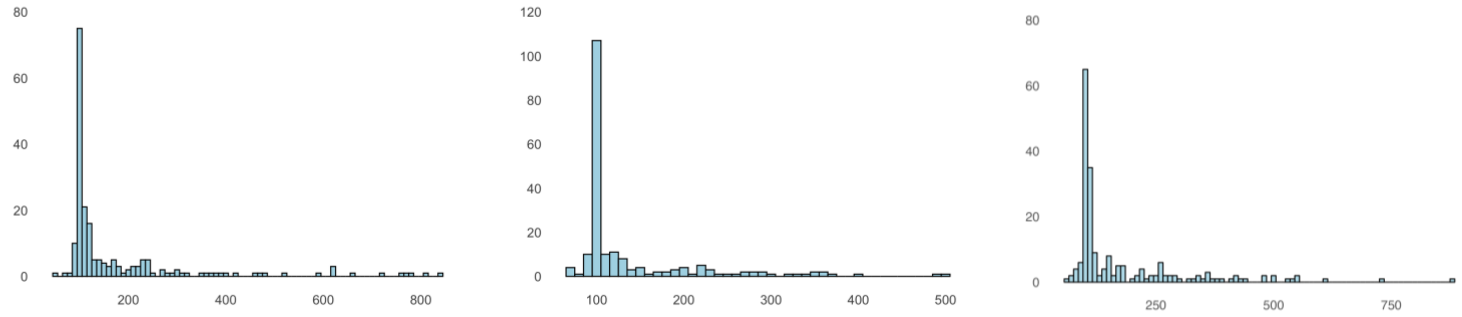
Visual Simulation and Subjective Probability Estimation: When Seeing is Believing

Figure SM.1 Histogram of the sum of probabilities across each study.



(a) Study 1 (b) Study 2 (c) Study 3

Table SM.1. Study 1 average estimates and comparison of overprecision measures.

		Tails			Centre		
		T_1	T_2	T_3	M_1	M_2	M_3
Control	*M*	0.075	0.080	0.083	0.108	0.104	0.101
	SD	0.038	0.031	0.023	0.051	0.039	0.023
Treatment	*M*	0.057	0.066	0.074	0.110	0.112	0.111
	SD	0.033	0.028	0.022	0.055	0.041	0.023
Comparison	Δ	-0.018***	-0.014***	-0.009*	0.002	0.008	0.010*
	CI	[-0.027, -0.008]	[-0.022, -0.006]	[-0.015, -0.002]	[-0.013, 0.017]	[-0.004, 0.019]	[0.002, 0.018]
	t	-3.483	-3.383	-2.604	0.261	1.347	2.604

Note. CI represent 95% confidence intervals. * $p < 0.05$, ** $p < .01$, *** $p < 0.001$.

Table SM.2. Study 1 regressions of the visualised landing bin on overprecision.

		Tails			Centre		
		T_1	T_2	T_3	M_1	M_2	M_3
Constant	*B*	0.079***	0.094***	0.100***	0.050**	0.064***	0.080***
	SE	0.010	0.009	0.007	0.017	0.012	0.008
	t	7.635	10.862	14.601	2.990	5.149	9.743
Imagined Outcome	*B*	-0.007*	-0.009**	-0.008***	0.019***	0.015***	0.010***
	SE	0.003	0.003	0.002	0.005	0.004	0.002
	t	-2.226	-3.450	-3.947	3.729	4.036	3.947

Note. * $p < 0.05$, ** $p < .01$, *** $p < 0.001$.

Table SM.3. Study 2 average estimates and comparison of overprecision measures.

		Tails		Centre	
		T_1	T_2	M_1	M_2
Control	*M*	0.120	0.128	0.171	0.162
	SD	0.005	0.026	0.060	0.035
Treatment	*M*	0.104	0.118	0.184	0.176
	SD	0.005	0.035	0.072	0.047
Comparison	Δ	-0.016*	-0.010*	0.013	0.014*
	CI	[-0.030, -0.002]	[-0.019, -0.002]	[-0.005, 0.032]	[0.002, 0.025]
	t	-2.247	-2.335	1.43	2.335

Note. CI represent 95% confidence intervals. * p < 0.05, ** p < .01, *** p < 0.001.

Table SM.4. Study 2 comparison against actual probabilities.

		Tails		Centre	
		$T_1^* = 0.122$	$T_2^* = 0.1305$	$M_1^* = 0.164$	$M_2 = 0.1593$
Control	Δ	-0.002	-0.002	0.007	0.003
	CI	[0.110, 0.129]	[0.123, 0.134]	[0.158, 0.183]	[0.155, 0.169]
	t	-0.432	-0.7845	1.137	0.794
Treatment	Δ	-0.018***	-0.012***	0.020**	0.016***
	CI	[0.093, 0.114]	[0.111, 0.125]	[0.170, 0.199]	[0.166, 0.176]
	t	-3.401	-3.511	2.851	3.518

Note. CI represent 95% confidence intervals. * p < 0.05, ** p < .01, *** p < 0.001.

Table SM.5. Study 2 regressions of the visualised landing bin on overprecision.

		Tails		Centre	
		T_1	T_2	M_1	M_2
Constant	*B*	0.151***	0.152***	0.114***	0.131***
	SE	0.013	0.008	0.017	0.011
	t	11.893	18.390	6.869	11.960
Imagined Outcome	*B*	-0.025***	-0.018***	0.037***	0.024***
	SE	0.006	0.004	0.008	0.005
	t	-3.984	-4.330	4.494	4.330

Note. * p < 0.05, ** p < .01, *** p < 0.001.

Table SM.6. Study 3 average estimates and comparison of overprecision measures.

		Tails			Centre		
		T_1	T_2	T_3	M_1	M_2	M_3
Control	*M*	0.068	0.074	0.079	0.113	0.109	0.105
	SD	0.035	0.029	0.023	0.062	0.043	0.028
Treatment	*M*	0.065	0.070	0.075	0.114	0.115	0.110
	SD	0.042	0.033	0.025	0.056	0.040	0.030
Comparison	Δ	-0.003	-0.004	-0.005	0.001	0.006	0.006
	CI	[-0.014 ,0.008]	[-0.013, 0.005]	[-0.011, 0.002]	[-0.015, 0.018]	[-0.006, 0.017]	[-0.003, 0.014]
	t	-0.555	-0.923	-1.351	0.146	0.975	1.351

Note. CI represent 95% confidence intervals. * $p < 0.05$, ** $p < .01$, *** $p < 0.001$.

Table SM.7. Study 3 regressions of the visualised landing bin on overprecision.

		Tails			Centre		
		T_1	T_2	T_3	M_1	M_2	M_3
Constant	*B*	0.040***	0.049***	0.058***	0.144***	0.142***	0.130***
	SE	0.007	0.005	0.004	0.009	0.006	0.005
	t	5.923	9.333	14.728	15.470	22.759	27.246
Imagined Outcome	*B*	0.004***	0.004***	0.003***	-0.005***	-0.005***	-0.003***
	SE	0.001	0.001	0.001	0.001	0.001	0.001
	t	4.324	4.900	4.956	-3.877	-5.257	-4.956

Note. * $p < 0.05$, ** $p < .01$, *** $p < 0.001$.

Study 4

The results of Studies 1 and 2 suggest that visual simulation can decrease [increase] estimates of tail [central] probabilities for aleatory distributions. However, whether this finding can extend to epistemic probability distributions is unclear. Thus, the current study explores whether mentally simulating outcomes increases relative precision for an unknowable distribution. Even though the distribution is unknowable, if mentally picturing outcomes increases precision, participants in the treatment group should allocate less [greater] probabilities to tail [central] bins.

Participants

The target sample size was 100 per condition, as in Studies 1 and 2. I recruited 202 American participants from Prolific (87 participants identified as Female and 2 preferred not to say; Age: *M* = 41.41, *SD* = 13.42). I removed one participant from the dataset based on the pre-registered exclusion criteria (total probability over 300).

Procedure

The procedure largely followed the previous Studies 1. The study began with a brief description of sleep, noting that (American) adults receive, on average, approximately 7 hours of sleep per night, but that this can vary greatly from person to person, with some individuals getting more sleep while others getting less. After passing an attention check question based on this description, participants are told that provided instructions on estimating the distribution of their sleep over the next 100 nights across the following bins: (0) less than 4 hours of sleep, (1) 4-6 hours sleep, (2) 6-8 hours sleep, (3) 8-10 hours sleep, and (4) more than 10 hours of sleep. Thus, $B = 4$ for this study. So, the selected tail and middle probability measures for comparison were $T_1 = \frac{1}{2}(P_0 + P_4)$ and $M_1 = P_2$.

Between the instructions and completing the SPIES question, the treatment group was prompted to “take a moment to mentally revisit your last night's sleep. This exercise aims to help you reflect on the amount of sleep you received last night, which can help you construct your distribution.” Then, participants in the treatment condition were told to “picture the moment you went to bed and try to recall the time” and report the time. Next, they were asked to “imagine the moment you woke up and the time you saw” and indicated this time. Finally, they answered, “How many hours of sleep did you get last night?” So, the treatment strongly focuses the participants on a single instance of one night’s sleep.

As in Study 1, all participants then answered two manipulation check questions (e.g., “While answering the previous questions, I imagined myself going to sleep and waking up” and “When responding to the scenario, I experienced images of myself going to sleep and waking up”), on 7-point Likert scales. The survey ended with questions on age and gender.

Results

First, I averaged the values from the manipulation check questions. Comparing the average responses between the control (*M* = 5.64, *SD* = 1.23) and the treatment conditions (*M* = 4.93, *SD* = 1.82), a difference of 0.71 (95% CI [0.27, 1.16]), suggests that the intervention successfully prompted the treatment group to engage in greater visual simulation, *t*(199) = 3.15, Cohen's *d* = 0.46, *p* = .002.

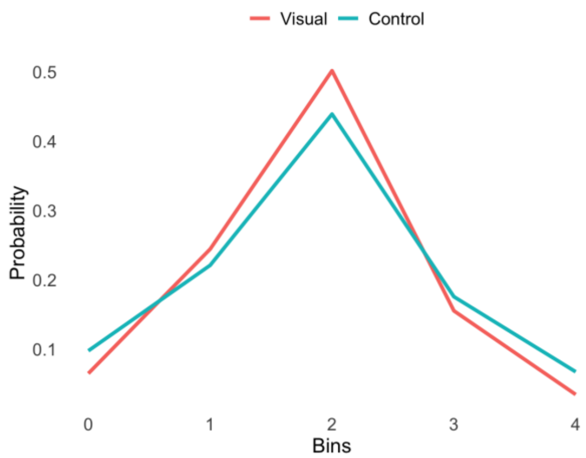


Figure SM.2. Mean probability estimates for each bin in the control and treatment group.

Figure 6 shows the average subjective probability estimates across the two conditions. (Note that no participants provided a flat distribution.) Again, the treatment [control] group appear to have lower [higher] estimates for the tail [middle] probabilities relative to the control [treatment] group. Indeed, Table A.1 shows a significant difference between the control and treatment groups across the tail estimates (with the central estimate not quite reaching statistical significance at the 0.05 level). Similarly, a regression (similar to those in Table 2) supports that the number of hours of sleep pictured significantly predicts the probability assigned to the middle bin (B = 0.099, SE = 0.049, p < 0.05). Thus, the results suggest visual simulations can lead to narrower subjective probability distributions for epistemic uncertainty.

Table SM.8. Average estimates and comparison of probability measures for all studies.

		Tail	Middle
Control	*M*	0.082	0.439
	SD	0.098	0.228
Treatment	*M*	0.049	0.502
	SD	0.057	0.228
Comparison	Δ	-0.033**	0.063†
	CI	[-0.056, -0.010]	[-0.010, 0.135]
	t	-2.788	1.710

Note. CI represent 95% confidence intervals. † p < 0.1, * p < 0.05, ** p < .01, *** p < 0.001.

Discussion

In this study, I tested if the effects extend to subjective probability distributions. In the experiment, participants estimated the distribution of their sleep over the next 100 days. The participants who imagined when they go to sleep and wake up each day had lower estimates on the number of days that they would receive either very little (< 4 hours) or a very high amount of sleep (> 10 hours) compared to the control group. Thus, the experiment results provided evidence that the findings can extend to other distributions.