannot help but feel that the benefits of any future research in this area will prove to be bountiful—although we concede that if the research is not done, the loss may not appear to be so great.

References


MENTAL ADDITION VERSUS SUBTRACTION


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