Worry and the Simulation of Future Outcomes

Article *in* Anxiety Stress & Coping · March 2002

DOI: 10.1080/10615800290007254

CITATIONS
40

READS
185

4 authors:

Gary Brown
Royal Holloway, University of London
60 PUBLICATIONS **11,971** CITATIONS
SEE PROFILE

Andrew Macleod
Royal Holloway, University of London
82 PUBLICATIONS **3,228** CITATIONS
SEE PROFILE

Philip Tata
Central and North West London NH...
48 PUBLICATIONS **4,178** CITATIONS
SEE PROFILE

Lorna Goddard
Goldsmiths, University of London
32 PUBLICATIONS **1,376** CITATIONS
SEE PROFILE

Anxiety Stress and Coping, 2002, Vol. 15, No. 1, pp. 1–17 BrunnerRoutledge Taylor & Francis healthsciences

WORRY AND THE SIMULATION OF FUTURE OUTCOMES

GARY P. BROWN,[a,*] ANDREW K. MACLEOD,[b]
PHILIP TATA[c] and LORNA GODDARD[d]

[a]*Salomons: Canterbury Christchurch University College;*
[b]*Department of Psychology, Royal Holloway, University of London;*
[c]*Department of Psychology, St. Mary's Hospital, London;*
[d]*Department of Psychology, Goldsmiths College, University of London*

(Received 18 July 2001; Revised 31 July 2001; In final form 1 August 2001)

This study describes the development of a methodology for studying dynamic aspects of ongoing thought processes drawing on the theories of Kahneman and Tversky on heuristics in thinking and judgement. Specifically, the potential role of the simulation heuristic (Kahneman and Tversky, 1982) in worry about future outcomes was examined. Women who were pregnant for the first time were asked to simulate going into labor and arriving at the hospital on time (the desired outcome). The resulting protocols were coded for "goodness-of-simulation" in terms of the simulation heuristic. The prediction was that goodness-of-simulation would lead to higher subjective probability of a positive outcome and less worry. This hypothesis was supported. The method developed in this study is potentially broadly applicable to various clinical and non-clinical phenomena.

Keywords: Cognitive processes; Simulation; Worry; Anxiety; Heuristics

The cognitive approach to emotional problems has been very productive, generating a large and varied body of research and informing clinical practice. The main thrust of the approach has been to test aspects of Beck's cognitive theory (Beck, 1967, 1976; Beck and Emery, 1985). Early research in this area relied considerably on self-report questionnaire methodology, but critiques of this reliance (e.g., Coyne and Gotlib, 1983) gave impetus to alternative approaches, particularly laboratory-based paradigms that often borrowed methods from experimental psychology (see Williams *et. al.* 1997).

Valuable as they have been, both questionnaire and laboratory approaches focus on phenomena only indirectly related to the type of thinking *processes* encountered in individuals with emotional problems (see also Hammen and Krantz, 1985, on this point). Specifically, many of the phenomena of interest in clinical research have at their core such processes as rumination, worry, and obsession that are by nature cyclical and repetitive, often consuming considerable portions of an individual's mental activity.

*Corresponding author. [1]Centre for Applied Social and Psychological Development, Salomons Centre, Canterbury Christchurch University College, Broomhill Road, Turnbridge Wells, Kent TN3 0TG, UK.

ISSN 1061-5806 print © 2002 Taylor & Francis Ltd
DOI: 10.1080/10615800290007254

It is also, arguably, these cognitive processes that are the main targets of psychotherapeutic interventions. The emphasis in questionnaire-based research, in contrast, has been on largely static constructs, such as levels of dysfunctional attitudes and different types of attributional styles. These instruments often capture important general themes found in the preoccupations of individuals with clinical problems, but have comparatively little bearing on their ongoing thinking processes.

Similarly, whereas typical laboratory experiments in this area are concerned with phenomena, such as interference effects and attentional biases, that have a more apparent link to actual thinking processes than questionnaires do, these links are indirect and need to be inferred. In addition, these paradigms are often built on procedures that, for example, call on the participant to imagine themselves in situations unrelated to them personally or to respond to standardized stimuli, such as subliminally presented words. In this regard, both laboratory and questionnaire approaches often deal with subject matter that may not be sufficiently personally engaging to set into motion the sustained elaborative processes at work in rumination and worry.

One promising point of entry into the study of cognitive processing for which a firm theoretical basis has been established is in the area of heuristics, largely due to the work of Tversky and Kahneman. Perhaps the best known of these is the *availability heuristic*. The availability heuristic describes the process whereby people estimate the likelihood of a particular event happening in the future by how easily they are able to bring relevant instances to mind. Tversky and Kahneman (1973) suggested two classes of mental operations that bring things to mind – retrieval of past instances, where similar events are recalled from long-term memory, and construction of scenarios. The more easily past examples are recalled or the easier it is to construct a scenario leading to the outcome in question, the more likely the event is judged to be.

The second mechanism – scenario construction – will be used when the event in question is uncommon or even unique, in which case there will not be a database of past experiences upon which to base the judgement. This second aspect of the availability heuristic was renamed the *simulation heuristic* in recognition that as a mechanism it was sufficiently distinct from recall of past instances to warrant separate consideration (Kahneman and Tversky, 1982).

Frequently, the concerns of individuals with clinical problems revolve around imagined events (developing a disease, going insane, financial ruin, etc.) that have never actually occurred. In these contexts, it is likely that the simulation heuristic will be employed. According to the simulation heuristic, judgments are based on the construction and running of a mental simulation of the situation of interest. Coherent scenarios that 'run' easily lead to a greater subjective probability for the outcome in question. Kahneman and Tversky (1982) suggest that "mental simulation yields a measure of the propensity of one's model of the situation to generate various outcomes... . The ease with which the simulation of a system reaches a particular state is eventually used to judge the propensity of the (real) system to produce that state" (pp. 201–202).

Consistent with the further development of the theory by Kahneman and Miller (1986), most applications of the simulation heuristic have focused on counterfactual reasoning, whereby an actual outcome is compared to an alternative that could have happened should some aspect of the situation have been different. This line of research has offered some insight into the cognitive processes underlying the so-called "counterfactual emotions" of guilt, frustration and regret. A separate account

of simulation should also be noted, which was provided by Taylor and Schneider (1989). While acknowledging the importance of simulation in making events seem true or real, Taylor and Schneider distinguish their account from Kahneman and Tversky's. They view simulation as a much more general cognitive process that is not limited to its heuristic function and enables people "to prepare for future events, interpret past events, alter their emotional states and muster arousal, and provide links between thought and action" (p. 175).

In support of the central prediction concerning the general impact of imagination on prospective judgments, there is abundant evidence that imagining a future event increases the subjective likelihood that the event will occur (Carroll, 1978; Gregory *et al.* 1982; Sherman *et al.* 1985). To take one example, before the 1976 US presidential election, Carroll (1978) asked participants to imagine that either Carter or Ford had won the election and then to make a prediction concerning the actual outcome of the election. Participants who imagined that Carter had won were more certain that he eventually would, and those who imagined Ford had won were more certain that he would later win.

However, several lines of research support the simulation heuristic more specifically as opposed to imagination *per se*. These show that imagination alone does not always increase subjective probability; a moderating factor is the *ease* with which the event can be imagined. In this connection, Sherman *et al.* (1985) asked subjects to imagine getting a disease whose symptoms were either easy or difficult to imagine. The ease with which subjects stated they could imagine the symptoms was tied to likelihood estimates: those who judged the symptoms as easy to imagine also tended to estimate the disease as more likely to occur; those who thought the symptoms were difficult to imagine thought it less likely to occur.

Further, it is not simply the ease with which a mental picture of an outcome can be brought to mind that influences its perceived likelihood. Additional factors have been identified that strengthen or weaken the simulation effect. For example, Levi and Pryor (1987) asked participants in their study to predict who would win a forthcoming presidential debate. Subjective estimates did not increase in the group instructed to rely on imagination alone, but did increase in the group instructed to provide explanations for why the particular candidate would win. Accordingly, MacLeod (e.g., 1999) has argued that the process of simulating a future event entails, among other things, causal reasoning about what would bring about the event. The ease with which such causal reasoning can be constructed should predict the perceived likelihood of the event in question. MacLeod and colleagues (see MacLeod, 1999 for a summary) have employed this application of the simulation heuristic to understanding the increased subjective likelihood of negative future events found in anxiety. Consistent with the simulation heuristic, they found that anxious, worried participants, relative to non-anxious controls, rated negative events to be more likely to happen to them and were more able to construct explanations for why the events would happen.

The research by MacLeod and colleagues illustrates the straightforward extension of the simulation heuristic to clinical issues, and links up with the well-established line of research begun by Butler and Mathews (1983) on the relationship between anxiety and heightened subjective probability for negative events. However, the operationalization of the simulation heuristic in terms of being able to generate reasons leading to the event happening (and not being able to generate counter reasons), although consistent with the simulation heuristic, does not capture fully the imaginal processes described by

Kahneman and Tversky (1982). The present study was undertaken to develop a method for operationalising the simulation heuristic that captures the constructive, scenario-building aspect conceived by Tversky and Kahneman (1982).

Participants were a group of women expecting their first child who were interviewed late in their pregnancy. These women were asked to perform a future-oriented thinking task involving the construction of a scenario, starting with going into labor at home alone and finishing with them reaching the hospital in plenty of time. They were asked to fill in the middle of the scenario, and their responses were coded in various ways that reflected 'goodness' of simulation, that is the ease with which the scenario could be simulated. They were also asked to estimate how likely this outcome was and how much they were worried about it.

This population was chosen for study as participants were undergoing a naturally occurring, never-before-experienced event that was personally meaningful and consequential. At the same time, entering labor and the pragmatics of reaching the hospital on time have fairly uniform characteristics across individuals, with little relative variation in starting and ending points. It was therefore felt that the resulting verbal protocols would provide a suitable basis for comparison across individuals. The positive outcome was chosen partly on ethical grounds, although the operation of the simulation heuristic is thought to be applicable across all outcomes. The *central* goal of the study was to develop a methodology that operationalized the original predictions of the simulation heuristic in terms of the relationship between ease or goodness-of-simulation and subjective probability and to examine, in turn, the relationship between these and worry. It was predicted that goodness-of-simulation of reaching the hospital on time would be inversely related to worry (i.e., those with well-running simulations should have low worry), but that the effect would be mediated by subjective probability.

METHOD

Participants

A sample of women who were pregnant for the first time was recruited from the obstetrics department at St. George's Hospital Medical School in London. The hospital is located in Tooting in southwest London and serves the surrounding predominantly working-class population. An initial pilot sample was comprised of 20 women. In the final sample, there were 83 additional participants who ranged in age from 22 to 43 ($M = 28.83$, $SD = 8.91$). They participated on a voluntary basis and were not compensated for their involvement in the study.

Materials and Procedure

Potential participants were identified from a list of women taking part in a separate study of late pregnancy. Their next regular appointment was noted, and a research assistant, who served as experimenter, approached prospective participants in the waiting room of the obstetrics department prior to the appointment.

Simulation Task and Associated Ratings

Those agreeing to participate were first administered the simulation task. The procedure for eliciting simulations was loosely modeled on the Means-Ends Problem Solving approach (MEPS; Platt and Spivack, 1977). Participants were provided with the beginning of an imaginary scenario (being at home alone at midday and going into labor) and the end of the scenario (arriving at the hospital with time to spare) and were asked to give a step-by-step account of what would happen in between these two points. The experimenter transcribed verbatim what the participant said.

The procedure was initially developed by administering it to eight of the twenty pilot participants. Based on their responses, the simulation instructions were reworded, and a list of permissible follow-up prompts was developed for use in specific circumstances in which it was apparent that a particular participant was not providing the desired step-by-step response. The actual wording of the final simulation instructions and permissible prompts are provided in Appendix I, and examples of protocols produced by participants are shown in Table I.

Immediately following the simulation task, participants were asked, "On a scale from 1–9, with 1 = not worried at all and 9 = extremely worried, how worried are you about reaching the hospital on time once you have gone into labor?" The scale was reproduced on a card and the participant selected a response. Any spontaneous comments the participant made relevant to the question were also recorded. The same procedure was followed for the next question, "How probable do you think it is that you will arrive at the hospital with plenty of time to spare? Please give an estimate from 1 to 7, with 7 = absolutely certain that I will arrive with plenty of time to spare and 1 = absolutely certain that I will NOT arrive with plenty of time to spare". The final question asked was open-ended: "Do you have any particular concerns about getting to the hospital on time?" Responses were recorded verbatim. Before ending, participants were also asked how long they estimated it would take them to travel to hospital in the circumstances described in the scenario, as this may have been a variable that moderated any effects.

TABLE I Examples of scenarios provided by participants in response to simulation instructions

Participant A: Depending on what stage–I'm taking it from that stage–I'll try to ride out the pain. I'll make a few phone calls–especially to my boyfriend and then my mum. Take a bath, eat something. Next stage – depending on the pain, I'll still be riding it out. By that time my boyfriend will have arrived and we will make our way to the hospital (by car). Then when I arrive they'll tell me what to do. I only live down the road so I would like to stay at home as long as possible.
Participant B: It's your first child–don't know what to expect. You're a bit frightened. No one around you–just to calm really. (P) Scream. (P) Call for help–nearest person is the next door neighbour–whoever I could get in touch with quickly. (P) If it's not all that bad you could get there in a car–say a neighbour's car. But if there's pain you call an ambulance. It would all happen so quickly you wouldn't think–just the first thing that comes to mind. Maybe when you get there you'll think I should have done this, I should have done that.
Participant C: Well, I'll ring the hospital first of all to check if it's all right to come. And my partner will take me down there. And I'll have my bag packed. Presumably he'll be calming me down. If it's during the day, I'll come in the back way and that's about all. I haven't thought about it really to tell you the truth. Oh, yeah–I should have my mum with me. (P) By car or my mum's. Someone will be with me–I won't be on my own.

Note: A "(P)" indicates that a prompt was given by the experimenter at that point in the scenario.

Scenario Coding

The scenarios from the remaining 12 pilot participants were used to develop a coding system that would operationalize goodness-of-simulation (GOS). A set of theory-based ratings anchored in specific criteria was developed based on the factors discussed in the literature that are thought to underlie goodness-of-simulation (Kahneman and Tversky, 1982; Kahneman and Miller, 1986). Seven central aspects were identified: 1. *logical sequencing* (the extent to which successive elements of a scenario are logically connected to each other with each step following logically from the previous one); 2. *temporal ordering* (the extent to which temporal order is communicated so that a sense of temporal flow is established); 3. *sensitivity to contingency* (the extent to which the narrator shows an awareness of alternative possibilities at various points in the scenario); 4. *minimization of uncertainty* (the extent to which aspects of the scenario that are inherently uncertain are addressed and unexpected elements are dealt with adequately); 5. *adequacy of problem space coverage*; 6. *smooth flow of the scenario*; and 7. *realistic time allocation* (the extent to which awareness is shown that there are time constraints in the scenario). Individual raters rated each scenario on each dimension using 5-point scales with each point on each scale anchored by detailed criteria.

The exact wording of the statements corresponding to each anchor point resulted from extensive discussions among the authors in the course of close examination of the content of the twelve development scenarios. In addition, during this process, more precise definitions of the seven dimensions were developed to aid in carrying out the ratings. The coding criteria are included in Appendix II along with the detailed definitions of the seven aspects.

Additional Measure

State-Trait Anxiety Inventory (STAI) The STAI is composed of two 20-item scales, one measuring state and one measuring trait anxiety. Only the trait scale was used in the present study. Trait anxiety is defined as "a relatively stable individual difference in anxiety proneness, a difference in disposition to perceive danger and threat, and a tendency to respond to threats with state anxiety reactions" (Spielberger, 1983, p. 39). Research on the STAI indicates good reliability and validity (Spielberger, 1983). The STAI was completed at an earlier appointment as part of a larger study.

RESULTS

Inter-Rater Reliability

Two raters (GPB and LG) made independent blind ratings of all 83 scenarios on the seven goodness-of-simulation dimensions. Half-point ratings were permitted. In the course of making these ratings, it became clear that a number of scenarios were invalid due to the experimenter's not having adequately prompted participants who had not spontaneously provided full responses. In these cases, if a consensus could be reached between the two raters, the scenario was discarded. This was true of ten scenarios, reducing the effective sample to 73.

Estimates of reliability are shown in Table II for the seven criterion-based GOS

TABLE II Inter-rater reliability of goodness-of-simulation dimensions

Aspect	*Agreement*			
	Exact	*Within 1 point*	*Arbitrated ratings*	*Inter-rater correlation*
Logical sequence	26 (36%)	58 (80%)	2 (3%)	0.65
Temporal order	23 (32%)	60 (82%)	4 (6%)	0.65
Sensitivity to contingency	21 (29%)	59 (80%)	6 (8%)	0.72
Minimization of uncertainty	18 (25%)	58 (80%)	8 (11%)	0.56
Coverage of problem space	32 (44%)	66 (90%)	2 (3%)	0.77
Flows smoothly	18 (25%)	64 (88%)	3 (4%)	0.67
Time allocation	17 (23%)	58 (80%)	4 (6%)	0.60

Note: $N = 73$.

TABLE III Intercorrelations of goodness-of-simulation dimensions and loadings on first principal component

	1	2	3	4	5	6	7
1. Flows smoothly	*0.93*						
2. Each step follows logically from the last	0.83	*0.88*					
3. Uncertainty is minimized	0.76	0.72	*0.87*				
4. Temporally ordered	0.83	0.85	0.66	*0.87*			
5. Good coverage of problem space	0.75	0.62	0.69	0.64	*0.81*		
6. Realistic time allocation	0.57	0.48	0.50	0.48	0.42	*0.67*	
7. Sensitivity to contingency	0.49	0.41	0.58	0.38	0.45	0.50	*0.64*

Note: $N = 73$. Loading on first principal component appear in the diagonal.

ratings. Exact agreement ranged from 25 to 44%, agreement within one rating point ranged from 80 to 90%, and the correlations between the ratings ranged from 0.56 to 0.72. In each case, *minimization of uncertainty* appeared to have the lowest reliability and *coverage of problem space* the highest reliability. However, reliability was clearly adequate for all dimensions. Each rating difference of > 1 point was discussed by the raters and, where a consensus could be reached, ratings were adjusted so that they differed by at most one point. If a consensus could not be reached, a third rater (AKM) arbitrated and provided a third rating. The final rating was the average of the ratings made.

The intercorrelations of the GOS dimensions are shown in Table III. These variables appear to be highly correlated and, accordingly, all had high loadings on the first principal component extracted from the correlation matrix, which was the only component that had an eigenvalue of at least one. Because the individual aspects appeared to be measuring a single underlying dimension, a single factor score was calculated based on the principal components analyses.

Tests of the Main Hypothesis

The central hypothesis was that goodness-of-simulation of a successful outcome as evidenced in the verbal protocols of the participants should be associated with a higher subjective probability for that outcome and consequently less worry. An initial correlation analysis provided support for the hypothesis, as shown in Table IV. Specifically, overall GOS (the factor score for the seven criterion-based dimensions)

TABLE IV Correlations of predictor and criterion variables

	1	2	3	4	5	6	7
1. Worry							
2. Subjective probability	−0.36						
3. GOS	−0.31	0.31					
4. Scenario length	0.11	0.13	0.32				
5. Sentences	0.26	−0.05	0.17	0.72			
6. Sentence length	−0.15	0.29	0.26	0.50	−0.21		
7. STAI	0.27	−0.27	0.01	−0.14	−0.01	−0.23	
8. Time to hospital	−0.14	−0.15	−0.06	−0.07	−0.07	−0.05	−0.01

Note: $N = 73$. Correlations > 0.23 are significant at $p < 0.05$

had a positive correlation with the subjective probability rating ($r = 0.31$) and a negative correlation with worry ($r = -0.31$). In addition, subjective probability was negatively correlated with worry ($r = -0.36$), as expected.

Potential Mediating Variables

Based on information collected, it was possible to consider alternative explanations for the findings. Firstly, it did not appear that the estimated traveling time to the hospital had a bearing on worry ($r = -0.14$), subjective probability ($r = -0.15$) or GOS ($r = 0.06$). In addition, whereas trait anxiety (as measured by the STAI) was related in the expected direction to worry ($r = 0.27$) and to subjective probability ($r = -0.27$), it was unrelated to GOS ($r = 0.01$), and therefore does not appear to be able to account for the relationship between GOS and the other two variables. Moreover, trait anxiety did not mediate the relationship between subjective probability and worry: when subjective probability was regressed on worry with STAI entered first into the equation, subjective probability still accounted for a significant increment of variance in worry, incremental $R^2 = 0.086$, $F(1,70) = 7.13$, $p < 0.01$.

A basic assumption about GOS is that it is a 'deep' property of the verbal protocols provided by the subjects and not simply a reflection of surface properties such as the mere amount of information provided. In order to examine this issue, GOS was correlated with scenario length (the number of characters in the scenario), the number of sentences produced (including prompted responses), and sentence length (average number of characters per sentence). It is clear from the pattern of results in Table IV that there is an association between these surface features of the scenarios and the variables of interest. Scenario length was correlated with GOS ($r = 0.32$) as was sentence length ($r = 0.26$). This is not surprising in light of the fact that a number of the GOS rating criteria stipulate higher ratings for the use of more complex sentence structures (e.g., through the use of words such as 'until' and 'otherwise'). However, the associations are low enough to rule out the conclusion that GOS is simply reducible to these surface features of the scenarios.

Sentence length was also correlated with subjective probability ($r = 0.29$), and it was therefore possible that it mediated the relationship between GOS and subjective probability. This was tested by means of a hierarchical regression analysis in which subjective probability was regressed on sentence length and GOS. If sentence length mediated the relationship between subjective probability and GOS, the partial regression coefficient for GOS would not be significantly greater than zero. The

actual result was an incremental reduction in the beta coefficient for GOS from 0.31 to 0.25; however, the reduced coefficient was still significantly greater than 0, $t(1, 70) = 2.18$, $p < 0.04$, which suggested that sentence length did not mediate the relationship between subjective probability and GOS. When the complementary analysis was carried out to test the extent to which GOS mediated the relationship between subjective probability and sentence length, the beta coefficient for sentence length was reduced from 0.29 to 0.23, which was still just significant, $t(1, 70) = 1.98$, $p < 0.05$. Apparently, then, sentence length is independently associated with subjective probability.

Overall Structural Model

The central hypothesis was tested by constructing a structural model depicting the simultaneous relationships between all of the variables of interest. It is presented in Fig. 1. For each path, the model was compared to the model excluding that path. The paths remaining in the figure are those whose deletion would result in a significant decrement in model fit. Overall, the predicted relationships were found, with GOS positively associated with subjective probability and both GOS and subjective probability negatively correlated with worry. In addition, the fact that the model is supported despite the inclusion of the STAI in the analysis contradicts the possibility that the predicted relationships are due to the spurious influence of trait anxiety. Likewise, however, the relationship between trait anxiety and worry is not fully mediated by subjective probability and goodness of simulation. Finally, the reciprocal paths were tested between worry, subjective probability, and GOS (these needed to be tested singly rather than simultaneously because the model that included all of the reciprocal paths was under-identified). None of the reciprocal paths was significant; thus, there was no evidence that greater worry decreased subjective probability or GOS or that greater subjective probability reciprocally increased GOS. The structural model analysis thus supports the central predictions regarding the relationship between goodness-of-simulation, subjective probability, and worry.

DISCUSSION

The present study was undertaken to develop a means for studying aspects of dynamic cognitive processes that are likely to be involved in various clinical phenomena. Using Kahneman and Tversky's (1982) simulation heuristic as a framework, we examined the verbal protocols of women who were pregnant for the first time and nearing their expected delivery dates to see if these would predict their level of worry about reaching the hospital on time after going into labor. The results were consistent with the predicted operation of the simulation heuristic: women whose accounts provided less coherent simulations of the anticipated events had lower subjective probabilities for a successful outcome and expressed more worry.

Several potential alternative explanations for the findings were considered, and none of these was supported. Perhaps the most significant of these was the possibility that the predicted pattern of findings was spurious and was actually due to the underlying relationship of the variables of interest to trait anxiety. This was a plausible alternative, as lower subjective probabilities for positive outcomes, higher worry, and impaired reasoning are all potential correlates of trait anxiety. What was found instead was

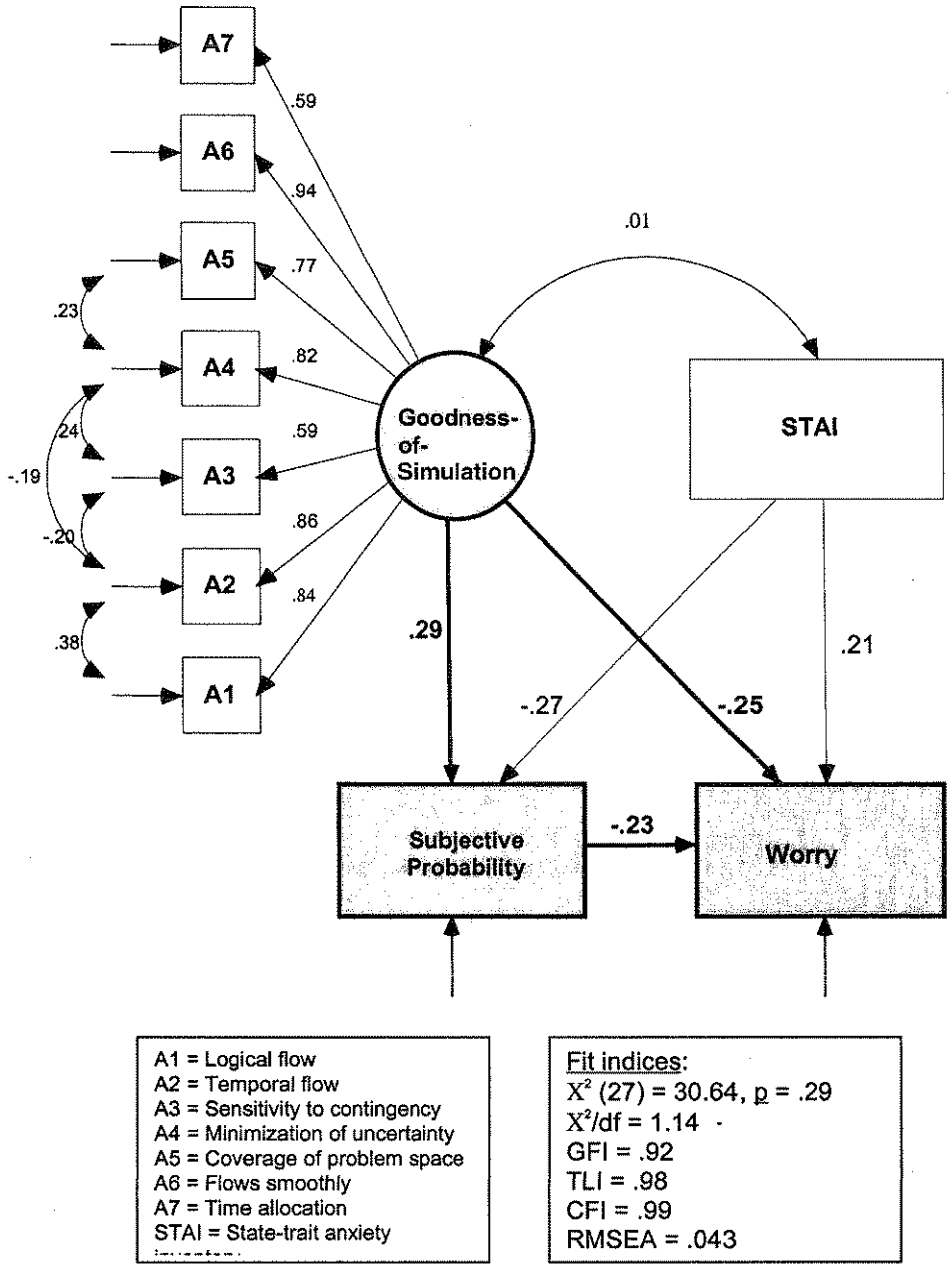

FIGURE 1 Overall structural model (Standardized solution).

that trait anxiety was unrelated to GOS. Further, whereas trait anxiety was related to both subjective probability and worry, it did not mediate the relationship between the two variables. It appears, then, that the main findings of interest were not indirectly due to a general underlying tendency to anxiety and worry.

If lowered GOS is not merely a byproduct of trait anxiety, it is still possible that what

it measures is simply surface features of the participants' verbal protocols, such as their sheer length. If so, this would weaken the case for the claim that the method being developed was indexing aspects of the participants' thinking processes that were discernible by way of the structure and coherence of their verbalizations. Consistent with this possibility, GOS was in fact correlated with scenario length and average sentence length. However, the magnitude of the correlations did not suggest that GOS was reducible to these more basic features of the protocols. Rather, these associations likely reflected the fact that GOS is partially defined in terms of the *complexity* of the verbalizations produced (including, for example, coverage of contingencies) which would also imply longer verbalizations.

Within clinical psychology, the criticism of questionnaire approaches in terms of their limited ecological validity has been made before, and a number of procedures have been proposed since the great upsurge of interest in cognitive approaches over the last few decades for better capturing ongoing thought processes. These include think-aloud and thought-listing approaches (e.g., Klinger, 1978; Hurlburt, 1979) and the means-ends approach adapted for the present study (Platt and Spivack, 1977). A parallel situation exists in experimental psychology, where protocol analysis is often promoted as a means for complementing laboratory-based methods and for compensating for some of their limitations (e.g. Ericsson and Simon, 1993; Wilson, 1994).

The likely reason such methods are not used more extensively is that the resulting data, like the thinking processes they are intended to reflect, are not uniform across respondents and are therefore difficult to quantify and analyze. One approach to making the data more manageable has been to impose parameters that constrain and delimit the output of a given procedure. The means-ends approach is one example of this strategy, whereby the beginning and ending points are fixed. The articulated thought in simulated situations approach (Davison *et al.* 1995) uses a similar strategy of structured vignettes to which participants are asked to provide semi-structured responses.

For the most part, verbal protocols elicited in the various ways outlined above are then typically analyzed strictly in terms of what their content suggests to the researcher about the respondent's thinking. The present approach differs in two important ways. First, it is less concerned with the content of the protocols, focusing instead on other, more dynamic parameters such as coherence and flow. Second, the significance of these variables is less in what they directly imply about the respondent's thinking processes, but rather in what heuristic value they hold for the respondent and, specifically, in the extent to which they make the target of judgment appear to be true or possibly true. These aspects of how the respondent simulates a possible future event are assumed to be informative regarding their present working model of their ongoing experience.

In this regard, the present approach has implications for the notion of mental models, which has been put forth as an alternative to schemas as a conceptual basis for explaining the shifts in mindset that take place between normal and problematic states of emotional functioning (e.g., Power and Champion, 1986; Teasdale *et al.* 1995). Simulations are effectively mental models of possible events, and the principles and mechanisms relating to simulations will likely also be relevant to mental models in general.

The present model should be regarded as a starting point and will no doubt need to be elaborated upon further. For example, the fact that degree of subjective probability did not fully mediate the relationship between goodness-of-simulation and worry is of interest. This does not contradict the predicted operation of the simulation heuristic,

but rather suggests either that there are other mediating variables that need to be identified or that simulation has a direct effect on worry in addition to the indirect one. Similarly, whereas reciprocal paths between the main variables in the model were not found to increase model fit in the structural model analysis, it is quite likely that further research using this approach will find evidence of reciprocal effects. For example, this might turn out to be the case with negative anticipated events, where mood congruence effects (which could for example increased, subjective probabilities) and otherwise disrupted thought processes might be more expectable.

More generally, further research will need to verify that the effects found generalize to other positive outcomes as well as to negative outcomes. It is likely that particular aspects of GOS will be more or less important, depending on the outcome in question. For example, time allocation was particularly salient to reaching the hospital to give birth, but may not be a factor for other outcomes. Likewise, additional aspects of GOS may come to light as other outcomes are considered.

What the current study shows is that it is possible to study cognitive processes, rather than just cognitive content, in a systematic, empirical way. In the present study, this approach has enhanced our understanding of how simulation of future outcomes relates to worry and the subjective probability of outcomes. Further research could usefully apply this approach to understanding other areas where mental simulation is likely to be important.

Acknowledgments

We thank Michael Anderson for important insights into how to operationalize the simulation heuristic.

References

Beck, A.T. (1967). *Depression: Clinical, Experimental, and Theoretical Aspects.* Harper and Row, New York.

Beck, A.T. (1976). *Cognitive Therapy and The Emotional Disorders.* International Universities Press, New York.

Beck, A.T. and Emery, G. (1985). *Anxiety Disorder and Phobias: A Cognitive Perspective.* Basic Books, New York.

Butler, G. and Mathews, A. (1983). Cognitive processes in anxiety. *Advances in Behaviour Research and Therapy*, **5**, 51–62.

Carroll, J.S. (1978). The effect of imagining an event on expectations for the event: an interpretation in terms of the availability heuristic. *Journal of Personality and Social Psychology*, **36**, 1501–1511.

Coyne, J.C., and Gotlib, I.H. (1983). The role of cognition in depression: A critical appraisal. *Psychological Bulletin*, **94**, 472–505.

Davison, G.C., Vogel, R.S. and Coffman, S.G. (1997). Think-aloud approaches to cognitive assessment and the articulated thought in simulated situations paradigm. *Journal of Consulting and Clinical Psychology*, **65**, 950–958.

Ericsson, K.A. and Simon, H.A. (1993). *Protocol Analysis: Verbal Reports as Data.* Rev. Edn. MIT Press, Cambridge, MA.

Gregory, W.L. Cialdini, R.B. and Carpenter, K.M. (1982). Self-relevant scenarios as mediators of likelihood estimates and compliance: does imagining make it so? *Journal of Personality and Social Psychology*, **43**, 88–89.

Hammen, C.L. and Krantz, S.E. (1985). Measures of psychological process in depression. In: Beckham, E.E. and Leber, W.R. (Eds.), *Handbook of Depression: Treatment, Assessment, and Research.* The Dorsey Press, Homewood, IL.

Hurlburt, R.T. (1979). Random sampling of cognitions and behavior. *Journal of Research in Personality*, **13**, 103–111.

Johnson, M.K. and Sherman, S.J. (1990). Constructing and reconstructing the past and the future in the

present. In: Higgins, E.T. and Sorrentino, R.M. (Eds.), *Handbook of Motivation and Social Cognition: Foundations of Social Behavior*, pp. 482–526. Guilford Press, New York.
Kahneman, D. and Tversky, A. (1982). The simulation heuristic. In: Kahneman, D., Slovik, P. and Tversky, A. (Eds.). *Judgment Under Uncertainty: Heuristics and Biases*, pp. 201–208. Cambridge University Press, New York.
Kahneman, D. and Miller, D. (1986). Norm theory: Comparing reality to its alternatives. *Psychological Review*, **93**, 136–153.
Klinger, E. (1978). Modes of normal conscious flow. In: Pope, K.S. and Singer, J.L. (Eds.) *The Stream of Consciousness: Scientific Investigations into the Flow of Human Experience*, pp. 225–258. Plenum, New York.
Levi, A.S. and Pryor, J.B. (1987). Use of the availability heuristic in probability estimates of future events: The effects of imagining outcomes vs imagining reasons. *Organization Behavior and Human Decision Processes*, **40**, 219–234.
MacLeod, A.K. (1999). Prospective Cognitions. In: Dalgleish, T. and Power, M. (Eds.). *Handbook of Cognition and Emotion*, pp. 267–280. Wiley, Chichester.
Platt, J.J. and Spivack, G. (1977). *Workbook for training in interpersonal problem-solving thinking*. Hahnemann Community Mental Health Center, Philadelphia.
Power, M.J. and Champion, L.A. (1986). Cognitive approaches to depression – a theoretical critique. *British Journal of Clinical Psychology*, **25**, 201–212.
Sherman, S.J., Cialdini, R.B., Schwartzman, D.F. and Reynolds, K.D. (1985). Imagining can heighten or lower the perceived likelihood of contracting a disease: the mediating effect of ease of imagery. *Personality and Social Psychology Bulletin*, **11**, 118–127.
Spielberger, C.D. (1983). *Manual for the State-Trait Anxiety Inventory*. Consulting Psychologists Press, Palo Alto.
Taylor, S.E. and Schneider, S.K. (1989). Coping and the simulation of events. *Social Cognition*, **7**, 174–194.
Teasdale, J.D., Taylor, M.J., Cooper, Z., Hayhurst, H. and Paykel, E.S. (1995). Depressive thinking-shifts in construct accessibility or in schematic mental models. *Journal of Abnormal Psychology*, **104**, 500–507.
Tversky, A. and Kahneman, D. (1973). Availability: a heuristic for judging frequency and probability. *Cognitive Psychology*, **5**, 207–232.
Williams, J.G., Watts, F.N., MacLeod, C. and Mathews, A. (1997). *Cognitive psychology and emotional disorders*, 2nd Edn. Wiley, New York.
Wilson, T.D. (1994). The proper protocol: Validity and completeness of verbal reports. *Psychological Science*, **5**, 249–252.

APPENDIX I

Anticipatory Simulation of Birth Experiences

Simulation Prompt

"In this study we are interested in the expectations of women who are pregnant for the first time. In particular, we would like to find out exactly what you anticipate will take place *before* the actual delivery".

"I am going to describe to you the beginning of a future situation and the end of the situation and I want you to tell me what you imagine the middle will be. At the beginning of the situation, you are at home alone at midday when you begin to go into labor. Take a moment to imagine that [that you are home alone at midday when you begin to go into labor]. At the end of the situation, imagine that you have arrived at the hospital with plenty of time to spare. Now go back to the beginning of the situation, where you are at home and just beginning to go into labor and describe step-by-step exactly what will happen from that point onwards".

Allowable follow-ups

1. If it is clear that participants are not anticipating a future scenario but rather pretending that something has already happened, clarify that they are to imagine something that will take place in the future.

2. If the participant gives an overly global response (e.g., "An ambulance will take me to the hospital"), say "Can you give more detail about (getting an ambulance to take you to the hospital), starting with the first step you will take?"
3. If the participant gives a vague response (e.g., "I'll call someone"), first ask "Can you be more specific?" If this does not elicit a specific response, ask "Whom will you call?"
4. If participants deviate from the facts given in the scenario (e.g., that it is a false alarm rather than the actual start of labor), clarify that the details given in the scenario are to be regarded as a given and that there is a set beginning and end.
5. If they are accompanied, clarify that we are interested in the subject's responses only.

APPENDIX II

Rating Criteria and Expanded Definitions of the Rating Dimensions

I. Rating Criteria

A. Logical sequence The extent to which successive elements of a scenario are connected logically with each step following from the previous one. Transitions between scenario elements are either *explicitly included* or *clearly implied* so that the scenario flows logically.

1. Logically disjoined – hard to follow
2. Basic logical thread is apparent, but mainly fragmented, or logic is due to prompting.
3. At least one logical transition is missing and this results in impaired flow.
4. No logical transitions are missing, but at least one needs to be inferred, resulting in slight impairment in flow.
5. All logical transitions are made explicit and there is little impairment in flow.

B. Temporal order Temporal ordering is communicated explicitly ("then...", "until...") or *clearly implied* so that a sense of *temporal flow* is established.

1. Elements are scattered in time.
2. Significant scatter or only ordered due to prompting.
3. No more than one clear jump or digression.
4. Basic temporal sequencing present, but is not made explicit through use of words like *until*, *then*, etc.
5: No digressions or jumps.

C. Sensitivity to contingency The extent to which the narrator shows an awareness of alternative possibilities at various points in the scenario. Indication of *planning in the face of uncertainty*, e.g., through backup plans or consideration of potential alternatives.

1. No suggestion that contingencies are considered.
2. Little suggestion that contingencies are considered or contingencies result from prompting.
3. Some suggestion that uncertainty is recognised, but not enough is included to be confident of planning in the face of uncertainty.

4. Consideration of contingencies is clearly implied, but not made explicit, e.g., through clear mention of alternative outcomes.
5. Explicit mention of contingencies (e.g., through use of words like *otherwise*, *if*, *unless*, etc. or mention of clear backup plans) and alternative outcomes are clearly considered.

D. Minimization of uncertainty The extent to which the scenario either increases or decreases a sense of uncertainty.

1. Uncertainty is heightened rather than minimised.
2. Uncertainty is introduced that is not adequately addressed or is only addressed when prompted.
3. Uncertainty is not introduced, but inherent uncertainty is unacknowledged or inadequately addressed.
4. Only slight uncertainty due to omission of detail.
5. Uncertainty is minimised as far as can be reasonably expected.

E. Adequate coverage of the problem space The extent to which the scenario give a comprehensive account of all of the basic elements of the situation.

Elements of problem space:

- Primary notification (driver, etc.)
- Secondary notification (neighbours, significant others, etc.)
- Practical preparation (packing, etc.)
- Physical preparation (bathing, eating, etc.)
- Co-ordination with hospital

1. Substantial gaps in coverage of problem space.
2. Partial coverage of problem space or only in response to prompting.
3. Most of problem space covered, but more than two clear gaps.
4. Problem space covered with only two clear gaps.
5. Problem space covered with at most one clear gap.

F. Flows smoothly A subjective judgment on the part of the rater of how well the scenario flows.

1. Scenario does not flow and is difficult to follow.
2. Impaired flow or flow depends substantially on prompting.
3. Scenario flows, but haltingly.
4. Scenario flows easily with only minor halts.
5. Scenario flows easily.

G. Realistic time allocation The extent to which the respondent communicates an awareness of and responsiveness to time constraints.

1. Optimal timing is not mentioned and no indication time is considered.
2. Little indication time is considered or only in response to prompting.
3. Consideration of time (waiting, co-ordinating arrival with hospital, filling time, rushing/not rushing, etc.) is only implied, but is not made explicit.

4. Time constraints are explicitly mentioned, but recognition of time pressure or excess time not clear.
5. Clear sense is communicated of working toward optimal timing.

II. Expanded Definitions of the Rating Dimensions

A. Logical sequence This involves the extent to which successive elements of a scenario are logically connected to each other with each step following logically from the previous one. This will be most apparent in a sense of the flow of the scenario. A scenario will score low on this dimension where there are "jumps" in the account, that is, where parts of an account are missing so that two adjacent statements do not logically connect. A scenario low on this dimension is one that leads the rater to wonder why the narrator said a particular thing at that particular point in the account.

B. Temporal order This involves the extent to which temporal order is communicated explicitly or is clearly implied so that a sense of temporal flow is established. Like the previous rating, flow is important, but here the emphasis is on the presence of a clear sense that the elements of the scenario are ordered in time. At the high end of the dimension, the narrator will show a clear sense of temporal order by the use of words such as "then", "afterwards", "before", and "until". It is a sense that the narrator knows what happens when so that their description unfolds in a smooth and ordered manner.

C. Sensitivity to contingency The extent to which the narrator shows an awareness of alternative possibilities at various points in the scenario. This is most evident when the narrator shows some planning in the face of this uncertainty, for example, through mention of backup plans or the consideration of potential alternatives. A low rating on this dimension indicates that the rater gets a sense that no consideration has been given to alternative possibilities, whereas a high rating indicates not only that the scenario demonstrates awareness of alternative possibilities, but that the alternatives are explicitly mentioned.

D. Minimization of uncertainty This dimension primarily reflects the extent to which the scenario either increases or decreases a sense of uncertainty in the rater's mind. This can involve either the narrator not adequately addressing aspects of the scenario that are inherently uncertain or, alternatively, the narrator may introduce unexpected elements to the scenario that are not justified or are not dealt with adequately. Secondarily, direct expressions by the narrator of their own uncertainty should also be taken into account.

E. Adequate coverage of the problem space Each hypothetical scenario has a number of elements to it and this dimension reflects the extent to which the account covers all of these elements in its description. It is mainly a measure of the comprehensiveness of the account rather than of the quality of what is said about each step/element. A low score therefore reflects omission of important elements.

F. Flows smoothly This is a subjective judgment on the part of the rater about how well the scenario flows. A poorly flowing scenario is one where the rater has to work to fill in gaps or to make inferences or just generally has to work harder to make the story fit in his or her mind. One indicator of this might be the amount of rereading that has to be done or how long the scenario takes to process (given its length).

G. Realistic time allocation This dimension reflects the extent to which someone is aware that there are time constraints in the scenario. That is, the person knows in advance that things will have to happen within a certain time frame, either through the inherent nature of what has been talked about or through having to coordinate with other people.