Can the Magnitude of the Belief-Bias in Causal Reasoning be Attenuated Through the Manipulation of Content?

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According to the two-stage model of causal reasoning (Fugelsang & Thompson, 2003), people automatically recruit their pre-existing beliefs when evaluating causal judgments. The current study investigates the effect of content in reducing the belief-bias effect in causal reasoning. The belief-bias was measured using the standard causal paradigm and in addition, the problems were divided equally into the following conditions: mental health, physical health, positive, and negative content. It was hypothesized that the belief-bias effect would be attenuated for the problems with negative content and mental health content because they are assumed to restrict the automatic recruitment of beliefs. This hypothesis was partially supported. It was found that the belief-bias effect was attenuated in the negative condition when compared to the positive condition, as expected. There was no difference in the magnitude of the belief-bias effect between the two health type conditions. Several explanations of the contrasting results are discussed.
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Can the Magnitude of the Belief-Bias in Causal Reasoning be Attenuated Through the Manipulation of Problem Content?

Imagine the following scenario: You have had a long day at work, are very tired, and have not yet eaten. Above all else you may be coming down with a cold. However, it is your best friend’s birthday and she is having a get together at her house that evening. Despite how you feel, you decide to make an appearance at the party and have a few drinks. At the party there are several appetizers to choose from. You begin by eating the usual items you know you like, and then decide to try something novel and slurp down a juicy raw oyster. Later that evening, you become very ill. What caused the illness? The seemingly obvious answer would be that you became ill from eating the oyster. However, there are several other factors that may have also caused or contributed to the illness, such as being physically run down, consuming alcohol, or eating other non-novel foods that were contaminated (e.g., the mayonnaise in the finger sandwiches could have gone bad).

The above scenario illustrates why the study of causal reasoning is so important. Theoretically, it is important to identify the mechanisms and processes involved in coming to a causal conclusion. For example, why does eating the oyster stand out as the logical cause of the sudden illness? There are also practical consequences to the study of causal reasoning and these consequences have a profound influence on future behaviour. For example, you may decide never to eat oysters again, even though the oyster may not have been the actual cause of the illness. Or, you may have attributed the illness to the mayonnaise and started to restrict your diet to avoid the condiment. In either case, your diet and food preferences would change, depending on what you decided was the cause of becoming ill.

What is Causal Reasoning?
Causal reasoning is a sophisticated, high-level cognitive activity by which cause-and-effect judgments are made. In other words, causal reasoning is an inductive process by which people determine a cause (or causes) for a given effect (Heit, 2007; Novick & Cheng, 2004; Schustack & Sternberg, 1981; Sloman, 2005). People make numerous cause-and-effect judgments everyday, and as the example above illustrates, these judgments, more likely than not, will have important implications for future behaviour. Because the ability to make accurate and effective cause-and-effect judgments is so important, cognitive psychologists have exerted considerable effort in examining the mechanisms and processes underlying this cognitive ability (e.g., Buehner, 2005; Downing, Sternberg, & Ross, 1983; Cheng, 1987; Einhorn & Hogarth, 1986; Fugelsang & Thompson, 2000, 2003; Fugelsang, Thompson, & Dunbar, 2006; White, 1989).

The fact that people make cause-and-effect judgments quickly and (computationally) efficiently implies that a systematic process is used to make such judgments. However, most systematic cognitive processes are not perfect and are accompanied by errors. In the area of causal reasoning, several types of errors have been reported. The illusory correlation is one example of such an error and stems from the tendency to overestimate the frequency with which two events co-occur (Baron, 1988; Tversky & Kahneman, 1982). For example, nausea is often a symptom of the flu; however, not all cases of nausea co-occur with the flu virus. The confirmation bias is another example of a systematic error in causal reasoning. The confirmation bias is simply the tendency to endorse causal conclusions that are believable, or the endorsement of conclusions that are consistent with one's belief about the causal relationship (Baron, 1988; Evans & Feeney, 2004). For example, if people believe that the flu shot will give them the flu, they will likely endorse the conclusion as such, or discount the
alternate conclusion that the flu shot will not give them the flu. Finally, the belief-bias effect is also a systematic error that occurs in the domain of causal reasoning. The belief-bias effect can be defined as the discounting of new information that contradicts one's pre-existing beliefs and the search for new evidence that confirms one's pre-existing beliefs (Feeney, 2007; Fugelsang & Thompson, 2000, 2003). For example, if people believe the flu shot will give them the flu, they will likely recall instances when the flu co-occurred with receiving the flu shot and discount instances when the flu did not co-occur with receiving the flu shot.

The purpose of this thesis is to examine the belief-bias effect in causal reasoning. This examination is important because pre-existing beliefs are often incorrect, as in the example above (i.e., receiving the flu shot will lead to getting the flu virus), thereby reducing one's ability to reason objectively with new information. Before any further discussion of the belief-bias effect, the following sections will introduce factors that are known to influence causal reasoning, and will outline several influential models of causal reasoning.

Factors that Influence Causal Reasoning

The first factor known to influence causal reasoning is called covariation. Covariation involves developing knowledge, through observation, about the pattern of relationships between potential causes and a particular effect. In other words, covariation is defined as how often two events regularly co-occur in time (Cheng, 1997; Fugelsang & Thompson, 2002). Generally speaking, the more often a cause and effect co-occur, the more likely that potential cause will be perceived as the cause to the effect (Cheng, 1997; Kelley, 1973; Wasserman, 1990). For example, when one is exposed to peanuts and an allergic reaction occurs 90% of the time, the peanuts will more likely be inferred as the cause of the allergic reaction than if the reaction occurred for only 10% of the exposed interactions. This influential factor is
purely empirical, such that it relies solely on observation. Thus, by simply observing causal events, people are able to evaluate the strength of causal relationships in order to make causal inferences.

A study conducted by Wasserman (1990) exemplifies the influence of covariation as a factor in causal reasoning. In this study participants were presented with data regarding meals eaten by a fictional patient and the occurrence of an allergic reaction after each meal. Participants were asked to determine a likely cause for the allergic reaction. The data presented to the participants was covariation based, such that the potential causes were either regularly or not regularly associated with the reaction. For example, some of the meals included either shrimp or strawberries, and an allergic reaction occurred for a given number of encounters with the shrimp or strawberries only. Wasserman found that when the covariation statistics for each potential cause presented was closer to 100%, the participants rated causation as more likely than when the covariation statistics were closer to 0%. Also, the results indicated intermediary effects as well, such that when the covariation statistics represented a 75% association, the cause was rated as more likely the source of the reaction than for a 25% association. This trend was the case regardless of the type of food eaten (i.e., it made no difference if the food was shrimp or strawberries). Therefore, the greater the co-occurrence between the putative cause and the effect, the more likely that cause was seen as eliciting the effect.

A second factor known to influence causal reasoning is referred to as pre-existing beliefs. As people interact with the world, they become knowledgeable about cause-and-effect relationships and incorporate this information into their belief systems. These pre-existing beliefs are then used to aid the reasoner in evaluating subsequent (often novel)
cause-and-effect relationships. Causal reasoning is then a matter of applying a causal belief to a new cause-and-effect problem (White, 1989). For example, through experience people know that if a hot element on a stove is touched it will burn one's hand. This information is then available for future interactions with stoves (or other similar things such as a camping stove) to prevent people from burning themselves. It is important to emphasize that people do not always consciously comprehend the power their pre-existing beliefs have on their everyday decision making.

Pre-existing beliefs include a variety of causal information, such as covariation, temporal order, and mechanism-information. Covariation was discussed above. Covariation information may be used independently, or incorporated into the belief repertoire. Temporal order refers to when a potential cause co-occurs close in time to an effect (Einhorn & Hogarth, 1986). For example, one is much more likely to infer that peanuts are the cause of an allergic reaction if they are eaten just prior to the reaction rather than if they are eaten days before the reaction. In addition, the cause must always precede the effect. (Hagmayer & Waldman, 2002; Sloman, 1996). Temporal order incorporates people's most basic understanding of causal events in the environment and can often be incorporated in one's belief system after only one instance, an important conceptual difference from the learning of covariation information, which requires a minimum of two instances. Finally, mechanism-information refers to the powers a cause possesses that can produce an effect. All objects have an inherent causal mechanism that people incorporate into their belief systems (White, 1989). For example, a hammer has an inherent causal mechanism to break fragile objects, whereas a feather does not have an inherent causal mechanism to break fragile objects.
The theoretical incorporation of pre-existing beliefs as an influential factor in causal reasoning is fairly recent. For example, White (1995) provided participants with cause-and-effect scenarios varying along dimensions of belief (i.e., high/low), and all of the scenarios included perfect covariate information for the proposed cause and effect. The results indicated that putative causes were chosen because the cause was believed to have the power to produce the effect, not because of its empirical association with the effect (i.e., covariation). Because higher causal ratings were observed in the high-belief condition than in the low-belief condition, this provided strong evidence that it was the pre-existing beliefs regarding the cause that determined the ratings rather than the covariate information. If the covariate information was actually causing the ratings, it would be expected that the two conditions would yield similar causal ratings because the two conditions were presented as perfect covariates.

Without pre-existing beliefs, determining cause-and-effect relationships would be a difficult and time consuming task, because a large number of hypothetical causes would have to be evaluated each and every time an individual needed to make a causal decision (White, 1989). That is, previous experience would not be available to guide behaviour. By recruiting pre-existing beliefs to aid in decision making, the number of hypothetical causes is narrowed to just a few plausible candidates (and in some cases just one candidate), allowing people to make cause-and-effect judgments in real time (Fugelsang & Thompson, 2002; White, 1989; 1995).

Covariation and pre-existing beliefs not only have independent effects on causal reasoning, the two factors have also been found to work together in facilitating cause-and-effect decisions. Depending on the nature of the causal reasoning problem, the two factors
have differing effects on causal decision making processes (Fugelsang & Thompson, 2003). In situations where the causal problem is believable rather than unbelievable (e.g., the oyster caused the illness), covariation information is given more weight when coming to a causal conclusion. This finding indicates that people search for evidence to confirm their initial beliefs, thereby making their pre-existing beliefs stronger. In situations where the causal problem is unbelievable (e.g., ulcers are caused by feeling relaxed), covariation information is given less weight when coming to a causal conclusion. This finding indicates that people rely more on their pre-existing beliefs than covariation information when the causal problem is unbelievable. The observation that these two factors interact lead to the development of the two-stage model of causal reasoning (Fugelsang & Thompson, 2003). This model will be discussed in more detail below.

**Models of Causal Reasoning**

Several models have been proposed to explain causal reasoning processes and the factors that influence them. The traditional manner of explaining causal reasoning is through covariation-based models, such as Kelly's 1973 ANOVA model and Cheng and Novick's (1990, 1992) probabilistic contract model. These models assume that people have an inherent ability to automatically process statistical relationships in the environment. A further assumption of these models is that people will judge two events that co-occur frequently as more likely to be causally related than two events that do not co-occur frequently. In other words, cause-and-effect judgments are made based on the perceived degree of covariation between a putative cause and the observed effect (Kelly, 1973; Cheng 1997; Cheng & Novick, 1990, 1992; Wasserman, 1990). For example, according to the probabilistic contrast model, in order to determine causality, people are able to unconsciously consider the
probability of the effect occurring in the presence of the cause \([P(e/c)]\) and the probability of
the effect occurring in the absence of the cause \([P(e/\sim c)]\). Based on these probabilities,
people are able to determine the strength of the cause's ability to produce the effect. This
probability is represented by the formula: \(AP = [P(e/c)] - [P(e/\sim c)]\), where a positive \(AP\)
indicates a strong causal relationship and a negative \(AP\) indicates no causal relationship. In
other words, if the effect occurs more regularly in the presence of the cause than in the
absence of the cause, then causality between the potential cause and the effect is more likely
to be inferred, whereas if the effect does not occur more regularly in the presence of the
cause than in the absence of the cause, then causality between the potential cause and the
effect is less likely to be inferred (Cheng & Novick, 1990, 1992).

Covariation-based models sufficiently describe the empirical process by which people
infer cause-and-effect relationships through observation, thereby explaining the influence of
covariation as a factor that influences causal reasoning. As well, the \(AP\) index has been
considered a normative index of causality for decades (e.g., Kao & Wasserman, 1993).
However, there are some fundamental problems with these models. One problem is the
importance these models place on covariation as being the primary cue indicating causation.
This assumption is problematic because covariation does not always imply causation (Baron,
1988; Einhorn & Hogarth, 1986; Fugelsang & Thompson, 2002; White, 1989). Two events
may co-occur in time but one may not have caused the other (e.g., because the moon rises
when the sun sets does not mean that the sun setting caused the moon to rise). Another
problem with covariation models is that the \(AP\) index requires several pieces of information
to calculate the probabilistic causal strength between the two events. This problem means
that these models rely on more than one observation of the cause and effect relationship to
determine if they co-occur in a pattern of regular association. People, however, will often infer cause and effect after only one observation. For example, only one observation would be necessary to infer that peanuts were the cause of an allergic reaction (Baron, 1988; Einhorn & Hogarth, 1986; Fugelsang & Thompson, 2002, 2003). Another problem is that these models do not allow for the complexity of everyday causal relationships to be represented adequately. First, AP only calculates the probability of a single cause for a given effect. Often effects have more than one possible cause, and AP as a normative index becomes problematic when choosing between multiple causes. The AP index only allows the calculation of one probable cause at a time. Multiple indexes would have to be calculated for each probable cause, thereby increasing processing time (Allen & Jenkins, 1980; Spellman, 1996). Further, covariation-based models do not include a mechanism that allows for people's pre-existing beliefs to influence which causal candidates are selected as causing an effect, because they rely exclusively on observation as the mechanism of causal inference. As a consequence, these models are unable to explain how people can infer causation after only one observation of the cause-and-effect relationship. By not incorporating pre-existing beliefs, covariation-based models are unable to use several critical pieces of information, such as mechanism-information, that make causal reasoning processing fast and efficient. For example, over time people become knowledgeable about an object's power to produce an effect, such as a hammer's ability to break fragile objects. This knowledge is then transferable to causal instances where observations have not yet occurred (e.g., perhaps the hammer has the power to break less fragile objects), something that covariation-based models do not allow for. These considerations strongly suggest that although people take into account covariation information, other factors are crucial when evaluating cause-and-effect
relationships, and thus models of causal reasoning need mechanisms that explicitly account for these additional factors.

Furthermore, there is research suggesting that the AP index may not be as normative as previously thought, contradicting the assumption that repeated observations are necessary to come to a causal conclusion (Allan & Jenkins, 1980; Spellman, 1996; White, 2002). The AP index requires multiple pieces of information to calculate the causal probability using both confirmatory \( P(e/c) \) and disconfirmatory \( P(e/\neg c) \) evidence to come to a conclusion. However, research indicates that people do not always use both confirmatory and disconfirmatory evidence to come to a conclusion, which also supports the contention that people can make causal judgments after only one observation (Einhorn & Hogarth, 1986; Shustack & Sternberg, 1981; White, 2002). For example, White (2002) has found that when people are exposed to varying amounts of covariation information for a given problem, they tended to focus on confirmatory information only. The confirmatory information is only one piece of the AP index, but people were still able to come to successful causal conclusions. In addition, participants were found to make strong causal conclusions after only one instance of the example event if that event was positive. If the putative confirmatory cause was linked to the given effect on the first observation, people were apt to provide their causal conclusions immediately. Furthermore, research conducted by Allan and Jenkins (1980) found that when complete covariation information was presented, there was no correlation between the use of the covariation information and participants' actual causal judgments. The results from these two studies indicate that AP may not be a normative or necessary index for causal relations, but merely one of many different factors used to assess causation.
Finally, there is also research indicating that pre-existing beliefs are an important factor influencing causal reasoning. In a study conducted by Ahn, Kalish, Medin, and Gelman (1995), participants were given causal problems and asked to indicate what kind of information they would need to make a causal judgment. Given several alternatives, such as covariation information and mechanism-information, participants tended to rely on the mechanism-information to make their judgments. These results indicate that people prefer information consistent with their beliefs or knowledge about causal information rather than information about covariation. The results from this study indicate that covariation-based models fail to incorporate an influential factor, namely pre-existing beliefs, in causal reasoning processing (see also Shultz, 1982).

More recently, concept-based models of causal reasoning have been developed to address the above concerns regarding covariation-based models. Importantly, although these models incorporate mechanisms for factors such as pre-existing beliefs, they do not discount the influence of covariation. An influential concept-based model of causal reasoning is White's (1989) causal powers model. The causal powers model gives priority to the role of pre-existing beliefs in causal reasoning above all other cues to causation. People become knowledgeable about the causal powers of things over their lifetime and automatically incorporate this knowledge into their daily causal judgments. Through interactions with the world, people develop a repertoire of causal beliefs and this information is then available for future causal judgments.

The causal powers model proposes that the incorporation of pre-existing beliefs about causal relationships assists in the fast and (computationally) efficient selection of potential causes for a given effect, thus making the determination of a cause concise and non-arbitrary.
Without the aid of pre-existing beliefs, people would likely be forced to evaluate numerous hypotheses pertaining to the causal relationship before being able to come to a decision (White, 1989, 1995). The recruitment of pre-existing beliefs for current causal judgments occurs quickly, automatically, and outside conscious awareness, therefore reducing the time and effort necessary for this type of mental processing (Fugelsang & Thompson, 2002).

White (1989) suggested that causal candidates are then determined by seeking objects that are believed to possess the power to produce the effect. For example, if a rock, a feather, and a pencil were placed next to a broken dish, which one would most likely be chosen as the cause of the break? By recruiting the appropriate mechanism-information for each potential cause, the candidates can be narrowed down quickly. Without this pre-existing knowledge, each potential cause would have to be evaluated independently.

Evidence supporting the causal powers model has been reported by White (1995). In a series of experiments, participants were given several causal scenarios and asked to judge between possible interpretations. White observed that when given perfect covariates (i.e., the cause and effect co-occurred 100% of the time), participants did not always select the covariation information as important in making their causal judgments. Given the covariation information in the scenarios, covariation-based models would predict that the covariate would be identified as the cause 100% of the time. However, White found that causes were chosen based on the content of the scenario. For example, participants were given a scenario asking them to choose between alternatives of a fear reaction to some dogs but not others (i.e., dogs with a black coat or dogs who are muzzled). Participants were given different alternative causes to choose from as well as complete covariation information for one of the alternatives. Two conditions were present, a high-belief covariation condition and a low-
belief covariation condition. The high-belief condition had a believable alternative as the cause of the fear reaction paired with 100% covariation. The low-belief condition had an unbelievable alternative cause paired with 100% covariation. Often, participants ignored the covariation information and chose the causal alternative that fit best with their pre-existing beliefs about dogs, regardless of which alternative was paired with the covariation information. The results of this study suggest that covariation information alone is not a sufficient or necessary cue to infer causation, as predicted by covariation-based models. In many cases, people override the use of covariation information in favour of mechanism-information (e.g., a muzzled dog is more likely identified as more dangerous than one with a black coat) when making cause-and-effect judgments.

Schustack and Sternberg (1981) provide additional evidence that the use of pre-existing beliefs is an important factor influencing causal reasoning. In a series of experiments, they investigated the importance of different sources of evidence people use to make causal judgments. Participants were given a series of scenarios and asked to judge the strength of the causal relationship on the basis of the evidence given. Using multiple regression analyses, Schustack and Sternberg reported that the most influential pieces of evidence used to make a causal inference included confirmatory information (e.g., the potential cause occurred with the given effect), and believable information (i.e., the given cause was a believable causal candidate to produce the effect). The least important sources of information were disconfirmations of the causal relationship (e.g., the cause was present but not the effect), and the quality of causal alternatives to the given effect (e.g., one cause may be a stronger cause of the effect than another given cause). This research indicates that pre-existing beliefs are an important source of causal information, given that this type of
information accounted for the majority of the variance over and above covariation information. Similar results indicating people's preference for pre-existing beliefs or mechanism-information as a source of causal information have been provided by Ahn, et al. (1995) and Shultz (1982).

To date, the evidence suggests that both covariation information and pre-existing beliefs are important factors that influence causal reasoning. However, the research cited above has focused on either one factor only, or compared the two factors against each other. Recently, Fugelsang and Thompson (2000, 2003) have suggested that people actually combine the evaluation of new covariation information with their pre-existing beliefs about cause-and-effect relationships. This combination of factors means that people evaluate new covariation information in conjunction with their pre-existing beliefs. Fugelsang and Thompson's (2003) two-stage model proposes that causal reasoning consists of two processing stages. The first stage involves the unconscious recruitment of pre-existing beliefs about the cause-and-effect relationship in question. These beliefs can consist of mechanism-information, covariation information, or both. The recruitment of information at this stage is accomplished outside of conscious awareness and therefore people are unaware of how their pre-existing beliefs influence their causal reasoning. This first stage can thus be seen as a heuristic device that quickly and (computationally) efficiently generates plausible causal candidates for a particular effect, while at the same time eliminating implausible causal candidates. The second stage of processing involves the evaluation of new evidence (i.e., new covariation information). Stage two processing is effortful and occurs consciously, utilizing attentional and working memory resources, allowing the reasoner to draw a causal conclusion. Finally, the model proposes that the information activated at stage one will
influence the processing at stage two. For example, the type of information that is automatically recruited at stage one (e.g., mechanism-information or beliefs about covariation) affects how new information is evaluated during stage two processing.

Recall the scenario at the beginning of this thesis as an example of how the two-stage model may work. Regarding the issue of what caused the illness, stage one processing automatically recruits information from a repertoire of pre-existing beliefs, such as the likelihood that oysters, spoiled mayonnaise, or consuming alcohol can make you sick, as well as previous experiences with such foods and drinks. These causal alternatives all entail mechanism-information for which the illness was caused. Second, stage two processing then evaluates new evidence related to the illness, such as did anyone else become ill, and if so, what did they eat? The new evidential information is covariate in nature (e.g., cause and effect both present, or cause present in the absence of the effect). Because the oyster, as the proposed cause of the illness, is highly believable in stage one processing, this is likely the response that stage two processing will work with. In stage two, because the putative cause is a believable candidate, the individual will likely search for covariation evidence that confirms the candidate belief (e.g., did anyone else become ill after eating oysters?). This is just one alternative conclusion, but it provides an example of how stage one processing can affect what happens during stage two processing.

The two-stage model (Fugelsang & Thompson, 2003) offers an elegant account of how covariation information and pre-existing beliefs may jointly influence causal reasoning. The incorporation of pre-existing beliefs into the model is important because it explains how people can infer causation in real time and with seeming ease, something covariation-based models have difficulty adequately addressing. Regarding the example above, several causes
to the sudden illness come quickly to mind. Without pre-existing beliefs about the cause of the illness, the task of generating causes would be extremely difficult and time consuming, because unnecessary and arbitrary causes would likely be generated. The two-stage model also provides an explanation for the influence of covariation as a variable, something conceptual models fail to adequately address. The two-stage model incorporates the influence of covariation information in two ways. First, the model, during stage one, processes covariation information from previous observations. Second, the model, during stage two, may process new covariation information relevant to the causal judgment.

Fugelsang and Thompson (2003) provided compelling empirical evidence for the two-stage model's account of causal reasoning that is consistent with what is outlined in the paragraph above. In their study, participants were provided with causal judgments that included both pre-existing belief information and covariation information that was manipulated orthogonally. Some scenarios began by making the putative cause a believable causal candidate of the effect, whereas in other scenarios the putative cause was an unbelievable candidate, thereby manipulating people's pre-existing beliefs about causal relationships. In addition, the scenarios provided participants with new covariation information that either supported or contradicted the belief statement. For example, one of the scenarios included the statement, "You have a hypothesis that flowers blooming may be due to being planted in red pots" (p. 814). Following this statement, participants were given hypothetical survey data that either supported or contradicted the statement. Fugelsang and Thompson (2003) reported a significant interaction between pre-existing belief and covariation information, indicating that the belief-bias effect was present. That is, if the belief statement was believable, the effect of the covariation information was larger than if the
belief statement was unbelievable. This result supports the model's assumption that stage one processing affects stage two processing. These results suggest that the two-stage model may be better at explaining how multiple forms of information interact during causal reasoning than either covariation-based models or conceptual-based models. One the one hand, covariation-based models do not include a mechanism for the influence of pre-existing beliefs, whereas, on the other hand, concept-based models do not include a mechanism for the influence of new covariation information. In conclusion, because covariation-based and concept-based models cannot account for an interaction between pre-existing beliefs and new covariation information; these models would not be able to account for the belief-bias effect in causal reasoning. Because the two-stage model is the only model that can adequately address the interaction of pre-existing beliefs and covariation information it provides the theoretical basis for the research presented in this thesis.

Causal Reasoning and the Belief-Bias Effect

The belief-bias effect occurs when people make errors in causal judgments directly related to the automatic recruitment and utilization of their pre-existing beliefs. As noted, the belief-bias effect occurs when new information that contradicts one's pre-existing beliefs is discounted and when new evidence is sought to confirm one's pre-existing beliefs (Feeney, 2007; Fugelsang & Thompson, 2000, 2003). People utilize their pre-existing beliefs as a source of knowledge and incorporate this information into their everyday lives. However, pre-existing beliefs are often incorrect, leading to the use of false information to make decisions. People reason with pre-existing beliefs and the problem with incorrect beliefs is that they lead to incorrect causal inferences (Evans & Curtis-Holmes, 2005; Klauer, Munsch, & Naumer, 2000). For example, if an individual believes that the flu shot will give them the
flu, then they will discount evidence that suggests it will not and be more likely to recall previous instances of someone they know getting the flu after receiving the flu shot. This effect is important to consider because of the great influence pre-existing beliefs have on reasoning processes. Because pre-existing beliefs are utilized automatically, people are not aware of how much their knowledge or pre-existing beliefs influence their decision making (e.g. Evans & Curtis-Holmes, 2005; White, 1995).

The belief-bias effect has been a well documented effect in the reasoning literature for decades (Evans, 2008). However, the theoretical inclusion of beliefs in causal reasoning is relatively recent (e.g., Fugelsang & Thompson, 2003; White, 1995), because traditionally the incorporation of beliefs in reasoning processing was deemed irrational (Evans, Brooks, & Pollard, 1985). Despite this view, research has shown that the incorporation of pre-existing beliefs in causal reasoning is indeed rational (see Evans, 2002). Without incorporating knowledge of the world in decision making processes, people may evaluate numerous potential hypotheses pertaining to the causal relationship before coming to a conclusion (Fugelsang & Thompson, 2002; White, 1989). The incorporation of past knowledge allows people to constrain the number of possible hypotheses under evaluation and thus make decisions in real time.

The influence of pre-existing beliefs becomes problematic under conditions in which pre-existing beliefs are incorrect representations of reality (e.g., the flu shot causes the flu). Fugelsang and Thompson's (2003) two-stage model provides a plausible account of how this could occur. According to the two-stage model, pre-existing beliefs are automatically recruited during stage one processing, and these beliefs then influence stage two processing. Because people are biased to place heavy emphasis on their pre-existing beliefs, any such
beliefs that are incorrect may lead an individual to disregard new, relevant information, and to seek out information consistent with the incorrect beliefs. Thus, for example, if an individual does not believe that a potential cause has the ability to produce a particular effect, then the evaluation of new relevant information will be ignored. Alternatively, if an individual believes that the potential cause has the ability to produce the effect, they will search for evidence that supports, or is consistent with, this belief (Fugelsang & Thompson, 2000; Klauer et al., 2000).

It should be noted that the two-stage model predicts that invalid causal reasoning will occur only under conditions in which the beliefs recruited during stage one processing are false. If the beliefs recruited during stage one processing are true, then the two-stage model predicts that valid causal reasoning will occur. This inclusion of beliefs is the model's explanation of why people may correctly infer cause-and-effect relationships, and that under many conditions (i.e., when people hold correct knowledge of the world), the incorporation of pre-existing beliefs is indeed adaptive or beneficial. The belief-bias effect exemplifies how important pre-existing beliefs are to causal reasoning processes, therefore making it important to systematically study the belief-bias effect.

White (1989) and Fugelsang and Thompson (2003) have demonstrated that pre-existing beliefs influence causal reasoning processes, and that their inclusion allows people to make decisions quickly and (computationally) efficiently. However, the belief-bias effect, under conditions in which false beliefs are used to make decisions on the relevance of new information or in which information that is consistent with the false belief is sought after, exemplifies how the inclusion of pre-existing beliefs can become problematic. An important question examined in this thesis, therefore, is whether the magnitude of the belief-bias effect
can be altered through the manipulation of the content of cause-and-effect problems. In other areas of reasoning, it has been shown that the content of a problem can influence reasoning processes. For example, Evans (2006) found that accuracy in syllogistic reasoning differed between problems with abstract content as compared to problems with concrete content. Thus, the purpose of this thesis is to examine whether the magnitude of the belief-bias effect can be altered by manipulating the content of cause-and-effect problems.

A recent study by Burnett, Fugelsang, Owen, and Siakaluk (2007) found initial support for the idea that the content of cause-and-effect problems can influence the belief-bias effect. This study used the same belief-bias paradigm as developed by Fugelsang and Thompson (2003), whereby participants were given a series of scenarios beginning with a belief statement that was either believable or unbelievable, followed by supporting or contradicting covariation information. Half of the scenarios contained specific content (e.g., specific health problems such as diabetes) in the belief statement and the remaining scenarios contained general content (e.g., general or overall health problems) in the belief statement. Participants were then asked to rate the likelihood that the putative cause produced the effect based on all of the information presented in the scenario. The following examples are of a specific, unbelievable scenario with contradicting survey data, and then of a general, believable scenario with supporting data:

Imagine you are trying to determine the cause of diabetes in males. You have a hypothesis that males' diabetes is caused by male pattern baldness. To test this theory you survey 10 men who have diabetes and 10 men who do not have diabetes. You find that 1 of the 10 men who have diabetes also has male pattern baldness; 9 of the 10 men who do not have diabetes do not have male pattern baldness. Given the above information, how likely do you think it is that males' diabetes is caused by male pattern baldness?
Imagine that you are trying to determine the cause of improved health. You have a hypothesis that cutting back on the amount of cigarettes smoked per day will improve health. To test this theory you survey 10 smokers who have recently cut back from smoking one pack of cigarettes per day to half a pack of cigarettes per day, and 10 smokers who continue to smoke one pack of cigarettes per day. You find that 9 of the 10 smokers who cut back on the amount of cigarettes smoked per day have improved health, and 1 of the 10 smokers who continued to smoke one pack per day have improved health. Given the above information, how likely do you think it is that cutting back on the amount of cigarettes smoked per day will improve health?

There were two important findings in this study. First, a significant belief-bias effect was present. This effect means that the covariation data was weighed more heavily for the believable than for the unbelievable statements. Second, new evidence was more likely to be evaluated objectively when the content of the scenario was specific than when it was general. This result suggests that there was a reduction of the belief-bias effect for scenarios containing specific content. It was proposed that by making the content of the problem more specific the number of available possible causes of the effect was reduced. In terms of the two-stage model, Burnett et al. (2007) proposed that, the content of the scenarios influenced the automatic recruitment of pre-existing beliefs during stage one processing by restricting the amount of possible causes available in the specific content condition. This in turn affected stage two processing, the stage at which the evaluation of new evidence occurs. Therefore, the results of this study showed that when the information was specific (e.g., diabetes) rather than general (e.g., poor health), the influence of pre-existing beliefs was attenuated, thereby reducing the belief-bias effect. In summary, the Burnett et al. study demonstrated that the mechanism by which pre-existing beliefs are recruited can be influenced by the type of content presented in the cause-and-effect problem.
The purpose of this research was to replicate and extend the Burnett et al. (2007) findings. More specifically, this thesis will further examine whether two new variables can alter the magnitude of the belief-bias effect in causal reasoning through the manipulation of content. This manipulation will be done using the same belief-bias paradigm that was developed by Fugelsang and Thompson (2003) (and used by Burnett et al., 2007), whereby participants were given causal problem scenarios beginning with a belief-statement, which was either believable or unbelievable, followed by hypothetical covariation data that either supported or contradicted the statement. Participants then made causal ratings as to the relationship between the putative cause and the given effect based on all the information in the scenario. The content of the problem scenarios was manipulated through the following novel variables: health type and positivity.

The first measure, health type, was selected as an attempt to replicate the findings of Burnett et al. (2007) that more specific content, as compared to general content, can lead to an attenuation of the belief-bias effect. The measure consisted of two content conditions: physical health and mental health. These two conditions were chosen because it was originally assumed that physical health content would be more specific than mental health content. That is, it was assumed that the physical health scenarios would elicit fewer hypothetical causes of an effect than the mental health scenarios (but see below). For example, fewer possible causes may be generated for ulcers (e.g., stress, alcohol) than for anxiety (e.g., chemical imbalance, heredity, drinking too much coffee, public speaking). Thus, it was originally hypothesized that the belief-bias effect should be smaller for the physical health scenarios than for the mental health scenarios.
The second measure, *positivity*, also consisted of two content conditions: positive and negative. This variable was chosen based on evidence from social psychology that there is a *positivity bias* in human cognition in that people have an implicit need to seek out positive information about the self and their surroundings, while placing less importance on negative information (Heine, Lehman, Markus, & Kitayama, 1999; Mezulis, Abramson, Hyde, & Hankin, 2004). For example, Schustack and Sternberg (1981) reported that people showed a bias toward positive information when testing causal inferences. When investigating causal sources for complex and uncertain information, they found that during reasoning, people were more confirmatory with positive information than with negative information. Thus, individuals showed a bias toward positively framed evidence as a source for the problem under evaluation rather than negatively framed evidence. Schustack and Sternberg attributed this finding to a "bias against negativity" (p. 117), because it seems that people, in general, have a tendency to undervalue information negatively framed in both form and meaning. Fitting with the belief-bias effect, and individual tendencies to search for evidence that confirms their pre-existing beliefs, it seems reasonable to assume that people should be more likely to have a larger belief-bias effect for positive than negative content. It is hypothesized that the belief-bias effect will be reduced for causal scenarios with negative content than it will be for causal scenarios with positive content, because negative scenarios will elicit fewer hypothetical causes of the effect and therefore reduce the likelihood that the presented covariation evidence will be discounted.

In summary, problem content will be manipulated in two independent ways. First, there will be a manipulation of *health type*, whereby some cause-and-effect scenarios will depict putative causes for physical health effects and others will depict putative causes for
mental health effects. Second, there will be a manipulation of *positivity*, whereby different cause-and-effect scenarios will depict putative causes for positive effects and others will depict putative causes for negative effects. Scenarios were selected to be believable or unbelievable based on believability pilot ratings. The hypothetical empirical evidence following the belief statements was presented in terms of covariation data consistent with the procedure used by Cheng (1997). That is, the empirical evidence included information about the probability of the effect occurring in the presence of the cause [P(e/c)] and the probability of the effect occurring in the absence of the cause [P(e/~c)]. These two pieces of information gave participants the ability to calculate AP. The presentation of the empirical evidence in this way allowed it to be either consistent or inconsistent with the belief statement. The experiment proper reported in this thesis had two content manipulations. First, there was a health type manipulation. This part of the experiment had a 2 (Health Type Content: mental health, physical health) x 2 (Believability: believable, unbelievable) x 2 (Covariation: consistent, inconsistent) repeated-measures design. Second, there was a positivity manipulation. This part of the experiment had a 2 (Positivity Content: positive, negative) x 2 (Believability: believable, unbelievable) x 2 (Covariation: consistent, inconsistent) repeated-measures design.

There are several hypotheses that are of primary importance for this thesis. First, it is hypothesized that the belief-bias effect should be present for both content manipulations. The belief-bias effect is represented through a two-way interaction between believability and covariation. Second, it is hypothesized that the belief-bias effect should be reduced for the physical health and negativity conditions compared to the mental health and positivity conditions, respectively. This hypothesis would be consistent with the findings from Burnett
et al. (2007) and is predicted by the two-stage model of causal reasoning (Fugelsang & Thompson, 2003), because the recruitment of pre-existing beliefs in stage one processing can influence stage two processing. Other important hypotheses include a main effect of believability and a main effect of covariation, whereby scenarios with believable statements or supporting covariation evidence will be rated as more causally relevant than scenarios with unbelievable statements or contradicting covariation evidence. These hypothesized main effects are consistent with the findings from both Fugelsang and Thompson and Burnett et al., and serve as important manipulation checks to ensure that these variables were influencing responding.

Pilot Study 1: Collection of Stimulus Norms for the Health Type Measure

Participants

Sixty undergraduate students from the University of Northern British Columbia (UNBC) participated in the pilot study. All participants gave informed consent and received bonus course credit for their participation. These participants did not participate in any of the other pilot studies or the Experiment.

Materials

Participants completed a questionnaire consisting of 22 cause-and-effect statements. The statements were divided into two categories: physical health topics (e.g., ulcers), and mental health topics (e.g., anxiety). The statements were generated from common physical and mental health myths that were found through an Internet search of relevant health websites. Common health myths were used because they should elicit strong beliefs and include general health topics for which most people should have some knowledge.
For the believability condition, the physical and mental health statements were randomly assigned to believable or unbelievable categories. Half of the statements were framed as believable (e.g., lung cancer is caused by smoking) and the other half of the statements were framed as unbelievable (e.g., ulcers are caused by feeling relaxed). The final set of statements selected for the health type content manipulation of the Experiment consisted of four conditions: physical believable, physical unbelievable, mental believable and mental unbelievable.

Each statement used the following structure: "Imagine you are trying to determine the cause of (effect). You have a hypothesis that (effect) may be due to (causal candidate)." This structure is consistent with other studies in causal reasoning (Fugelsang, Thompson, & Dunbar, 2006; Fugelsang & Thompson, 2003). Participants were then asked to rate how believable each statement was on a 7-point Likert scale, with a rating of 1 indicating that the statement was highly unbelievable and a rating of 7 indicating that the statement was highly believable.

Procedure

Participants were tested in groups of 2-3 people. Each group was given the following instructions:

You will be asked to rate the degree to which you think the two variables are causally linked (i.e., the degree to which you believe that the first variable has the potential to cause the second to occur). To do this, you will be asked to assign to each scenario a value from the scale provided, where 1 means that the given cause is not a believable cause of the given effect, and 7 means that the given cause is a highly believable cause of the given effect. The more believable the causal relationship, the higher the value you should assign to that scenario. Please do not go back and change your answers.
The participants worked independently and at their own pace. The questionnaire took, on average, 20 minutes to complete. A complete list of the items is included in Appendix 1.

Results and Discussion

Two statements from each condition were chosen to be used in the Experiment. Statements were chosen based on high means and low standard deviations for the believable categories, and low means and low standard deviations for the unbelievable categories. The means and standard deviations of the selected statements for each condition are shown in Table 1. The difference between the physical believable and physical unbelievable conditions and the difference between the mental believable and mental unbelievable conditions (3.05 and 2.98, respectively) was not significant, \( t < 1 \). Thus, the two physical conditions and the two mental conditions were matched in terms of believability. For each condition, the statements chosen for the Experiment are indicated with an asterisk in Appendix 1.

Pilot Study 2: Collection of Stimulus Norms for the Positivity Measure

Participants

Thirty undergraduate students from UNBC participated in the pilot study. All participants gave informed consent and received bonus course credit for their completion of the questionnaire. These participants did not participate in any of the other pilot studies or the Experiment.

Materials and Procedure

Positivity Ratings. Participants were presented with a questionnaire that consisted of 27 topics. The topics presented were the effects from the above cause-and-effect statements. The topics chosen included every day cause-and-effect relationships (e.g., pollution causes global warming) that included concepts that were either negative (e.g., global warming) or
positive (e.g., environmental health). The participants were asked to rate each concept's positivity on a 7-point Likert scale, with a rating of 1 indicating 'negative' and a rating of 7 indicating 'positive'. The positivity questionnaire is presented in Appendix 2.

Believability Ratings. The same group of participants was presented with a second questionnaire that listed all 27 cause-and-effect statements included in the positivity questionnaire. Participants were asked to rate how believable each statement was on a 7-point Likert scale with a rating of 1 indicating that the statement was highly unbelievable and a rating of 7 indicating that the statement was highly believable.

The positivity variable was crossed with the believability variable such that the negative and positive statements were randomly assigned to be framed as either believable or unbelievable. Thus, a total of four categories were created: positive believable, positive unbelievable, negative believable, and negative unbelievable. An example of a positive believable statement included 'environmental health may be due to recycling,' and an example of a negative believable statement included 'global warming may be due to pollution.' A complete list of the items is presented in Appendix 3. Each statement used the same word structure as in Pilot Study 1. The believability questionnaire was always administered before the positivity questionnaire, so that the positivity ratings would not influence the believability ratings. The procedure and instructions were the same as in Pilot Study 1. However, the two questionnaires took, on average, an additional 10 minutes to complete.

Results and Discussion

Two statements from each condition were chosen in the following manner. Positive believable statements were chosen based on high means and low standard deviations for each
measure. Negative believable statements were chosen based on low means and low standard deviations for the positivity measure and high means and low standard deviations for the believability measure. Positive unbelievable statements were chosen based on high means and low standard deviations for the positivity measure and low means and low standard deviations for the believability measure. Finally, negative unbelievable statements were chosen based on low means and low standard deviations for each measure. The means and standard deviations for each of the four conditions are shown in Table 2.

The positive and negative statements were matched such that there was no difference in positivity ratings between conditions. The negativity ratings for the believable and unbelievable conditions had means of 1.93 and 2.02, respectively, which were not significantly different, $t(29) = 1.10$, $SEM = 0.076$, $p = 0.28$. The positivity ratings for both the believable and unbelievable conditions had means of 6.18 and 6.10, respectively, which were not significantly different, $t < 1$. The statements were also matched so that there was no difference in the believability ratings between conditions. The believability ratings for the positive and negative believable conditions were 5.97 and 6.03, respectively, which were not significantly different, $t < 1$. Finally, the believability ratings for the positive and negative unbelievable conditions were 1.83 and 1.88, respectively, which were not significantly different, $t < 1$. The statements chosen for positivity content manipulation of the Experiment are indicated with an asterisk in Appendix 3.

Pilot Study 3: Generation of Causal Hypotheses for the Health Type and Positivity Measures

The purpose of the third pilot study was to directly examine the hypothesis that the content manipulations outlined above can restrict the number of hypothetical causes recruited during stage one of causal reasoning processing. More specifically, this pilot study examined
whether people were sensitive to the different types of content manipulated by the health type and positivity measures. It was hypothesized that physical health content would yield fewer hypothetical causes to a given effect compared to the mental health content. It was assumed that this outcome would occur due to the fact that physical health ailments are generally more concrete than mental health ailments. In other words, mental health ailments may have a wider variety of possible causes than physical health ailments. For example, anxiety may be caused by public speaking, drinking too much coffee, a chemical imbalance, depression, et cetera; whereas, an ulcer may be caused by stress, or a bacteria in the lining of the stomach. In addition, it was hypothesized that negative content would yield fewer hypothetical causes to a given effect compared to the positive content. This hypothesis was based on results from social psychological research suggesting that people have a bias toward positive content. For example, Heine et al. (1999) have demonstrated that people have a general tendency to be more likely to respond to positive content than negative content. In other words, people may be able to generate more possible causal alternatives to positive content than negative content due to their bias against negativity. To test these hypotheses, participants were asked to generate multiple alternative causal hypotheses for each statement chosen from the results of Pilot Studies 1 and 2.

Participants

Thirty-two undergraduate students from UNBC participated in the pilot study. All participants gave informed consent and received bonus course credit for their participation. These participants did not participate in any of the other pilot studies or the Experiment.

Materials and Procedure
Participants were presented with the list of 16 cause-and-effect statements. For each statement participants were asked to list as many alternative causes as they could for the effect listed in each statement. For example, if given the following statement "Imagine you are trying to determine the cause of anxiety. You have a hypothesis that anxiety may be due to public speaking.", participants used the effect of 'anxiety' to try and list as many alternative causes to the example cause provided in the statement. Participants were given two minutes to complete each statement and the statements were counterbalanced for presentation order. An example questionnaire is presented in Appendix 4.

Participants were given the questionnaire in booklet format. Each participant was also given a complete example at the beginning of the questionnaire, and was permitted to ask questions before they began. Participants were given the following instructions:

For each of the following statements, try to come up with as many alternative causes for the effect as you can. You will have two minutes for each statement to try to write down as many as you can. The researcher will let you know when to go on to the next statement.

Participants were instructed to let the researcher know when they were ready to begin and the researcher timed the two minute intervals for each statement. Participants were tested on an individual basis. The complete questionnaire took approximately 45 minutes to complete.

Results and Discussion

For each statement, the total number of causes generated was calculated. Means and standard deviations were calculated for each condition (i.e., physical health vs. mental health, and positive vs. negative), and were collapsed across the believability condition. The mean number of causes generated for the physical health and mental health conditions were 4.64 (SD = 1.42) and 4.09 (SD = 1.64), respectively. A paired samples Mest indicated that
significantly more causes for the physical health condition were generated than for the mental health condition, \( t(31) = 2.74, SEM = .20, p < .05 \). The mean number of causes generated for the positive and negative conditions were 4.67 (SD = 1.57) and 3.83 (SD = 1.35), respectively. A paired samples \( t \)-test indicated that significantly more causes for the positive condition were generated than for the negative condition, \( t(31) = 5.03, SEM = .17, p < .001 \).

The original hypothesis that participants would generate fewer causal hypotheses for the physical health condition than for the mental health condition was not supported. In actuality, participants generated significantly more causal hypotheses for the physical health condition than for the mental health condition. Even though the original hypothesis was not supported, the results still suggest that participants were sensitive to this manipulation of content. Because the results suggest that the restriction of pre-existing beliefs in stage one processing is occurring in the mental health condition rather than in the physical health condition, the hypothesis for the health type content manipulation of the Experiment was altered, such that the belief-bias effect should be attenuated for the mental health condition compared to the physical health condition.

The results from Pilot study 3 provided support for the hypothesis that participants would generate fewer causal hypotheses for the negative content condition compared to the positive content condition, and therefore that the belief-bias effect should be attenuated for statements depicting negative content compared to statements depicting positive content. Overall, the results from this pilot study indicated that people were sensitive to different manipulations of content in causal reasoning, and that the recruitment of pre-existing beliefs
during stage one processing can be restricted in the physical health and negative content conditions.

Experiment

The purpose of this experiment was to attempt to replicate and extend the results reported by Burnett et al. (2007), which demonstrated that the magnitude of the belief-bias effect may be manipulated through the presentation of different types of content. The Burnett et al. results suggested that the belief-bias effect may be attenuated under conditions in which the content presented in the causal problem was specific. Under the conditions in which the content of the problem was more specific, it was suggested that fewer pre-existing beliefs were recruited during stage one processing of the two-stage model of causal reasoning (Fugelsang & Thompson, 2003). Because fewer pre-existing beliefs were recruited and therefore examined, a reduction in the belief-bias effect occurred. To further examine the use of content on the belief-bias effect and to extend the results of the Burnett et al. study, the current experiment applied two new content variables to the belief-bias paradigm in order to measure the effects of content manipulations on the magnitude of the belief-bias effect. Because the Burnett et al. variable, specificity, consisted of both specific and general health topics across the two conditions, specific and general, the first manipulation of the current experiment used a related but novel variable, health type. The health type variable divided the cause-and-effect problems into physical health and mental health conditions. Because the specificity variable used in the Burnett et al. study included all types of health content, the novel variable, health type, disentangled the problem content into physical health content and mental health content. As the results of Pilot Study 3 indicated, more alternative causes were generated for the physical health statements than for the mental health statements. Therefore,
the hypothesis was that the belief-bias effect should be attenuated in the mental health condition compared to the physical health condition.

The second manipulation of the current experiment consisted of the variable *positivity*. The purpose of this manipulation was to extend the findings of the Burnett et al. (2007) study using a novel variable unrelated to specificity. The *positivity* variable consists of two content conditions: positive and negative. The positivity variable was chosen based on evidence from social psychology that suggests there is a positivity bias in human cognition (Heine et al., 1999; Shustack & Sternberg, 1981), such that people seek out positive information about the self and its surroundings, and place less emphasis on negative information (Mezulis et al., 2004). Related to decision making, people show an inclination to focus on positive content, ignoring negative content when making decisions (Schustack & Sternberg, 1981). The hypothesis for the positivity measure was that people would have a smaller belief-bias effect for cause-and-effect scenarios depicting negative content than for those scenarios depicting positive content. This should occur because fewer pre-existing beliefs should be recruited and examined for negative content during stage one of the two-stage model (Fugelsang & Thompson, 2003).

**Participants**

Fifty-six UNBC undergraduate students and 67 University of Waterloo (UW) undergraduate students participated in the experiment (for a total number of 123 participants). Of the participants, 47 were male and 73 were female, and the mean age was 21.48 years ($SD = 5.52$) All participants provided informed consent and received partial course credit for participating. Course credit was assigned based on the research participant pool guidelines of the relevant university.
Materials

Belief-Bias Measure for Health Type. This measure consisted of eight scenarios in which participants judged the relationship between a potential cause and a potential effect. Each factor of the design was manipulated orthogonally among the three independent variables: believability, covariation, and health type. Each scenario began with a cause-and-effect statement (half depicting physical health scenarios and the other half depicting mental health scenarios) that was either believable or unbelievable. Hypothetical covariation data was also included that either supported or contradicted the belief statement. For each scenario, participants were given enough covariation information to evaluate the strength of the causal relationship according to covariation models (Cheng, 1997). Participants were given two pieces of information in each scenario: the probability of the effect occurring in the presence of the cause \([P(e/c)]\) and the probability of the effect occurring in the absence of the cause \([P(e/\neg c)]\). In this experiment, the supporting data included a 90% probability that the effect occurred in the presence of the cause and a 10% probability that the effect occurred in the absence of the cause. The probabilities were reversed (10% and 90%) in the scenarios where the data contradicted the statement. Participants were then required to rate how likely it was that the cause would produce the effect based on all of the given information.

Belief-Bias Measure for Positivity. This measure also consisted of eight scenarios that were developed in an identical fashion as the belief-bias measure for health type. However, the measure was altered so that the causal scenarios contained content reflective of the positivity variable.

Believability Ratings. Participants were also given the sixteen believability statements and were asked to rate each statement’s believability. These statements were identical to
those in the belief-bias measure but without the additional covariation information. The results from this portion of the questionnaire were then compared to those obtained from Pilot Studies 1 and 2.

Procedure

The participants were tested in groups of 3-5 people, and informed consent was obtained before continuing with the questionnaire. Two booklets were generated, with the type of scenario (physical health/mental health or positive/negative) counterbalanced for presentation order. There were a total of 16 scenarios per booklet, eight from each of the health type and positivity measures. A version of the general questionnaire is presented in Appendix 5.

The researcher went over the instructions with the participants, and the instructions were also provided on the front of the booklets for additional review. The instructions provided were similar to those presented in Pilot Studies 1 and 2; however, participants were also instructed to consider the covariation evidence in conjunction with the statements before making their ratings. After the participants completed the general experiment questionnaire, they were given the believability ratings questionnaire. The believability ratings questionnaire is provided in Appendix 6. The believability ratings questionnaire instructions were identical to those used in Pilot Studies 1 and 2. The believability ratings were always presented after the belief-bias questionnaire so that the participant's believability ratings would not prime their responses to the belief-bias scenarios. Once both questionnaire booklets were completed, participants were provided with a debriefing sheet and were told the purpose of the experiment. The entire experiment took approximately 40 minutes to complete.
**Design**

*Health Type Measure.* This portion of the experiment consisted of a 2 (Believability: believable, unbelievable) x 2 (Covariation: support, contradict) x 2 (Health Type: physical health, mental health) repeated-measures design.

*Positivity Measure.* This portion of the experiment consisted of a 2 (Believability: believable, unbelievable) x 2 (Covariation: support, contradict) x 2 (Positivity: positive content, negative content) repeated-measures design.

**Results**

*Health Type Measure.* The means and standard errors are presented in Figure 1. A three-way repeated-measures analysis of variance (ANOVA) revealed a significant main effect of believability, $F(1, 122) = 38.53, MSE = 2.99, p < .001, \eta^2 = .24$, with believable scenarios rated as significantly more likely to occur than unbelievable scenarios. A significant main effect was also observed for covariation, $F(1, 122) = 358.83, MSE = 4.58, p < .001, \eta^2 = .75$, with scenarios with supporting covariation information being rated as significantly more likely than scenarios with contradicting covariation information. The main effect of health type was not significant, $F < 1$, as neither the physical health nor the mental health conditions were rated as more likely to occur. This non-significant effect was expected.

The omnibus ANOVA also revealed a significant interaction between believability and covariation, $F(1, 122) = 47.40, MSE = 2.29, p < .001, \eta^2 = .28$. This interaction indicates that the belief bias effect was present. The belief-bias interaction indicates that the effects of covariation were higher for the believable than for the unbelievable condition. The overall belief-bias score collapsed across the health type conditions was 1.35, which indicates that
the believable scenarios were rated on average 1.35 points higher than the unbelievable scenarios. The significance of the belief-bias interaction also means that the scenarios were successful in inducing belief-bias in the participants in order to test the manipulation of the additional variable of health type. The ANOVA did not reveal a significant interaction between health type and believability, $F < 1$, health type and covariation, $F(1, 122) = 2.68$, $MSE = 1.80, p = .10, r| = .02$, or the three-way interaction between believability, covariation, and health type, $F < 1$. Regarding this last null result, the belief-bias difference scores were 1.31 and 1.35 for the physical health and mental health conditions, respectively.

*Positivity Measure.* The means and standard errors are presented in Figure 2. A three-way repeated-measures ANOVA revealed a significant main effect of believability, $F(1, 122) = 77.06, MSE = 3.18, p < .001, r^2 = .39$, with believable scenarios being rated as significantly more likely to occur than the unbelievable scenarios. There was also a significant main effect of covariation, $F(1, 122) = 387.81, MSE = 4.41, p < .001, r = .76$, with scenarios with supporting covariation information being rated as significantly more likely than scenarios with contradicting covariation information. The main effect of positivity was not significant, $F < 1$, as neither the positive nor the negative scenarios were rated as more likely to occur. This non-significant effect was expected.

The omnibus ANOVA also revealed a significant interaction between believability and covariation, $F(1, 122) = 41.71, MSE = 2.15, p < .001, r| = .26$. This interaction indicates that the belief-bias effect was present. This belief-bias interaction indicates that the effects of covariation were higher for the believable than the unbelievable condition. The overall belief-bias score collapsed across positivity conditions was 1.24, which indicates that the
believable scenarios were rated on average 1.24 points higher than the unbelievable scenarios. The significance of the belief-bias effect interaction also means that the scenarios were successful in inducing the belief-bias in the participants in order to test the manipulation of the additional variable of positivity. The ANOVA revealed a significant interaction between positivity and believability, $F(1, 122) = 13.22, \text{MSE} = 1.32, p < .001, f^2 = .10$. The positive scenarios, both believable and unbelievable were rated as more likely than the negative scenarios, both believable and unbelievable. The interaction between positivity and covariation was not significant, $F(1, 122) = 3.04, \text{MSE} = 1.78, p = .08, f = .02$.

Importantly, the three-way interaction between believability, covariation, and positivity was significant, $F(1, 122) = 4.42, \text{MSE} = 1.29, p < .05, f = .04$. This result indicates that there is a significant difference in the size of the belief-bias effect between the positive and negative conditions. The belief-bias effect difference score for the positive and negative conditions were 1.50 and .90, respectively (see Figure 2).

Believability Ratings

Health Type Measure. Means and standard deviations were calculated for the believability ratings of the eight experimental scenarios in order to provide a comparison between the pilot and experimental groups. Because it was shown in Pilot Study 1 that there was no significant difference between the believability ratings for the believable statements across covariation conditions and between the unbelievable statements across the covariation conditions, the scores were collapsed to create one mean for the believable and one mean for the unbelievable conditions in this analysis. The means (and standard deviations) for the believable condition for the pilot and experimental groups were 5.16 (.86) and 5.37 (.76), respectively. An independent samples t-test revealed that these means were not significantly
different, $t(181) = 1.66$, $SEM = .13$, $p = .10$. The means (and standard deviations) for the unbelievable condition for the pilot and experimental groups were 2.15 (.87) and 2.10 (.93), respectively. An independent samples $Mest$ revealed that these means were not significantly different, $t < 1$. These results indicate that the sample of participants from both the pilot and experimental groups rated believability in a similar fashion.

**Believability Ratings for Positivity Measure.** Means and standard deviations were calculated for the believability ratings of the eight experimental scenarios in order to provide a comparison between the pilot and experimental groups. Because it was shown in Pilot Study 2 that there was no significant difference between the believability ratings for the believable statements across covariation conditions or for the unbelievable statements across covariation conditions, the scores were collapsed to create one mean for the believable statement and unbelievable statement conditions in this case. The means (and standard deviations) for the believable condition for the pilot and experimental groups were 6.00 (.77) and 5.94 (.79), respectively. An independent samples $Mest$ revealed that these means were not significantly different, $t < 1$. The means (and standard deviations) for the unbelievable condition for the pilot and experimental groups were 1.86 (.83) and 2.16 (.89), respectively. An independent samples $Mest$ revealed that these means were not significantly different, $?(151) = 1.71$, $SEM = .18$, $p = .10$. These results indicate that the sample of participants from both the pilot and experimental groups rated believability in a similar fashion.

**General Discussion**

The purpose of this thesis was to examine the influence of manipulations of content on the magnitude of the belief-bias effect. A recent study by Burnett et al. (2007) found initial support for the idea that the content of cause-and-effect problems can influence the
magnitude of the belief-bias effect. They found that when the content was relatively more specific, and hence elicited fewer pre-existing beliefs, the magnitude of the belief-bias effect was attenuated. The current thesis attempted to further examine whether the belief-bias effect can be attenuated, through the reduction of the number of pre-existing beliefs elicited, by using two new variables, health type and positivity, in cause-and-effect scenarios.

Health Type

The first new variable used in this thesis was health type, with the following conditions: physical health content and mental health content. The original hypothesis was that the physical health content statements would generate fewer pre-existing beliefs than the mental health content statements, which should result in an attenuated belief-bias effect for the physical health content condition. However, as the results of Pilot Study 3 revealed, it was in fact the mental health content statements that generated significantly fewer pre-existing beliefs. As a consequence, the original hypothesis was altered, such that the belief-bias effect should be attenuated for the mental health content condition.

There were main effects of believability and covariation. Participants rated believable scenarios as more likely to occur than unbelievable scenarios, and supporting covariation scenarios as more likely to occur than contradicting covariation scenarios. These two results were necessary for the belief-bias interaction to occur, and served as important manipulation checks to ensure that the believability and covariation variables were influencing participants' responses. In addition, the significant two-way interaction between believability and covariation, which represents the belief-bias effect, was observed. The belief-bias effect interaction indicated that pre-existing beliefs did impact reasoning, such that the covariation evidence was taken into account more for the believable cause-and-effect scenarios than for
the unbelievable cause-and-effect scenarios. In other words, the belief-bias interaction suggests that the covariation information was used to a greater extent as support for the reasoner's pre-existing beliefs in the believable scenarios, and therefore supporting the idea that people relied on their pre-existing beliefs to aid them through causal reasoning processing when it made the most sense to do so.

The hypothesis that the belief-bias effect would be attenuated for the mental health content condition but not for the physical health content condition was not supported: there was no difference in the size of the belief-bias effect across the two health type conditions. This finding suggests that although people provided significantly fewer causal candidates for the mental health content condition than for the physical health condition in Pilot Study 3, this did not influence the magnitude of the belief-bias effect. Possible explanations for this finding will be discussed below. In addition, it must be noted that the non-attenuated belief-bias effect was not due to weak manipulations of either believability or covariation. Rather, the explanations below will focus on the health type manipulation itself.

**Positivity**

The second new variable used in this thesis was *positivity*, with the following conditions: positive content and negative content. It was first hypothesized that the negative content statements would generate fewer causal candidates than the positive content statements, and this was supported by the results of Pilot Study 3. As a consequence, it was further hypothesized that the belief-bias effect should be attenuated for the negative content condition.

There were main effects of believability and covariation. Participants rated believable scenarios as more likely to occur than unbelievable scenarios, and supporting covariation
scenarios as more likely to occur than the contradicting covariation scenarios. These two results were necessary for the belief-bias interaction to occur. Again, these effects served as important manipulation checks to ensure that the believability and covariation variables were influencing participants' responses. In addition, the significant two-way interaction between believability and covariation was observed. As noted, the belief-bias effect interaction indicated that pre-existing beliefs did impact reasoning, such that the covariation evidence was taken into account more for the believable cause-and-effect scenarios than for the unbelievable cause-and-effect scenarios.

Unlike the health type variable, there was a significant difference in the size of the belief-bias effect across the two positivity conditions, such that, as hypothesized, the belief-bias effect was attenuated for the negative condition compared to the positive condition. This finding is consistent with the Burnett et al. (2007) results and provides further support for the contention that differences in content can influence causal reasoning processing. What these results mean for the two-stage model of causal reasoning will be discussed further in the next section.

The Two-Stage Model's Ability to Account for the Present Findings

As noted, according to the two-stage model (Fugelsang & Thompson, 2003), causal reasoning involves two distinct stages of processing. The recruitment of pre-existing beliefs relevant to the causal problem occurs during stage one processing. This recruitment is automatic and unconscious. The first stage is necessary in order to make causal problem solving quick and efficient (White, 1989). The conscious evaluation of new evidence relevant to the causal problem occurs during stage two processing. The strength of the two-stage model is that it provides an explicit mechanism for explaining the belief-bias effect. More
specifically, the belief-bias effect occurs because people are biased to place heavy emphasis on their pre-existing beliefs as a source of causal information (Fugelsang & Thompson, 2000; Klauer et al., 2000). If such pre-existing beliefs are incorrect, they may lead individuals to disregard new and relevant information to the causal problem while seeking evidence to confirm their pre-existing beliefs. This bias places heavy emphasis on stage one processing, which negatively impacts stage two processing, such that if an individual does not believe that a cause has the ability to produce the effect, the evaluation of new relevant information during stage two processing may be ignored, leading to a biased conclusion based on those pre-existing beliefs. Although causal problem solving is still quick and efficient in these cases, it is nevertheless biased (i.e., incorrect causal conclusions will be made).

The two-stage model of causal reasoning accounts for the attenuation of the belief-bias effect found for the specificity and positivity variables in the following manner. The process by which the belief-bias effect may be reduced is such that the specific and negative content conditions, compared to the general and positive content conditions, recruit fewer pre-existing causal beliefs during stage one processing. The restriction in the number of pre-existing beliefs recruited reduces the impact of stage one processing on stage two processing, because the new information has to be considered in conjunction with fewer pre-existing beliefs. The reduced impact on stage two reasoning then results in an attenuated belief-bias effect. In other words, by restricting the number of pre-existing beliefs relevant to the causal problem, the bias may be reduced because there are fewer pre-existing beliefs from which to choose and therefore reasoners are less likely to discount new information when reasoning with new information. The model may be able to currently predict the attenuation of the belief-bias for the specificity and positivity variables, however; it cannot currently account for
the difference in results found between the health type variable and the positivity and specificity variables. Possible explanations for these differences will be discussed next.

The results from the specificity and positivity variables suggest that the magnitude of the belief-bias effect may be manipulated through changes in content of the causal problem. However, the results produced from the health type variable were contradictory. There are two possible explanations for the difference in results between the specificity and positivity variables and the health type variable. The first possible explanation for the contradictory results deals with the recruitment of the pre-existing beliefs themselves. In Pilot Study 3 there was a significant difference in the number of pre-existing-beliefs recruited between the two conditions for both the health type and positivity variables. The difference between the attenuation of the belief-bias effect for the positivity variable and the non-attenuation of the effect for the health type variable may be due to the difference between the number of pre-existing beliefs recruited between the positive and negative conditions versus the difference of pre-existing beliefs recruited between the physical health and mental health conditions (the difference was larger in the former manipulation than in the latter). It is possible that the difference between the number of pre-existing beliefs recruited between the two health type conditions was not salient enough to make a difference in the size of the belief-bias effect. To test this hypothesis, an additional repeated measures /-test was conducted to determine if the difference in the recruitment of pre-existing beliefs between the two variables was significant. The analysis revealed that the difference in the recruitment of pre-existing beliefs between the two variables was not significant. The first possible explanation of the contradicting results from the thesis, that is that the difference between the number of pre-existing beliefs recruited between the positive and negative conditions was greater than the
difference of pre-existing beliefs recruited between the physical health and mental health conditions, was not supported.

A second possible explanation for the difference in findings may be due to the use of different variable types. On the one hand, the health type variable was categorical, such that the statements belonged either to the physical health condition or the mental health condition. On the other hand, the positivity variable was continuous, such that the statements could be evaluated on a graded scale, where the ratings ranged from highly negative to highly positive. It should also be noted that the Burnett et al. (2007) specificity variable was also a continuous variable (even though specificity ratings were not collected in the Burnett et al. study, a clear operational definition of degree of specificity was used to distinguish between statements that were specific in content from those that were general in content).

It is proposed that the two independent variables, health type and positivity, were processed differently by the participants and that this can be accounted for by the two-stage model in the following manner. First, it is proposed that the health type variable was in fact processed as two distinct problem domains in the Experiment (i.e., physical health, and, independently, mental health), rather than being treated as one problem domain varying in content along a single dimension (i.e., physical health content on one end and mental health content on the other end of a 'health type' dimension). In other words, it is possible that the health type scenarios in the Experiment were not processed along three sources of variability; namely believability, covariation, and health type. Instead, the physical health scenarios and the mental health scenarios were likely being independently evaluated on only the believability and covariation sources of variability, and, as a result, no attenuation of the belief-bias effect was possible. Second, it is proposed that the positivity variable was
processed in the originally expected manner, that is, as one problem domain varying in content along a single dimension (i.e., negative content on one end and positive content on the other end of a ‘positivity’ dimension). In contrast to the health type variable, the positivity variable was processed along all three sources of variability (in this case believability, covariation, and positivity), such that an attenuation of the belief-bias effect was possible due to the influence of the variability of the positivity variable on the believability and covariation variables (the same general explanation would also account for the Burnett et al., 2007, results using the specificity variable).

In summary, what seems to be a critical factor in whether the belief-bias effect can be attenuated is the nature of the content variable. If the content variable is categorical (as the health type variable was in the scenarios presented in the Experiment), then it seems that people treat the different levels as distinct and separate problem domains, which effectively makes only the believability and covariation variability available for processing. It is recognized that in the real world, mental and physical health may not be so discrete in terms of causal generation. There most likely are bi-directional causes between mental and physical health. It is therefore important to point out that any implications regarding the discrete nature of type of health may be limited to casual problems as they were presented in the Experiment presented in this thesis. In terms of the two-stage model, the pre-existing beliefs that are recruited during stage one processing for, say, the physical health content are only relevant for the further processing of the physical health content scenarios (and vice versa). In other words, there is no content variable variability available during stage two processing, and hence no way for the belief-bias effect to be attenuated. If, however, the content variable is continuous (as the positivity variable was in the scenarios presented in the Experiment),
then it seems that people treat the different levels as variability on a single problem domain. In such cases, there is a third source of variability that is processed in addition to the believability and covariation variability. In terms of the two-stage model, the pre-existing beliefs that are recruited during stage one processing are relevant for the further processing for both levels of the content variable, because the content variable is treated as a single problem domain. In other words, there is much content variable variability available during stage two processing, and hence it is possible for the belief-bias effect to be attenuated.

To test the hypothesis that the current *health type* variable did not provide a relevant source of variability for the attenuation of the belief-bias effect due to its categorical nature, the following is proposed. Each health type would be transformed into a continuous variable by finding scenarios that vary on either the dimension of mental health content or the dimension of physical health content. For example, for the mental health dimension, the continuum would range from "contributing to good mental health" to "inhibiting good mental health" and would include such topics as: substance abuse (inhibiting) or exercising (contributing). The physical health dimension would range from "contributing to good physical health" to "inhibiting good physical health" and would include such topics as: stress (inhibiting) or social support (contributing). The variability along a single dimension (e.g., mental health content) would allow for the necessary variability the two-stage model needs to attenuate the belief-bias effect. If the two types of health content are successfully transformed into continuous variables, it is predicted that the low end of each dimension (e.g., 'inhibiting good mental/physical health' content) would serve to attenuate the belief-bias by restricting the number of pre-existing beliefs recruited during stage one processing. Here it is assumed that the 'inhibiting good mental/physical' content is more specific, and the 'contributing to
good mental/physical health' content is more general, thereby recruited a greater number of pre-existing beliefs. This hypothesis is consistent with the results using the positivity variable of the present thesis and the specificity variable of Burnett et al. (2007). A second proposed experiment would attempt to replicate the findings of this thesis by introducing a novel continuous content variable. If the above hypothesis is true, that the variability in the continuous content variable is important to the attenuation of the belief-bias effect, then the same pattern of results as observed for the positivity and specificity variables should be observed for the new continuous content variable. Again, it is expected that the end of the new content variable dimension that recruits fewer pre-existing beliefs will attenuate the belief-bias effect, an expectation that is consistent with the results using the positivity variable of the present thesis and the specificity variable of Burnett et al. (2007).

A third proposed experiment would test the above hypothesis that continuous variables are necessary to attenuate the belief-bias effect by using a novel categorical content variable. If the two conditions of the categorical content variable are being processed independently of each other, then no attenuation of the belief-bias effect should be observed, as was the case with the health type variable of the present thesis.

How Other Models of Causal Reasoning May or May Not Account for the Present Findings

As mentioned in the introduction, there are two other classes of models that have been proposed to provide an account of causal reasoning processing. First, covariation models, such as Cheng and Novick’s (1990, 1992) probabilistic contrast model, suggest that people have an inherent ability to automatically process statistical causal relationships in the environment. This model explains causal processing through covariation, or the regularity of events co-occurring as causal (i.e., the more often two events co-occur, the more likely it is
they will be perceived as causally related) (Kelly, 1973; Cheng, 1997; Cheng & Novick, 1990, 1992; Wasserman, 1990). This model has had much success in predicting causality based on covariation, and as noted previously the model does not allow for the use of mechanism-information or pre-existing beliefs (White, 1989) as a source of causal information. Because pre-existing beliefs are not incorporated into this model of causal reasoning, this model does poorly in explaining the belief-bias effect and how it may be attenuated, and therefore the results reported in this thesis and in Burnett et al. (2007). If the use of pre-existing beliefs as a source of causal information were included in the model, it would resemble the two-stage model of Fugelsang and Thompson (2003).

The other class of model important to the explanation of causal reasoning processing is the concept-based model. This type of model is exemplified by White's (1989) causal powers model. This model gives preference to pre-existing beliefs as a source of causal information when making cause-and-effect judgments. The incorporation of pre-existing beliefs as a source of causal information can explain the efficiency of causal reasoning, and the ability to make causal judgments after only one observation, something that covariation models cannot do. Pre-existing beliefs allow the appropriate mechanism-information to be recruited and putative causal candidates for the effect narrowed down quickly. However, White's causal powers model focuses on the use of pre-existing beliefs alone as a source of causal information, not allowing for the use of covariation information. Because the model does not incorporate both sources of information, it is not sufficient to explain the belief-bias effect or how it may be attenuated, as reported in this thesis or by Burnett et al. (2007). Again, if this model were to include such a mechanism, it would resemble the two-stage model of Fugelsang and Thompson (2003).
It is evident that both sources of causal information, pre-existing beliefs and covariation, are important to causal reasoning processing. Because of this, covariation models and concept-based models are insufficient to explain causal reasoning processing and the belief-bias effect and the conditions in which it may be attenuated. The two-stage model (Fugelsang & Thompson, 2003) of causal reasoning seems to be adequate to sufficiently explain the incorporation of both pre-existing beliefs and covariation information as sources of causal information. The two-stage model also provides a framework to explain the belief-bias effect and the conditions under which it may be attenuated. However, the results reported in the present thesis (and possibly from the additional experiments proposed above) suggest that the type of variable used to make content manipulations is important in determining whether the belief-bias effect can be attenuated. Thus, the two-stage model, as currently proposed, must accommodate the fact that the attenuation of the belief-bias effect may only be made with content manipulations based on continuous variables.
References


Footnotes

American Psychiatric Association, Canadian Psychiatric Association, American Heart and Stroke Foundation, American Heart Association, Canadian Cancer Society, American Cancer Society, and the National Institute of Mental Health.
### Table 1

*Means and Standard Deviations for the Eight Health Type Cause-and-Effect Scenarios Used in the Experiment*

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Table 2

Means and Standard Deviations for the Eight Positivity Cause-and-Effect Scenarios Used in the Experiment

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Physical Health Type

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• Support
• Contradict

Mental Health Type

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• Support
0 Contradict

Figure 1. Three-way analysis between believability, covariation, and health type
Figure 2. Three-way analysis between believability, covariation, and positivity.
Appendix 1

Complete list of items used for Pilot Study 1, Chosen Items for the Health Type scenarios in the Experiment are indicated with an *

Physical/Believable:

- Imagine you are trying to determine the cause of heart disease in women. You have a hypothesis that heart disease in women may be due to menopause. How believable do you think it is that heart disease in women may be due to menopause?

- (*)Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to abstaining from alcohol. How believable do you think it is that good health may be due to abstaining from alcohol?

- Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to having low blood pressure. How believable do you think it is that good health may be due to having low blood pressure?

- Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to having strong muscles. How believable do you think it is that good health may be due to having strong muscles?

- Imagine you are trying to determine the cause of a heart attack. You have a hypothesis that a heart attack may be due to depression. How believable do you think it is that a heart attack may be due to depression?

- Imagine you are trying to determine the cause of arthritis. You have a hypothesis that arthritis may be due to cracking your knuckles. How believable do you think it is that arthritis may be due to cracking your knuckles?

- Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to herbal remedy use. How believable do you think it is that good health may be due to herbal remedy use?

- (*)Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to vigilant exercising. How believable do you think it is that good health may be due to vigilant exercising?
Physical/Unbelievable:

• (*)Imagine you are trying to determine the cause of high levels of cholesterol. You have a hypothesis that high cholesterol may be due to a decrease in fat intake. How believable do you think it is that high cholesterol may be due to a decrease in fat intake?
• (*)Imagine you are trying to determine the cause of ulcers. You have a hypothesis that ulcers may be due to feeling relaxed. How believable do you think it is that ulcers may be due to feeling relaxed?

• Imagine you are trying to determine the cause of improved health. You have a hypothesis that improved health may be due to switching from light cigarettes to regular cigarettes. How believable do you think it is that improved health may be due to switching from light cigarettes to regular cigarettes?

• Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to increasing the number of cigarettes smoked per day. How believable do you think it is that good health may be due to increasing the number of cigarettes smoked per day?

• Imagine you are trying to determine the cause of diabetes. You have a hypothesis that diabetes may be due to eating broccoli. How believable do you think it is that diabetes may be due to eating broccoli?

Mental/Believable:

• Imagine you are trying to determine the cause of mental illness. You have a hypothesis that mental illness may be due to character flaws. How believable do you think it is that mental illness may be due to character flaws?

• Imagine you are trying to determine the cause of violent behaviour. You have a hypothesis that violent behaviour may be due to a mental illness. How believable do you think it is that violent behaviour may be due to mental illness?

• (*)Imagine you are trying to determine the cause of dementia. You have a hypothesis that dementia may be due to increasing age. How believable do you think it is that dementia may be due to increasing age?

• (*)Imagine you are trying to determine the cause of an increase in positivity in a depressed person. You have a hypothesis that the increase in positivity may be due to taking anti-depressant medication. How believable do you think it is that the increase in positivity may be due to taking anti-depressant medication?

• Imagine you are trying to determine the cause of your teenage sister's mood swings. You have a hypothesis that the mood swings may be due to depression. How believable do you think it is that the mood swings may be due to depression?
Mental/Unbelievable:

- (*)Imagine you are trying to determine the cause of an addiction. You have a hypothesis that addiction may be due to having lots of willpower. How believable do you think it is that addiction may be due to having lots of willpower?

- Imagine you are trying to determine the cause of violence in epileptics. You have a hypothesis that violence in epileptics may be due to watching television. How believable do you think it is that violence in epileptics may be due to watching television?

- Imagine you are trying to determine the cause of an increase in depressive symptoms. You have a hypothesis that an increase in depressive symptoms may be due to talking about the disorder. How believable do you think it is that an increase in depressive symptoms may be due to talking about the disorder?

- (*)Imagine you are trying to determine the cause of intelligence. You have a hypothesis that intelligence may be due to a mental illness. How believable do you think it is that intelligence may be due to a mental illness?
**Pilot 2 Positivity Questionnaire for the collection of Positivity Ratings**

Instructions:

**Note:** Please read and sign the enclosed Consent Form before continuing.

In the following questionnaire you will be asked to make 27 ratings about several statements, specifically, how positive do you think they are.

In the space next to the statement, please rate how **positive** you think the overall concept is. Please assign each statement a rating on the scale provided, where 1 means the concept is negative, and a 7 means the concept is positive. The more positive the concept, the higher the value you should assign to that scenario.

**How positive do you think of the following?**

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<th>POSITIVE</th>
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Blindness ____________________________ Global Warming
Cardiovascular Disease ____________________________ Recovery from illness
Pneumonia ____________________________ Liver Failure
Good Health ____________________________ Good heart health
Male Sterility ____________________________ Pollution
Physical Energy ____________________________ Lung Cancer
Recovery from heart disease ____________________________ Good eye health
Recovery from Cancer ____________________________ Longevity
Weight Loss ____________________________ Kidney Failure
Environmental Health ____________________________ Anorexia
Heart Disease ____________________________ Headaches
Good Lung Health ____________________________ Cancer Progression
Appendix

Complete list of items used for Pilot Study 2. Chosen Items for the Positivity scenarios in the Experiment are indicated with an *

Unbelievable/Negative:

- (*)Imagine you are trying to determine the cause of pneumonia. You have a hypothesis that pneumonia may be due to coughing.

- Imagine you are trying to determine the cause of pollution. You have a hypothesis that pollution may be due to ozone layer depletion

- (*)Imagine you are trying to determine the cause of anorexia. You have a hypothesis that anorexia may be due to nausea

- Imagine you are trying to determine the cause of male sterility. You have a hypothesis that male sterility may be due to wearing condoms.

- Imagine you are trying to determine the cause of cardiovascular disease. You have a hypothesis that cardiovascular disease may be due to heartburn.

- Imagine you are trying to determine the cause of kidney failure. You have a hypothesis that the kidney failure may be due to eating too much sugar.

- Imagine you are trying to determine the cause of liver failure. You have a hypothesis that liver failure may be due to stress.

Unbelievable/Positive:

(*)Imagine you are trying to determine the cause of good lung health. You have a hypothesis that good lung health may be due to inhaling asbestos.

Imagine you are trying to determine the cause of good heart health. You have a hypothesis that a healthy heart may be due to drinking green tea.

Imagine you are trying to determine the cause of good eye health. You have a hypothesis that good eye health may be due to eating carrots.

(*)Imagine you are trying to determine the cause of physical energy. You have a hypothesis that physical energy may be due to allergies

Imagine you are trying to determine the cause of weight loss. You have a hypothesis that weight loss may be due to eating cake.
• Imagine you are trying to determine the cause of longevity. You have a hypothesis that longevity may be due to smoking

Believable/Negative

• (*)Imagine you are trying to determine the cause of pneumonia. You have a hypothesis that pneumonia may be due to a lung infection.

• Imagine you are trying to determine the cause of global warming. You have a hypothesis that global warming may be due to pollution.

• (*)Imagine you are trying to determine the cause of lung cancer. You have a hypothesis that lung cancer may be due to smoking.

• Imagine you are trying to determine the cause of someone's cancer progression. You have a hypothesis that their cancer progression may be due to stress.

• Imagine you are trying to determine the cause of heart disease. You have a hypothesis that heart disease may be due to having diabetes.

• Imagine you are trying to determine the cause of blindness. You have a hypothesis that blindness may be due to having diabetes.

• Imagine you are trying to determine the cause of headaches. You have a hypothesis that headaches may be due to emotional distress.

Believable/Positive

• Imagine you are trying to determine the cause of environmental health. You have a hypothesis that good environmental health may be due to recycling

• (*)Imagine you are trying to determine the cause of good heart health. You have a hypothesis that good heart health may be due to a good diet.

• Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to having a healthy diet.

• Imagine you are trying to determine the cause of someone's recovery from an illness. You have a hypothesis that this person's recovery from an illness may be due to taking penicillin.

• Imagine you are trying to determine the cause of someone's recovery from cancer. You have a hypothesis that their recovery from cancer may be due to chemotherapy treatment
• (*)Imagine you are trying to determine the cause of someone's recovery from heart disease. You have a hypothesis that their recovery from heart disease may be due to having a heart transplant.

• Imagine you are trying to determine the cause of longevity. You have a hypothesis that longevity may be due to abstaining from alcohol.
Appendix 1

The Causal Generation Task used in Pilot Study 3

For each of the following statements, try to come up with as many alternative causes for the effect as you can. You will have two minutes for each statement to try to write down as many as you can. The researcher will let you know when to go on to the next statement. An example is given below:

Example:

Imagine you are trying to determine the cause of anxiety. You have a hypothesis that anxiety may be due to public speaking.

Potential Alternative causes: stress, chemical imbalance, drinking too much coffee, etc.

Please let the researcher know when you are ready to begin.

Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to abstaining from alcohol.

Imagine you are trying to determine the cause of pneumonia. You have a hypothesis that pneumonia may be due to coughing.

Imagine you are trying to determine the cause of ulcers. You have a hypothesis that ulcers may be due to feeling relaxed.

Imagine you are trying to determine the cause of dementia. You have a hypothesis that dementia may be due to increasing age.
Imagine you are trying to determine the cause of physical energy. You have a hypothesis that physical energy may be due to having allergies.

(_PosUB)

Imagine you are trying to determine the cause of lung cancer. You have a hypothesis that lung cancer may be due to smoking.

(_NegB)

Imagine you are trying to determine the cause of good heart health. You have a hypothesis that good heart health may be due to eating a good diet.

(_PosB)

Imagine you are trying to determine the cause of high levels of cholesterol. You have a hypothesis that high levels of cholesterol may be due to decrease in fat intake.

( PUB)

Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to vigilant exercising.

( PB)

Imagine you are trying to determine the cause of someone's recovery from heart disease. You have a hypothesis that their recovery may be due to having a heart transplant

(PosB)

Imagine you are trying to determine the cause of pneumonia. You have a hypothesis that pneumonia may be due to having a lung infection.

(_NegB)
Imagine you are trying to determine the cause of good lung health. You have a hypothesis that good lung health may be due to inhaling asbestos.
(PosUB)

Imagine you are trying to determine the cause of anorexia. You have a hypothesis that anorexia may be due to nausea.
(NegUB)

Imagine you are trying to determine the cause of an addiction. You have a hypothesis that addiction is caused by having lots of willpower.
(MUB)

Imagine you are trying to determine the cause of intelligence. You have a hypothesis that intelligence may be due to a mental illness.
(MUB)

Imagine you are trying to determine the cause of an increase in positivity in a depressed person. You have a hypothesis that the increase in positivity may be due to taking antidepressant medication.
(MB)
Appendix 1

Belief-Bias Questionnaire used in the Experiment

Instructions

Please complete the following information before we begin.

Subject #:.
Gender:.
Age:.
Year of studies:.

Note: Please read and sign the enclosed Consent Form before continuing.

In the following experiment you will be asked to make 16 judgments about the relationship between two variables, a potential cause and a potential effect.

You will be asked to rate the degree to which you think the two variables are causally linked (i.e., the degree to which you believe that the first variable has the potential to cause the second to occur). To do this, you will be asked to assign to each scenario a value from the scale provided, where 1 means that the given cause is not a likely cause of the given effect, and 7 means that the given cause is a highly likely cause of the given effect. The more you think the provided cause produced the stated effect, the higher the value you should assign to that scenario. An example scenario is given below:

Imagine you are an economist who is trying to determine the cause of a thriving economy. You have a hypothesis that the thriving economy may be due to low taxes. In order to test this theory, you survey 10 countries with thriving economies, and 10 countries that do not have thriving economies. A thorough investigation revealed the following information: of the 10 countries with thriving economies, 9 had lower taxes; of the 10 countries that do not have thriving economies, 1 had lower taxes.

Given the above information, how likely do you think it is that lower taxes caused the thriving economies?

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For the following 16 scenarios, please rate how likely you think the provided cause produced the stated effect. Please provide these ratings in the order that the scenarios are presented. Do not go back and change any of your answers.
Imagine you are trying to determine the cause of dementia. You have a hypothesis that dementia may be due to increasing age. To test this theory, you gather statistics for 10 people who had dementia and 10 people who did not have dementia. Your investigation revealed that 9 of the 10 people who had dementia were elderly; 1 of the 10 people who did not have dementia was elderly.

Given the above information, how likely do you think it is that dementia may be due to increasing age?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely

Imagine you are trying to determine the cause of good lung health. You have a hypothesis that good lung health may be due to inhaling asbestos. To test this theory you survey 10 people who have good lung health and 10 people who do not have good lung health. Your investigation reveals that 1 out of the 10 people who have good lung health have inhaled asbestos; 9 out of the 10 people who do not have good lung health have inhaled asbestos.

Given the above information, how likely do you think it is that good lung health may be due to inhaling asbestos?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely

Imagine you are trying to determine the cause of intelligence. You have a hypothesis that high intelligence scores may be due to a mental illness. To test this theory, you survey 10 people with high intelligence scores and 10 people with low intelligence scores. Your investigation revealed that 1 of the 10 people with high intelligence scores had a mental illness; 9 of the 10 people who had low intelligence scores had a mental illness.

Given the above information, how likely do you think it is that intelligence may be due to a mental illness?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely
Imagine you are trying to determine the cause of someone's recovery from heart disease. You have a hypothesis that their recovery from heart disease may be due to having a heart transplant. To test this theory you survey 10 people who have recovered from heart disease and 10 people who have not recovered from heart disease. Your investigation reveals that 9 out of 10 people who have recovered from heart disease have had a heart transplant; 1 out of 10 people who have not recovered from heart disease have had a heart transplant.

Given the above information, how likely do you think it is that recovery from heart disease may be due to having a heart transplant?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely

Imagine you are trying to determine the cause of physical energy. You have a hypothesis that physical energy may be due to having allergies. To test this theory you survey 10 people who have lots of physical energy and 10 people who do not have lots of physical energy. Your investigation reveals that 9 of the 10 people who have lots of physical energy also have allergies; 1 out of the 10 people who do not have lots of physical energy also have allergies.

Given the above information, how likely do you think it is that physical energy may be due to having allergies?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely

Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to abstaining from alcohol. To test this theory, you survey 10 people who are in good health and 10 people who are not in good health. Your investigation reveals that 9 of the 10 people who are in good health abstain from alcohol; 1 of the 10 people who are not in good health abstains from alcohol.

Given the above information, how likely do you think it is that good health may be due to abstaining from alcohol?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely
Imagine you are trying to determine the cause of good heart health. You have a hypothesis that good heart health may be due to eating a good diet. To test this theory you survey 10 people who have good heart health and 10 people who do not have good heart health. Your investigation reveals that 1 out of 10 people who have good heart health also eat a good diet; 9 out of 10 people who do not have good heart health also eat a good diet.

Given the above information, how likely do you think it is that good heart health may be due to eating a good diet?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely

Imagine you are trying to determine the cause of lung cancer. You have a hypothesis that lung cancer may be due to smoking. To test this theory you survey 10 people who have lung cancer and 10 people who do not have lung cancer. Your investigation reveals that 1 out of the 10 people who have lung cancer smoke; 9 out of the 10 people who do not have lung cancer smoke.

Given the above information, how likely do you think it is that lung cancer may be due to smoking?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely

Imagine you are trying to determine the cause of pneumonia. You have a hypothesis that pneumonia may be due to coughing. To test this theory, you survey 10 people who have pneumonia and 10 people who do not have pneumonia. Your investigation reveals that 1 of the 10 people who have pneumonia cough frequently; 9 out of the 10 people who do not have pneumonia cough frequently.

Given the above information, how likely do you think it is that pneumonia may be due to coughing?
Imagine you are trying to determine the cause of pneumonia. You have a hypothesis that pneumonia may be due to having a lung infection. To test this theory you survey 10 people who have pneumonia and 10 people who do not have pneumonia. Your investigation reveals that 9 out of the 10 people who have pneumonia also have a lung infection; 1 out of the 10 people who do not have pneumonia also have a lung infection.

Given the above information, how likely do you think it is that pneumonia may be due to having a lung infection?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely

Imagine you are trying to determine the cause of anorexia. You have a hypothesis that anorexia may be due to having nausea. To test this theory, you survey 10 people who are anorexic and 10 people who are not anorexic. Your investigation reveals that 9 out of the 10 people who are anorexic also have frequent nausea; 1 out of the 10 people who are not anorexic also have frequent nausea.

Given the above information, how likely do you think it is that anorexia may be due to having nausea?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely

Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to vigilant exercising. To test this theory, you survey 10 people who are in good health and 10 people who are not in good health. Your investigation reveals that 1 of the 10 people who are in good health exercise vigilantly; 9 of the 10 people who are not in good health exercise vigilantly.

Given the above information, how likely do you think it is that good health may be due to vigilant exercise?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely
Imagine you are trying to determine the cause of high levels of cholesterol. You have a hypothesis that high cholesterol levels may be due to a decrease in fat intake. To test this theory, you gather statistics for 10 people who have high cholesterol levels and 10 people who have low cholesterol levels. An investigation of the statistics revealed that 9 of the 10 people with high cholesterol levels eat low fat diets; 1 of the 10 people who have low levels of cholesterol levels eat low fat diets.

Given the above information, how likely do you think it is that high cholesterol levels may be due to a decrease in fat intake?

Not likely 2 3 4 Moderately likely 5 6 7 Highly likely

Imagine you are trying to determine the cause of an increase in positivity in a depressed person. You have a hypothesis that the increase in positivity may be due to taking anti-depressant medication. To test this theory, you survey 10 depressed people taking medication, and 10 depressed people not on medication. Your investigation revealed that 1 of the 10 depressed persons taking medication had an increase in positivity; 9 of the 10 depressed persons not on medication had an increase in positivity.

Given the above information, how likely do you think it is that an increase in positivity in a depressed person may be due to taking anti-depressant medication?

Not likely 2 3 4 Moderately likely 5 6 7 Highly likely

Imagine you are trying to determine the cause of an addiction. You have a hypothesis that addiction may be due to having lots of willpower. To test this theory, you investigate 10 people who have an addiction and 10 people who do not have an addiction. Your investigation revealed that 9 of the 10 people who had an addiction had lots of willpower; 1 of the 10 people who did not have an addiction had lots of willpower.

Given the above information, how likely do you think it is that an addiction may be due to having lots of willpower?

Not likely 2 3 4 Moderately likely 5 6 7 Highly likely
Imagine you are trying to determine the cause of ulcers. You have a hypothesis that ulcers may be due to feeling relaxed. To test this theory, you survey 10 people who have ulcers and 10 people who do not have ulcers. Your investigation revealed that 1 of the 10 people who have ulcers feel relaxed most of the time; 9 of the 10 people who do not have ulcers feel relaxed most of the time.

Given the above information, how likely do you think it is that ulcers may be due to feeling relaxed?

1 2 3 4 5 6 7
Not likely Moderately likely Highly likely

**Thank you for your participation**

*Please return the questionnaire booklet and the signed consent form to the research assistant and pick up a copy of the information sheet.*
Appendix 1

Believability Ratings Questionnaire used in the Experiment

Instructions: ***For each of the following statements, please rate how believable you think it is that the cause produced the effect on a scale of 1-7 (1 = highly unbelievable; 7 = highly believable).

Imagine you are trying to determine the cause of pneumonia. You have a hypothesis that pneumonia may be due to coughing.

How believable do you think it is that pneumonia may be due to coughing?

1 2 3 4 5 6 7
Highly UnBelievable Moderately Believable Highly Believable

Imagine you are trying to determine the cause of high levels of cholesterol. You have a hypothesis that high cholesterol levels may be due to a decrease in fat intake.

How believable do you think it is that high levels of cholesterol may be due to a decrease in fat intake?

1 2 3 4 5 6 7
Highly UnBelievable Moderately Believable Highly Believable

Imagine you are trying to determine the cause of someone's recovery from heart disease. You have a hypothesis that their recovery from heart disease may be due to having a heart transplant.

How believable do you think it is that their recovery from heart disease may be due to having a heart transplant?

1 2 3 4 5 6 7
Highly UnBelievable Moderately Believable Highly Believable
Imagine you are trying to determine the cause of dementia. You have a hypothesis that dementia may be due to increasing age.

How **believable** do you think it is that dementia may be due to increasing in age?

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Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to abstaining from alcohol.

How **believable** do you think it is that good health may be due to abstaining from alcohol?

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Imagine you are trying to determine the cause of anorexia. You have a hypothesis that anorexia may be due to nausea.

How **believable** do you think it is that anorexia may be due to nausea?

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Imagine you are trying to determine the cause of ulcers. You have a hypothesis that ulcers may be due to feeling relaxed.

How **believable** do you think it is that ulcers may be due to feeling relaxed?

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Imagine you are trying to determine the cause of physical energy. You have a hypothesis that physical energy may be due to allergies.

How **believable** do you think it is that physical energy may be due to allergies?

1  
Highly UnBelievable

4  
Moderately Believable

7  
Highly Believable

Imagine you are trying to determine the cause of an increase in positivity in a depressed person. You have a hypothesis that the increase in positivity may be due to taking anti-depressant medication.

How **believable** do you think it is that the increase in positivity may be due to taking anti-depressant medication?

1  
Highly UnBelievable

4  
Moderately Believable

7  
Highly Believable

Imagine you are trying to determine the cause of good heart health. You have a hypothesis that good heart health may be due to having a good diet.

How **believable** do you think it is that good heart health may be due to having a good diet?

1  
Highly UnBelievable

4  
Moderately Believable

7  
Highly Believable

Imagine you are trying to determine the cause of an addiction. You have a hypothesis that addiction may be due to having lots of willpower.

How **believable** do you think it is that addiction may be due to having lots of willpower?

1  
Highly UnBelievable

2  3  4  5  6  7  
Moderately Believable

Highly Believable
Imagine you are trying to determine the cause of pneumonia. You have a hypothesis that pneumonia may be due to a lung infection.

How believable do you think it is that pneumonia may be due to a lung infection?

1  2  3  4  5  6  7
Highly Moderately Highly UnBelievable Believable Believable

Imagine you are trying to determine the cause of lung cancer. You have a hypothesis that lung cancer may be due to smoking.

How believable do you think it is that lung cancer may be due to smoking?

1  2  3  4  5  6  7
Highly Moderately Highly UnBelievable Believable Believable

Imagine you are trying to determine the cause of good health. You have a hypothesis that good health may be due to vigilant exercising.

How believable do you think it is that good health may be due to vigilant exercising?

1  2  3  4  5  6  7
Highly Moderately Highly UnBelievable Believable Believable

Imagine you are trying to determine the cause of good lung health. You have a hypothesis that good lung health may be due to inhaling asbestos.

How believable do you think it is that good lung health may be due to inhaling asbestos?

1  2  3  4  5  6  7
Highly Moderately Highly UnBelievable Believable Believable
Imagine you are trying to determine the cause of intelligence. You have a hypothesis that high intelligence scores may be due to a mental illness.

How **believable** do you think it is that intelligence may be due to having a mental illness?

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