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Background. *People who exhibit value-induced bias—distorting relevant probabilities to justify medical decisions—may make suboptimal decisions.* ***Objective.*** *The authors examined whether and in what conditions people exhibit value-induced bias.* ***Design***. *Volunteers on the Web imagined having a serious illness with 2 possible diagnoses and a treatment with the same "small probability" of success for each diagnosis. The more serious diagnosis was designed as a clear-cut decision to motivate most subjects to choose treatment; the less serious diagnosis was designed to make the treatment a close-call choice. Subjects were randomized to estimate the probability of treatment success before or after learning their diagnosis. The "after group" had the motivation and ability to distort the probability of treatment success to justify their treatment preference. In study 1, subjects learned they had the more serious disease. Consistent with value-induced bias, the after group was expected to give higher probability judgments than the "before group." In study 2, subjects learned they had the less serious disease, and the after group was expected to inflate the probability if they desired treatment and to reduce it if they did not, relative to the before group.* ***Results***. *In study 1, there was no difference in the mean probability judgment between groups, suggesting no distortion of probability. In study 2, the slope of probability judgment regressed on desire for treatment was steeper for the after group, indicating that distortion of probability did occur.* ***Conclusion.*** *In close-call but not clear-cut medical decisions, people may distort relevant probabilities to justify their preferred choices.* ***Key words:*** *value-induced bias; cognitive dissonance; subjective probability; risk perception; wishful thinking.* ***(Med Decis Making 2008;28:269–276)***

Judging the probability of relevant outcomes is a central part of making medical decisions. Accurate probability judgments are critical to physicians' ability to make optimal medical decisions for or about their patients and to patients' ability to make optimal medical decisions for themselves. However, the value-induced bias, in which the nature of an outcome influences judgments of its probability of occurring, has been found in studies of physicians' medical decisions.[1,2] Value-induced bias violates a principle of decision theory, which holds that the probability of an outcome is independent of its value or importance.[3]

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Value-induced bias can be thought of as a type of cognitive dissonance reduction, desirability bias, or wishful thinking. Cognitive dissonance is the discomfort experienced when there is inconsistency between multiple cognitions or behaviors.[4] To reduce this discomfort, we adjust or distort one of the cognitions to justify it or to make the cognitions consistent with each other. For instance, Brehm[5] had participants choose between 2 objects that were either equally desirable (thereby creating high dissonance about the desirable, unchosen object) or very different in their desirability (thereby creating no dissonance about the less desirable, unchosen object). In the high dissonance condition, but not the low dissonance condition, participants increased their rating of the desirability of a chosen object and/or decreased their desirability rating of an unchosen object to reduce the dissonance associated with not getting the unchosen object.

In this article, we focus on the adjustment or distortion of the probability of relevant outcomes to justify one's preferred medical treatment choice. Much work has shown the distortion of probabilities to reduce dissonance or because of wishful thinking,[6–10] although other work has failed to find such an effect.[11] For instance, Weinstein[7] found that people estimate their own chance of positive events (e.g., a good job offer) as higher than that of the average person and their own chance of negative events (e.g., having a heart attack) as lower than that of the average person. Irwin and colleagues[8–10] found that subjects estimate their chance of drawing a card with a payoff attached to it (but not cards without a payoff) as higher than the card's known relative frequency.

This distortion of probabilities, when exhibited regarding probabilities relevant to medical decisions, can create misperceptions of the decision options and may result in suboptimal decisions. Smokers, for example, may try to align their knowledge of the harms of smoking with their smoking behavior to reduce or avoid dissonance. They may change the belief that smoking is harmful by convincing themselves that the data on the harms of smoking are inconclusive. Alternatively, they may try to add new cognitions to reduce the perceived threat, such as adopting the belief that the filter traps the truly harmful chemicals in the cigarette.[4]

Previous research on the value-induced bias examined hypothetical medical decisions by physicians. Wallsten[1] found that, relative to judgments made by a computer, physician judges assigned a higher probability to a patient having a malignant tumor than a cyst, despite the higher objective probability of a cyst. This tendency was attributed to a value-induced bias; the greater importance of ruling out a tumor compared with a cyst, argued the author, led to the inflation of the subjective probability of a tumor. However, the finding in this study that physicians gave high probability judgments for the tumor may not be due to value-induced bias. Rather, it may simply be the result of the common error of overestimating the likelihood of a low probability event.[12] In a second study, Poses and others[2] found that physicians who had already recommended antibiotics for patients with symptoms of strep throat assigned a higher probability to a strep diagnosis than those who had not. Poses and others concluded that the physicians were also committing the value-induced bias, that they were justifying their diagnosis and treatment recommendation by raising the probability of strep. However, this conclusion is also problematic because the reverse pathway (i.e., a higher probability judgment leading to the treatment recommendation) cannot be ruled out.

What has not been considered to date is that patients may also be vulnerable to a value-induced bias. As patients are being encouraged to assume greater responsibility for their medical decisions,[13–15] the potential consequences of biases in patient decision making are growing. Overweighting or underweighting the probability of any given outcome can lead to suboptimal decisions or search for information. For example, the value-induced bias may lead a patient to discount the probability of the risks of smoking to justify continued smoking. Only 1 study to our knowledge has tested for value-induced bias in patients or potential patients.[16]

Thus, we conducted 2 studies with laypeople on the Web to seek evidence for the value-induced bias in laypeople (i.e., potential patients). We hypothesized that to justify getting treatment (or not), those with a formulated desire for (or against) a medical treatment would increase (or decrease) their subjective probability of the treatment's success compared with those without a formulated desire.

STUDY 1

Methods

With institutional review board approval from the University of Pennsylvania, we placed a questionnaire on the Web (http://www.psych.upenn.edu/~baron/qs.html). Subjects were paid $2 in exchange for completing the questionnaire. Use of the Web for research has several advantages over the alternatives for this kind of research (usually conducted with undergraduates): the subjects are much more varied than those from other convenience samples, expenses connected with data entry and checking are reduced, and because it is easy to check answers as the subject enters them, fewer responses need to be discarded because they are nonsensical.[17] Moreover, the general quality of the data is at least as high as that of data from paper questionnaires, and in general, substantive results do not differ from those of comparable methods.[18–21]

Subjects ($n = 203$) were asked to imagine that they had been diagnosed with a disease that causes severe pain and weakness for 2 months with type I of the disease or forever with type II of the disease. Their doctor described a treatment that has a "small possibility" of working regardless of which type they have. To create in subjects a strong motivation to justify getting treatment, we told all subjects that a blood test determined that they have the type of the disease that lasts forever.

However, the timing of the presentation of the information and questions was varied to experimentally manipulate subjects' motivation to justify their desire for treatment. To this end, subjects were randomly assigned to 1 of 3 groups. Group 1 ($n = 64$) reported their judgment of the probability of treatment success and how certain they were about this probability while still waiting to learn their blood test results. On the Web screen that followed, group 1 learned that they have the forever type of the disease and then reported their desire for treatment. Group 2 ($n = 62$) learned immediately that they have the forever type of the disease, reported their desire for treatment, and then gave a probability judgment and reported their certainty. Group 3 ($n = 77$) was told the disease type earlier, as in group 2, but like group 1, the desire question came after the probability question.

We expected that, knowing that they have the type of the disease that lasts forever, groups 2 and 3 would be more highly motivated to justify getting the treatment compared with group 1 and thus would judge the probability of treatment success to be higher than group 1 (hypothesis 1). We also hypothesized that there would be no order effect, so that the probabilities of treatment success would be no different between groups 2 and 3 (hypothesis 2). All reported results are from 2-tailed t tests of the differences between means.*

Results

Subjects. Subjects were mostly women (70%) and white (86%) and had a mean age of 40 years (SD = 12). Fifty percent of subjects earned more than $50,000 per year, and 51% had completed college or more. As expected from randomization, there was no significant difference across the 3 groups in any of these demographic characteristics.

Judgments of probability of success of treatment. Contrary to hypothesis 1, according to 2-sample t tests, there was no significant difference between group 2 and group 1 in their probability judgments (group 2: 40.9 v. group 1: 39.2, $t(124) = .46$, $P = 0.64$) or between group 3 and group 1 (group 3: 38.9 v. group 1: 39.2, $t(139) = -.09$, $P = 0.93$). Even after removing those subjects who reported that they "really had no idea" about their probability judgment ($n = 8$ in group 1, $n = 7$ in group 2, $n = 4$ in group 3), these probability judgments still were not significantly different (group 2: 42.4 v. group 1: 40.6, $t(109) = .48$, $P = 0.63$; group 3: 39.1 v. group 1: 40.6, $t(127) = -.39$, $P = 0.70$).

Hypothesis 2 regarding a lack of order effect was supported; there was no significant difference between group 2 and group 3 in their probability judgments (group 2: 40.9 v. group 3: 38.9, $t(137) = .51$, $P = 0.61$). The lack of a significant difference between these groups remained after removing subjects who reported they "had no idea" about their probability judgment (group 2: 42.4 v. group 3: 39.1, $t(126) = .82$, $P = 0.41$).

Discussion

The results of study 1 revealed no evidence of the value-induced bias. Although we created a disease of high severity (very unpleasant symptoms that last forever) to observe this bias, the null result may actually be attributable to the fact that the disease was so severe. Subjects would not need to justify their decision to get treatment by raising the probability of success (even with a low probability of treatment success) if the severity of the disease was more than sufficient to justify getting treatment. This explanation is supported by the high and homogeneous ratings of desire for treatment that subjects reported. Fully 68% of subjects expressed a desire for treatment at a level of 6 or 7 on a 1 to 7 scale, and only 5% expressed a desire lower than 4. Thus, in study 2, we altered the scenario to make the decision to get treatment less clear-cut (a "close call") and, therefore, in greater need of justification in *either* direction: justification for getting treatment or not getting treatment.

STUDY 2

Methods

Study 2 subjects ($n = 182$) were recruited as in study 1 and were given the same scenario, but to make the treatment decision a close call, they were told that they had the 2-month type of the disease. This was designed to yield considerable variety in preferences for treatment, allowing us to see how subjective probability judgments covary with desire for treatment. As in study 1, subjects were randomly assigned to group 1 ($n = 59$), group 2 ($n = 64$), or group 3 ($n = 59$).

*To achieve an effect size of 0.5 (Cohen's d), with an alpha level of 0.05, a sample of 64 subjects in each group yields a t test with a power of 0.8 for testing the difference between 2 independent means. For an alpha level of 0.10, the same sample sizes yield a power of 0.876.

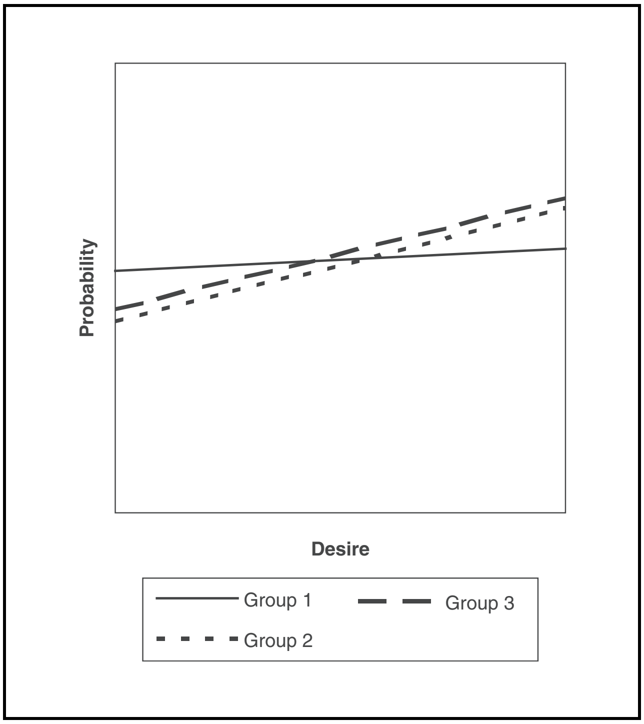

Figure 1 Hypothesized slopes by group for probability regressed on desire for study 2.

Because this close-call decision has the potential to yield distortion of probability both upward (to justify getting treatment) and downward (to justify not getting treatment), it is no longer appropriate to simply test for distortion by comparing the mean probability judgments in the groups. Instead, if subjects who desire treatment inflate the probability of treatment success to justify getting treatment and subjects who do not want treatment reduce the probability of treatment success to justify not getting treatment, we would expect the slopes of probability judgments regressed on desire to be steeper in groups 2 and 3 than in group 1 (hypothesis 3), as shown in Figure 1. This is because relative to group 1 subjects, who should not have a motivation to justify, group 2/3 subjects who wanted the treatment would inflate the probability of treatment success to justify their decision, and group 2/3 subjects who did not want the treatment would lower their probability judgment to justify their decision. Of course, greater preference for treatment could well be associated with higher perceived probability of treatment success, so one might see a positive slope even for group 1. However, our test for probability distortion is simply that the slopes will be steeper in groups 2 and 3 than in group 1. We also hypothesized that the slopes of groups 2 and 3 would be the same (hypothesis 4), although we were open to the possibility that subjects who first stated a desire (group 2) might have a steeper slope than those who had not yet been asked to state their desire when reporting their probability judgment (group 3).

The slope differences among the 3 groups were assessed by examining the interaction terms when regressing probability on desire, group, and the interaction of desire and group. All reported results are from 2-tailed statistical tests.

Results

Subjects. One subject was eliminated from group 1 for failing to answer the desire question. Subjects were mostly women (80%) and white (83%) and had a mean age of 39 years (SD = 11). Forty-two percent earned more than $50,000 per year, and 46% had completed college or more. There was no significant difference across the 3 groups in any of these demographic characteristics.

Judgments of probability of success of treatment. The mean probability judgments in groups 1, 2, and 3 were 41.9, 42.5, and 37.3, respectively. There were no significant differences for any pair of these means ($P > 0.24$ for all).

Desire for treatment. As expected, the mean desire for treatment was much lower in all 3 groups in study 2 compared with study 1, and there was also considerable variability. Thirty-five percent of subjects expressed a desire for treatment lower than 4 on the 1 to 7 scale, compared with only 5% in study 1.

Relationship between desire and probability. The 3 regression lines of probability judgments regressed on desire are shown in Figure 2. The slope for group 1 is positive but not significant (2.0, $t(56) = 1.35$, $P = 0.183$). The slopes for the other 2 groups are positive and significant (group 2: 8.4, $t(62) = 6.61$, $P < 0.0001$; group 3: 6.7, $t(57) = 4.37$, $P < 0.0001$). The slope for group 2 is steeper than the slope for group 1 (8.4 v. 2.0, $t(121) = 3.32$, $P = 0.001$), and the slope for group 3 is steeper than the slope for group 1 (6.7 v. 2.0, $t(116) = 2.22$, $P = 0.028$). The slopes for groups 2 and 3 are not significantly different from each other (8.4 v. 6.7, $t(122) = .87$, $P = 0.38$).

Thus, hypotheses 3 is supported, and we fail to reject hypothesis 4. Apparently, the formulated desire

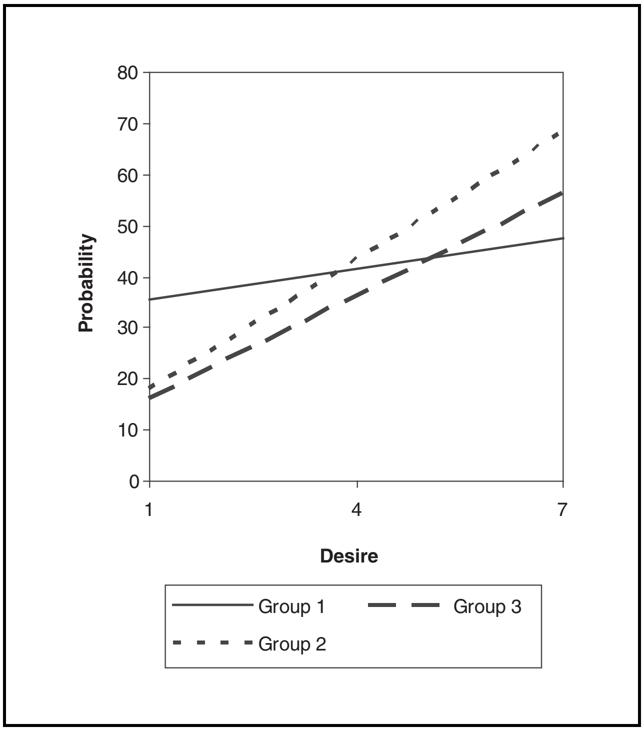

Figure 2 Actual slopes by group for probability regressed on desire for study 2.

for or against treatment led subjects in groups 2 and 3 to adjust the probability of treatment success, upward for those who wanted the treatment and downward for those who did not. The order of the desire and probability items did not affect responses, as long as disease type had been revealed.

These conclusions are not affected by removing those who said they "really had no idea" about their probability judgment ($n=7$ for group 1, $n=8$ for group 2, $n=9$ for group 3) or those who took less than 2 minutes to complete the survey ($n=11$ for group 1, $n=17$ for group 2, $n=22$ for group 3). When removing those who "really had no idea," the slope for group 2 is still steeper than that for group 1 (9.2 v. 1.8, $t(106)=3.55$, $P=0.001$), and the slope for group 3 is still steeper than that for group 1 (6.7 v. 1.8, $t(100)=1.93$, $P=0.050$) and is no different from the slope for group 2 (9.2 v. 6.7, $t(105)=1.33$, $P=0.19$). When removing those who took less than 2 minutes, the slope for group 2 is also still steeper than that for group 1 (8.0 v. 2.3, $t(94)=2.68$, $P=0.009$), and the slope for group 3 is still steeper than that for group 1 (6.6 v. 2.3, $t(84)=1.93$, $P=0.057$), and is no different from the slope for group 2 (6.6 v. 8.0, $t(83)=.63$, $P=0.530$).

General Discussion

This research demonstrates that, when faced with clear-cut decisions—those that are easily justified through decision factors other than the probability of a relevant outcome, such as the severity of the outcome—distortion of relevant probabilities does not seem to occur (study 1). But when faced with difficult, "close-call" decisions, people demonstrate the value-induced bias: they distort relevant subjective probabilities to justify their preference for or against a decision option (study 2). In this research, compared with those without a motivation to justify their desire for or against treatment, those with this motivation who wanted the treatment judged the probability of treatment success as being higher, and those who did not want the treatment judged it to be lower. This distortion effect was seen regardless of the order in which subjects' desire for treatment and probability judgment is assessed. These results are consistent with much previous work demonstrating that people distort relevant cognitions, including probability, to reduce cognitive dissonance or in the interest of wishful thinking. The current research demonstrates that this distortion also occurs in the context of medical decisions.

If the desirability of decision options actually *affects* perceptions of relevant probabilities, this can lead to misperceptions of the decision options and, therefore, to suboptimal medical decisions. The results of this research suggest that treatment preferences were not just correlated with relevant probabilities; preferences appear to have led to alterations of perceived probabilities. In a related study,[16] we found similar distortions even when subjects were given a specific numeric expression of probability.

Altering beliefs in this way may reduce the cognitive dissonance or discomfort that is generated by the inconsistent beliefs[22,23] but may adversely affect medical decisions. As an example of an upward adjustment of probability, the perceived severity of a cancer diagnosis could lead to an inflation of its subjective probability to justify undergoing an unnecessary biopsy in search of reassurance about this terrible disease. This would align the desire for the reassurance from the test with key reasons for getting the test. The problem is that this distortion may lead to the pursuit of costly (physically and financially) health care services and, among patients with an extremely low objective risk of cancer, potentially unnecessary use of these services. As an example of downward adjustment, patients with a fear of needles may decrease their subjective probability of getting the flu to justify their desire not to get a flu shot. Especially among patients at high risk of complications from the flu, this may be a suboptimal decision.

The results of this study must be considered within its limitations. The subjects were from the Web and are not representative of the general population. Another concern is that the study used hypothetical scenarios that are removed from reality in several important ways. In particular, the participants in the study did not have to make a real medical decision and may not have been influenced by the manipulations attempted in the scenarios. In fact, this may explain the null result observed in study 1. However, the hypothetical nature of the study made the study feasible and allowed us to manipulate factors experimentally that we could not control in a real medical setting. Furthermore, the manipulation in the hypothetical scenario in study 2 was successful, suggesting that the null result in study 1 was not attributable to the failure of the hypothetical scenario. Nevertheless, we cannot be certain that these results would replicate in a real medical setting.

Another concern is that the order of questions in a given group could produce a kind of demand effect. For example, in group 2, participants might anchor on their response to the desire question when answering the subsequent probability question. High desire could prompt a high probability, and low desire could prompt a low probability. This could be all the more likely because of the close proximity of the 2 questions. The same concern could be raised in group 3, but in the opposite direction.

If there were such an order effect, we would expect more variability for whichever component is positioned second, relative to when it is positioned first. To test for this, we conducted an F test for variances for each component across the 2 studies. There was no significant difference for desire (group 2: SD 1.87 v. group 3: SD 1.83, $F = 1.05$, P [2-tailed] $= 0.86$) or for probability (group 2: SD 24.4 v. group 3: SD 24.3, $F = 1.01$, P [2-tailed] $= 0.98$).[†]

Another possible alternative explanation for the results of study 2 is that in the course of making this decision, people's cognitions coalesce around a common disposition. Holyoak and Simon[24] call this "coherence;" in their experiments, people's inferences shifted toward a pattern of coherence with the emerging decisions. Simon and others[25] examined whether coherence shifts precede, or only follow, arrival at a decision. They demonstrated that a coherence shift can be triggered before a decision one expects to make later. This suggests the hypothesis that a coherence-generating mechanism can operate to make a decision, not to rationalize a decision that has already been made.

In our second experiment, this would suggest a positive slope for probability judgments regressed on desire for all 3 groups. We observe this in groups 2 and 3, but the slope for group 1 is positive but not significant (2.0, $t(56) = 1.35$, $P = 0.183$). Note that, from a normative point of view, probability *should* inform desire, in that a higher perceived probability of success *should* lead to a greater desire for treatment. If, in addition to this normative prediction, coherence is also at work in group 1, its effect must be small, given the small slope.

Still, coherence would also predict the observed steeper slopes for groups 2 and 3 than for group 1 because groups 2 and 3 had more of an ability to allow their cognitions to coalesce when they answered both the probability and desire questions. On this basis, coherence and justification make the same prediction.

It is also important to consider the possibility that instead of distorting probability of treatment success to justify desire for treatment, subjects distorted their desire for treatment to justify their previously stated probability of treatment success. For example, in study 2, it is possible that relative to groups 2 and 3, group 1 distorted their desire to justify their probability judgment by reporting a particularly high desire when expressing a high probability and a particularly low desire when expressing a low probability. We cannot disentangle these competing explanations in our study design, and it is likely that both played a role to some degree. However, it does not seem intuitive that subjects would feel compelled to distort their desire for treatment—to say that they want treatment even though they do not, or vice versa—simply to bring their desire in line with their previously stated probability judgment. In contrast, probability judgments could be more susceptible to such distortion, as a convenient means to justify a close-call decision.

Thus, this study provides evidence that the motivation to justify one's medical decisions and preferences may lead people to distort their perception of relevant probabilities. Such distortions may explain why some people demand unnecessary health care services and others avoid recommended health behaviors and health care services, despite having been clearly told the relevant probabilities. The possibility that the value-induced bias can lead patients

[†]As stated earlier, there are no significant differences for any pair of mean probability judgments. The mean desire judgments in groups 1, 2, and 3 were 4.1, 3.9, and 4.1, respectively. These were no significant differences for any pair of these means ($P > 0.43$ for all).

to make suboptimal medical decisions highlights the need to explore the impact of the value-induced bias in real medical settings.

APPENDIX
Scenario for Studies 1 and 2

Imagine that you go to your doctor because for the past week, you have been experiencing severe leg pain and weakness such that it is usually impossible to carry out your normal daily activities. Your doctor confidently diagnoses you with Warren's disease, a condition that causes this pain and weakness, and has no other effects.

However, the doctor explains that there are 2 types of this disease. Type I lasts for approximately 2 months with the same symptoms you have now and goes away completely after that. Type II lasts forever with the same symptoms you have now.

The doctor says that the treatment for type I and type II is the same and, for both types, needs to be started within 2 weeks of the onset of symptoms to work (it has been 1 week since your symptoms began). The doctor says that there is only a small possibility that the treatment will work.

The treatment involves a series of daily injections for 1 week that cause nausea and vomiting for the duration of the week. Most days during the week of injections, you will feel lousy but will still be able to do some of your normal activities. If the treatment works, it completely eliminates the symptoms forever, but unfortunately, it does not always work. The doctor repeats that there is only a small possibility that the treatment will work and that this probability is the same for type I and type II.

The doctor runs a blood test to see whether you have type I or type II.

MEASURES

Probability Judgment

What do you believe the chance is that the treatment will work for you if you get it?

Please enter a number from 0 to 100.

0 means "the treatment will definitely not work."
50 means "the treatment is just as likely to work as not to work."
100 means "the treatment will definitely work."

Certainty

How sure are you of the number you entered for the chance that the treatment will work for you?

Please click on the dot that corresponds to your answer.

1 means "I really had no idea."
4 means "Somewhat sure."
7 means "Completely sure."

Desire for Treatment

How much do you want to get the treatment?
Please click on the dot that corresponds to your answer.

1 means "I definitely do not want the treatment."
4 means "I am right in the middle between wanting and not wanting the treatment."
7 means "I definitely want the treatment."

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