Online Appendix for "Anticipatory Anxiety and Wishful Thinking"

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A Additional Tables and Figures

Table A.1: Average fraction of correct answers by experiment and treatment (excluding the Neutral condition).

	Experiment 1 (Elec. Shock) $N = 60$	Experiment 2 (Mon. Losses) $N = 221$	Experiment 3 (Seq. gabors) $N = 426$	Experiment 4 (Countable dots) $N = 407$
Aggregate	70.5	68.5	75.6	75.3
	(4.55)	(13.0)	(11.6)	(10.1)
No Shock/loss pattern	72.3	77.1	77.8	79.7
	(6.45)	(16.9)	(12.9)	(11.9)
Shock/loss pattern	68.6	60.3	73.4	71.1
	(6.57)	(17.5)	(15.3)	(16.4)
Difficulty Level 1	79.1	76.1	continuous	85.1
(easiest)	(6.17)	(17.6)		(12.8)
Difficulty Level 2	70.5	60.9	continuous	79.7
	(6.08)	(11.6)		(12.9)
Difficulty Level 3	62.9	-	continuous	72.6
	(7.95)	-		(14.6)
Difficulty Level 4	-	-	continuous	64.1
(hardest)	-	-		(15.0)
Accuracy bonus Low	70.1	68.7	75.2	74.7
	(5.68)	(14.2)	(12.6)	(11.4)
Accuracy bonus High	70.9	68.2	75.9	76.3
	(5.59)	(14.7)	(75.6)	(12.6)
Low Stake	-	68.5	-	-
	-	(14.0)	-	-
High Stake	-	68.7	-	-
	-	(15.0)	-	-

An observation is one individual's average accuracy in the specified condition. Standard deviations in brackets. Averages for Experiment 2 and 4 exclude the Neutral condition, which does not constitute a test of wishful thinking, and is reported in Table A.2.

Table A.2: Average fraction of correct answers by treatment in the Neutral condition.

	Experiment 2 $N = 221$	Experiment 4 $N = 407$
Aggregate	71.2 (19.1)	75.7 (18.2)
Difficulty Level 1 (easiest)	79.1 (20.1)	86.4 (13.8)
Difficulty Level 2	63.3 (14.1)	81.5 (15.2)
Difficulty Level 3	- -	72.3 (15.5)
Difficulty Level 4 (hardest)	- -	62.6 (18.1)
Accuracy bonus Low	70.8 (16.9)	75.1 (12.3)
Accuracy bonus High	71.7 (16.2)	76.3 (12.8)

An observation is one individual's average accuracy in the Neutral condition in Experiment 2 and 4 (data were not collected in Experiment 1 and 3). Standard deviations in brackets.

Table A.3: Average fraction of correct answers in the gain and loss treatments.

	Gain treatment $N = 300$	Loss treatment $N = 300$
Aggregate	62.2 (13.8)	59.7 (12.7)
No loss/Gain pattern	59.7 (16.2)	66.1 (20.7)
Loss/No gain pattern	64.9 (21.22)	52.8 (16.0)

An observation is one individual's average accuracy in the specified condition. Standard deviations in brackets.

A Experiment 1

Table A.4: Accuracy levels in Experiment 1

	(1) Accuracy	(2) Accuracy	(3) Accuracy	(4) Accuracy	(5) Accuracy	(6) Accuracy
Loss pattern	-3.698	-3.073	-3.698	-3.073	-4.111	-2.833
	(1.202)	(1.891)	(1.202)	(1.891)	(1.264)	(1.948)
High accuracy bonus (HAB)	0.885	0.174	0.885	0.174	0.785	0.313
	(0.857)	(1.270)	(0.857)	(1.270)	(0.878)	(1.389)
Medium difficulty (MD)	-8.606	-8.551	-8.611	-8.555	-8.639	-8.583
	(0.813)	(1.138)	(0.814)	(1.138)	(0.822)	(1.144)
High Difficulty (HD)	-17.15	-14.60	-17.14	-14.59	-17.20	-14.64
	(1.270)	(1.584)	(1.272)	(1.585)	(1.269)	(1.593)
Shock pattern x HAB		1.424		1.424		0.944
		(1.695)		(1.695)		(1.789)
Shock pattern x MD		-0.111		-0.111		-0.111
		(1.889)		(1.889)		(1.895)
Shock pattern x HD		-5.097		-5.097		-5.139
		(2.186)		(2.186)		(2.206)
Constant	80.50	80.19	80.50	80.19	80.76	80.12
	(1.020)	(1.250)	(0.871)	(1.085)	(1.056)	(1.314)
Observations	11520	11520	11520	11520	720	720
R^2	0.019	0.020	0.020	0.020	0.261	0.268
ID clustering	✓	✓	✓	✓	✓	✓
Individual fixed effects			✓	✓		
Averages by ID/treatment					✓	✓

Linear regressions of accuracy on treatment dummies. Columns 1-4 are panel data regressions, columns 3-4 include individual fixed effects. Columns 5-6 are OLS regressions where each observation is average accuracy per treatment and individual. Standard errors in parentheses clustered by individual.

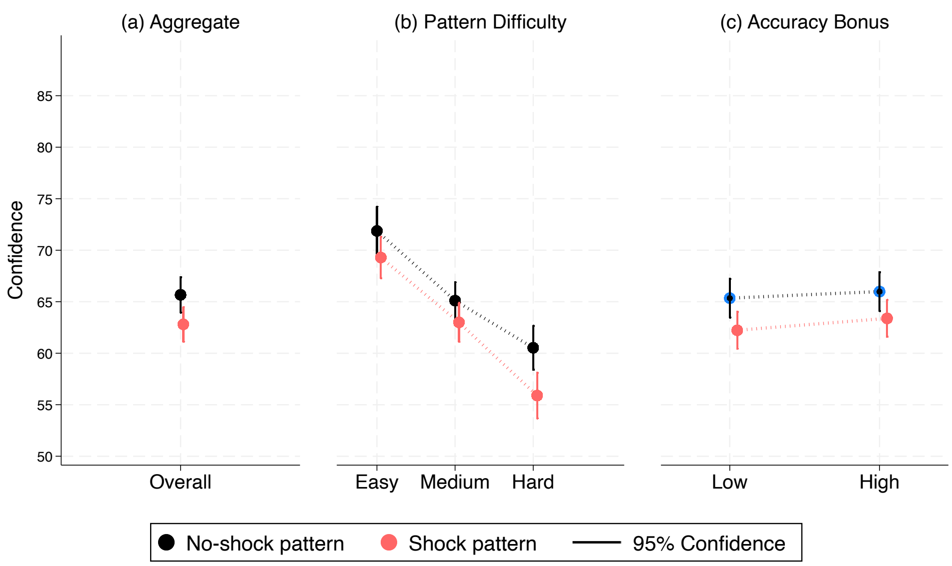


Figure A.1: **Electric shocks and confidence in the correct answer.** Average confidence levels in the correct answer, split by shock and no-shock pattern. Bars indicate 95% confidence intervals. One observation is the average over an individual's trials in a given category, so $N = 60$ in each category. Panel a) shows aggregate results. Panel b) disaggregates the results by difficulty (tilt) of the pattern. Panel c) disaggregates by incentives for accuracy.

Table A.5: Belief levels in Experiment 1

	(1) Belief	(2) Belief	(3) Belief	(4) Belief	(5) Belief	(6) Belief
Loss pattern	-2.858	-2.835	-2.858	-2.835	-3.108	-2.943
	(0.938)	(1.231)	(0.938)	(1.231)	(0.977)	(1.236)
High accuracy bonus (HAB)	0.898	0.642	0.898	0.642	0.841	0.478
	(0.533)	(0.788)	(0.533)	(0.788)	(0.562)	(0.842)
Medium difficulty (MD)	-6.503	-6.739	-6.516	-6.752	-6.532	-6.767
	(0.568)	(0.797)	(0.568)	(0.798)	(0.570)	(0.801)
High Difficulty (HD)	-12.34	-11.32	-12.32	-11.30	-12.37	-11.34
	(0.959)	(1.224)	(0.965)	(1.228)	(0.956)	(1.228)
Shock pattern x HAB		0.510		0.510		0.726
		(0.930)		(0.930)		(0.939)
Shock pattern x MD		0.472		0.472		0.470
		(1.109)		(1.109)		(1.112)
Shock pattern x HD		-2.040		-2.040		-2.056
		(1.348)		(1.348)		(1.360)
Constant	71.56	71.55	71.56	71.55	71.72	71.63
	(1.072)	(1.231)	(0.688)	(0.827)	(1.101)	(1.251)
Observations	11520	11520	11520	11520	720	720
R^2	0.027	0.028	0.028	0.029	0.255	0.258
Observations	11520	11520	11520	11520	720	720
R^2	0.027	0.028	0.028	0.029	0.255	0.258
ID clustering	✓	✓	✓	✓	✓	✓
Individual fixed effects			✓	✓		
Averages by ID/treatment					✓	✓

Linear regressions of beliefs on treatment dummies. Beliefs are constructed from confidence judgments on a scale from 0 to 100, where the latter is perfect confidence in the correct answer. Columns 1-4 are panel data regressions, columns 3-4 include individual fixed effects. Columns 5-6 are OLS regressions where each observation is average accuracy per treatment and individual and correspond to those in Table 2. Standard errors in parentheses clustered by individual.

B Experiment 2

Table A.6: Accuracy levels in Experiment 2

	(1) Accuracy	(2) Accuracy	(3) Accuracy	(4) Accuracy	(5) Accuracy	(6) Accuracy
Loss pattern	-16.59	-9.155	-16.59	-9.143	-16.54	-8.248
	(1.531)	(3.284)	(1.531)	(3.287)	(1.605)	(3.489)
High accuracy bonus (HAB)	-0.0284	-0.119	-0.0574	-0.157	-0.588	-1.081
	(0.806)	(1.004)	(0.812)	(1.012)	(0.851)	(1.089)
Difficult pattern (DP)	-15.29	-10.82	-15.29	-10.82	-15.68	-11.04
	(0.968)	(1.019)	(0.970)	(1.020)	(1.019)	(1.114)
Loss size (LS)	0.0380	1.100	0.0929	1.163	-0.617	0.776
	(0.893)	(1.212)	(0.892)	(1.209)	(0.906)	(1.245)
Loss pattern x HAB		0.221		0.242		0.994
		(1.618)		(1.620)		(1.771)
Loss pattern x DP		-8.806		-8.795		-9.200
		(1.586)		(1.586)		(1.701)
Loss pattern x LS		-2.079		-2.096		-2.784
		(1.813)		(1.815)		(1.869)
Constant	84.57	80.77	84.54	80.73	85.82	81.65
	(1.944)	(2.210)	(1.719)	(2.068)	(1.964)	(2.310)
Observations	11396	11396	11396	11396	3415	3415
R^2			0.064	0.066	0.134	0.140
ID clustering	✓	✓	✓	✓	✓	✓
Individual fixed effects			✓	✓		
Averages by ID/treatment					✓	✓

Linear regressions of accuracy on treatment dummies. Columns 1-4 are panel data regressions, columns 3-4 include individual fixed effects. Columns 5-6 are OLS regressions where each observation is average accuracy per treatment and individual and correspond to those in Table 2. Standard errors in parentheses clustered by individual.

C Experiment 3

Table A.7: Accuracy levels in Experiment 3

	(1) Accuracy	(2) Accuracy	(3) Accuracy	(4) Accuracy	(5) Accuracy	(6) Accuracy
Loss pattern	-4.415	-3.592	-4.407	-3.584	-4.266	-3.052
	(0.765)	(0.862)	(0.765)	(0.862)	(0.766)	(0.865)
High accuracy bonus (HAB)	0.728	0.484	0.723	0.479	0.630	0.685
	(0.471)	(0.589)	(0.473)	(0.590)	(0.474)	(0.601)
Difficult pattern (DP)	-20.76	-19.68	-20.80	-19.72	-20.55	-19.39
	(0.668)	(0.795)	(0.668)	(0.797)	(0.668)	(0.794)
Loss pattern x HAB		0.478		0.479		-0.110
		(0.838)		(0.838)		(0.881)
Loss pattern x DP		-2.137		-2.138		-2.317
		(0.849)		(0.849)		(0.892)
Constant	87.79	87.37	87.98	87.56	87.66	87.06
	(0.773)	(0.812)	(0.546)	(0.574)	(0.791)	(0.829)
Observations	33507	33507	33507	33507	3408	3408
R^2			0.064	0.064	0.236	0.236
ID clustering	✓	✓	✓	✓	✓	✓
Individual fixed effects			✓	✓		
Averages by ID/treatment					✓	✓

Linear regressions of accuracy on treatment dummies. Columns 1-4 are panel data regressions, columns 3-4 include individual fixed effects. Columns 5-6 are OLS regressions where each observation is average accuracy per treatment and individual and correspond to those in Table 2. Standard errors in parentheses clustered by individual.

D Experiment 4

Table A.8: Accuracy levels in Experiment 4

	(1) Accuracy	(2) Accuracy	(3) Accuracy	(4) Accuracy	(5) Accuracy	(6) Accuracy
Loss pattern	-8.438	-6.523	-8.455	-6.529	-8.452	-7.339
	(1.035)	(1.292)	(1.035)	(1.292)	(1.044)	(1.314)
High accuracy bonus (HAB)	1.729	1.205	1.798	1.286	1.732	1.050
	(0.567)	(0.801)	(0.572)	(0.807)	(0.628)	(0.856)
Difficult pattern (DP)	-7.023	-6.204	-7.025	-6.207	-7.064	-6.466
	(0.256)	(0.342)	(0.256)	(0.342)	(0.270)	(0.361)
Loss pattern x HAB		1.034		1.011		1.363
		(1.203)		(1.204)		(1.325)
Loss pattern x DP		-1.613		-1.613		-1.196
		(0.470)		(0.470)		(0.504)
Constant	89.37	88.40	89.31	88.33	89.53	88.98
	(0.707)	(0.794)	(0.674)	(0.757)	(0.734)	(0.800)
Observations	21114	21114	21114	21114	6502	6502
R^2			0.046	0.046	0.109	0.110
ID clustering	✓	✓	✓	✓	✓	✓
Individual fixed effects			✓	✓		
Averages by ID/treatment					✓	✓

Linear regressions of accuracy on treatment dummies. Columns 1-4 are panel data regressions, columns 3-4 include individual fixed effects. Columns 5-6 are OLS regressions where each observation is average accuracy per treatment and individual and correspond to those in Table 2. Standard errors in parentheses clustered by individual.

Table A.9: Regressions of cognitive effort on accuracy bonus across experiments

	(1) Concen-tration	(2) Concen-tration	(3) Concen-tration	(4) Response time (log)	(5) Response time (log)	(6) Response time (log)	(7) Response time (log)
High accuracy bonus (HAB)	0.117 (0.0330)	0.120 (0.0169)	0.173 (0.0259)	0.0377 (0.0169)	0.0525 (0.0129)	0.0311 (0.00646)	0.132 (0.0177)
Experiment no.	2	3	4	1	2	3	4
Fixed effects				✓	✓	✓	✓
Observations	442	852	814	11520	11396	33507	21111
R^2	0.007	0.017	0.012	0.001	0.003	0.001	0.013

Regressions of cognitive efforts on a dummy for the high accuracy bonus by experiment. Columns 1-3 show regressions on self-reported concentration, where an observation is an individual's average concentration over all trials in the High Bonus and Low Bonus condition. Concentration is measured as agreement with the statement "In the past 8 trials I was very concentrated on the task" on 5-point Likert scale. Columns 4-7 show panel regressions where the outcome variable is log response time in each trial, where the latter is measured in milliseconds. Panel regressions include individual fixed effects. Standard errors in parentheses are clustered by individual.

Table A.10: Accuracy levels in Experiment 4 split by dot counting behavior

	(1) Accuracy	(2) Accuracy	(3) Accuracy	(4) Accuracy
High accuracy bonus (HAB)	0.806 (0.759)	1.925 (0.969)	4.836 (1.976)	2.369 (0.871)
Counting dots:	Never	Sometimes	Always	Sometimes/Always
Observations	11255	7839	1863	9859
R^2	0.000	0.001	0.006	0.001

OLS regressions of accuracy on the accuracy bonus, split by dot-counting behavior. Standard errors in parenthesis are clustered at the individual level.

Table A.11: Response times in Experiment 4 split by dot counting behavior

	(1) Response time	(2) Response time	(3) Response time	(4) Response time
High accuracy bonus (HAB)	0.0579	0.251	0.207	0.234
	(0.0165)	(0.0390)	(0.0750)	(0.0359)
Counting dots:	Never	Sometimes	Always	Sometimes&Always
Observations	11255	7836	1863	9856
R^2	0.002	0.019	0.013	0.014

OLS regressions of log response times on the high accuracy bonus, split by dot-counting behavior in different columns. Standard errors in parenthesis are clustered at the individual level.

Table A.12: Accuracy levels in Experiment 4 split by dot counting behavior

	(1) Accuracy	(2) Accuracy	(3) Accuracy	(4) Accuracy
Loss pattern	-7.937	-11.46	-3.732	-10.12
	(1.733)	(2.090)	(2.849)	(1.810)
High accuracy bonus (HAB)	1.220	-0.171	4.389	0.720
	(1.097)	(1.356)	(2.306)	(1.177)
Loss pattern x HAB	-0.795	4.131	0.898	3.263
	(1.721)	(1.950)	(3.021)	(1.660)
Constant	76.69	80.64	87.85	81.88
	(0.991)	(1.157)	(2.209)	(1.048)
Counting dots:	Never	Sometimes	Always	Sometimes/Always
Observations	11255	7839	1863	9859
R^2	0.009	0.013	0.008	0.012

OLS regressions of accuracy on treatment dummies, split by dot-counting behavior. Each observation is the average accuracy per treatment and individual. Standard errors in parenthesis are clustered at the individual level.

E Losses versus gains

Panel A: Anxiety **Panel B: Excitement**

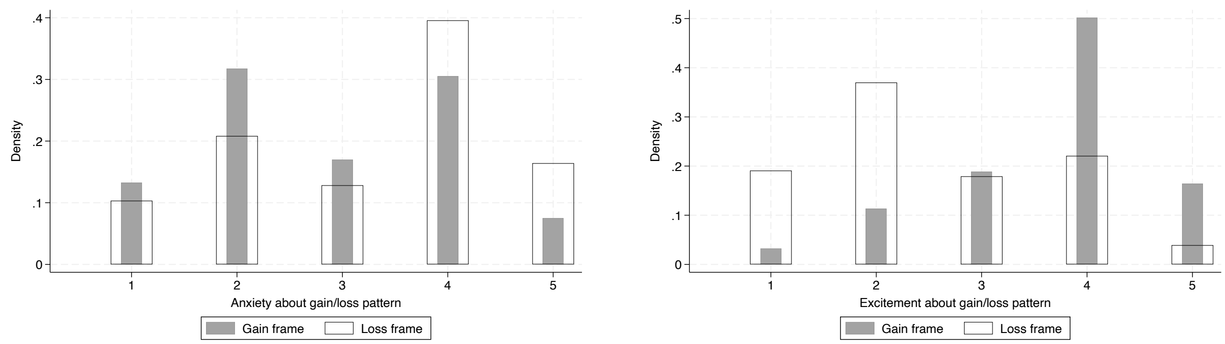


Figure A.2: Histogram of agreement with the statement "During the last set of trials, I felt anxious about whether or not the pattern would be a loss [gain] pattern (the word "anxious" refers to an uneasy, uncomfortable or unpleasant feeling)." (Panel a), or "During the last set of trials, I felt excited about whether or not the pattern would be a loss [gain] pattern (the word "excited" refers to a pleasant or even exhilarating feeling)."" (Panel b) in the Loss Frame [Gain Frame] treatment. Answers are measured on a 5-point Likert scale, split by loss size. Each report in an 8-trial block counts as one observation.

Table A.13: Accuracy in the gain and loss frame treatment.

	(1) Accuracy	(2) Accuracy	(3) Accuracy	(4) Accuracy
Loss/No-gain	-4.050	-13.03	-0.848	1.842
	(1.133)	(1.517)	(2.677)	(2.080)
Gain Frame		-6.667		
		(1.524)		
Gain Frame X Loss/No-gain		17.98		
		(2.148)		
Low Emotions (d)			-0.259	
			(2.019)	
Loss/No-gain X Low Emotions (d)			9.580	
			(3.197)	
Risk Averse (d)				0.793
				(1.923)
Loss/No-gain X Risk Averse (d)				6.930
				(3.016)
Constant	63.01	66.36	59.85	59.32
	(0.774)	(1.186)	(1.665)	(1.292)
Treatment	Gain and loss	Gain and loss	Gain only	Gain only
Observations	19200	19200	9600	9600
R^2	0.002	0.011	0.007	0.006

OLS regressions of accuracy on treatment dummies. Columns 1-2 include data from both Gain and Loss Frame domain, columns 3-4 from the Gain Frame only. ”Loss/No-gain” is a dummy that equals 1 if the pattern is associated with a Loss (Loss Frame) or the absence of a gain (Gain Frame). ”Gain frame” is a dummy that equals 1 in Gain Frame. ”Risk Averse” is a dummy that is 1 if a subject self-reports being risk-averse, i.e. scores lower than 4 on the question “How would you evaluate your own attitude towards risk: Are you rather a risk-taking or risk-averse person (trying to avoid risks)? 1: Very risk-averse, 7: Very risk-seeking”. ”Low Emotions” is a dummy that equals 1 if a subject scores lower than 7 (an approximate median split) on an index that sums the average reported anxiety and excitement in the experiment. Standard errors in parentheses clustered by individual.

F Dynamics

Table A.14: The dynamics of wishful thinking

	(1) Accuracy	(2) Accuracy	(3) Accuracy	(4) Accuracy	(5) Accuracy	(6) Accuracy	(7) Accuracy	(8) Accuracy
Loss pattern	-6.519	-17.22	-2.441	-7.374	-5.592	-17.02	-3.590	-6.375
	(2.089)	(2.066)	(1.003)	(1.856)	(1.672)	(1.968)	(0.784)	(1.661)
Trial	0.0411	0.0464	0.0164	0.0240				
	(0.0138)	(0.0299)	(0.0158)	(0.0267)				
Loss pattern x Trial	0.0260	0.0159	-0.0477	-0.0250				
	(0.0156)	(0.0458)	(0.0233)	(0.0388)				
Second half					5.190	2.946	0.0352	2.897
					(1.812)	(1.540)	(0.704)	(1.169)
Loss pattern x Second half					3.422	0.731	-1.566	-2.783
					(2.206)	(2.422)	(0.937)	(1.807)
Experiment	1	2	3	4	1	2	3	4
Observations	11520	11396	33507	21114	11520	11396	33507	21114
R^2	0.008	0.035	0.003	0.010	0.008	0.035	0.003	0.011

OLS regression of accuracy on shock/loss and no-shock/no-loss patterns and temporal indices in various experiments. All regressions include participant fixed effects. Standard errors in parenthesis clustered at the participant level.

Table A.15: Accuracy and response to previous losses

	(1) Accuracy	(2) Accuracy	(3) Accuracy	(4) Accuracy	(5) Accuracy	(6) Accuracy	(7) Accuracy	(8) Accuracy
Loss/shock pattern	-3.559	-16.83	-4.200	-8.269	-6.375	-17.52	-2.219	-7.202
	(1.243)	(1.569)	(0.795)	(1.082)	(2.157)	(2.089)	(1.015)	(1.886)
Lagged actual loss	-0.462	-1.655	-0.731	1.134	-0.409	-1.679	-0.699	1.124
	(1.695)	(1.406)	(0.821)	(1.083)	(1.696)	(1.407)	(0.821)	(1.084)
Loss pattern x Lagged loss	-0.933	1.727	-1.487	-0.928	-0.950	1.660	-1.570	-0.932
	(2.677)	(2.257)	(1.268)	(1.717)	(2.702)	(2.259)	(1.266)	(1.718)
Trial					0.0411	0.0464	0.0166	0.0237
					(0.0138)	(0.0299)	(0.0158)	(0.0267)
Loss pattern x Trial					0.0260	0.0161	-0.0484	-0.0250
					(0.0156)	(0.0458)	(0.0232)	(0.0388)
Constant	72.42	77.27	78.14	79.42	67.95	75.36	77.46	78.42
	(0.667)	(0.789)	(0.415)	(0.569)	(1.544)	(1.275)	(0.739)	(1.249)
Experiment	1	2	3	4	1	2	3	4
Observations	11520	11396	33507	21114	11520	11396	33507	21114
R^2	0.002	0.035	0.003	0.010	0.008	0.035	0.003	0.010

OLS regression of accuracy on shock/loss and no-shock/no-loss patterns and lagged shocks or losses. All regressions include participant fixed effects. Standard errors in parenthesis clustered at the participant level.

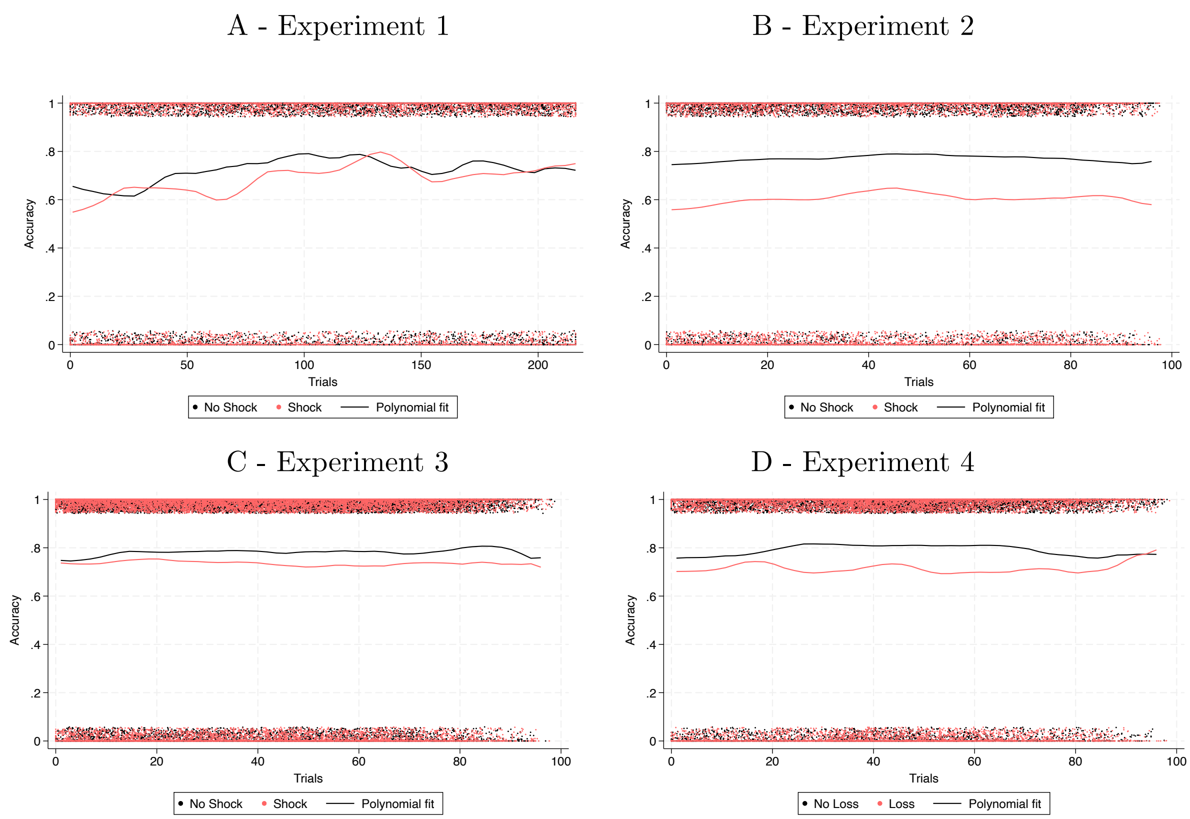


Figure A.3: Dynamics of wishful thinking over time by experiment. x-Axis shows trial numbers. y-Axis is accuracy in single trials (dots - jitter added) and a polynomial fit (line). Note that in Experiment 2, 3, and 4, not all participants completed the same number of trials, as trials stopped when participants reached 5 cumulative (and stochastic) losses from their endowment.

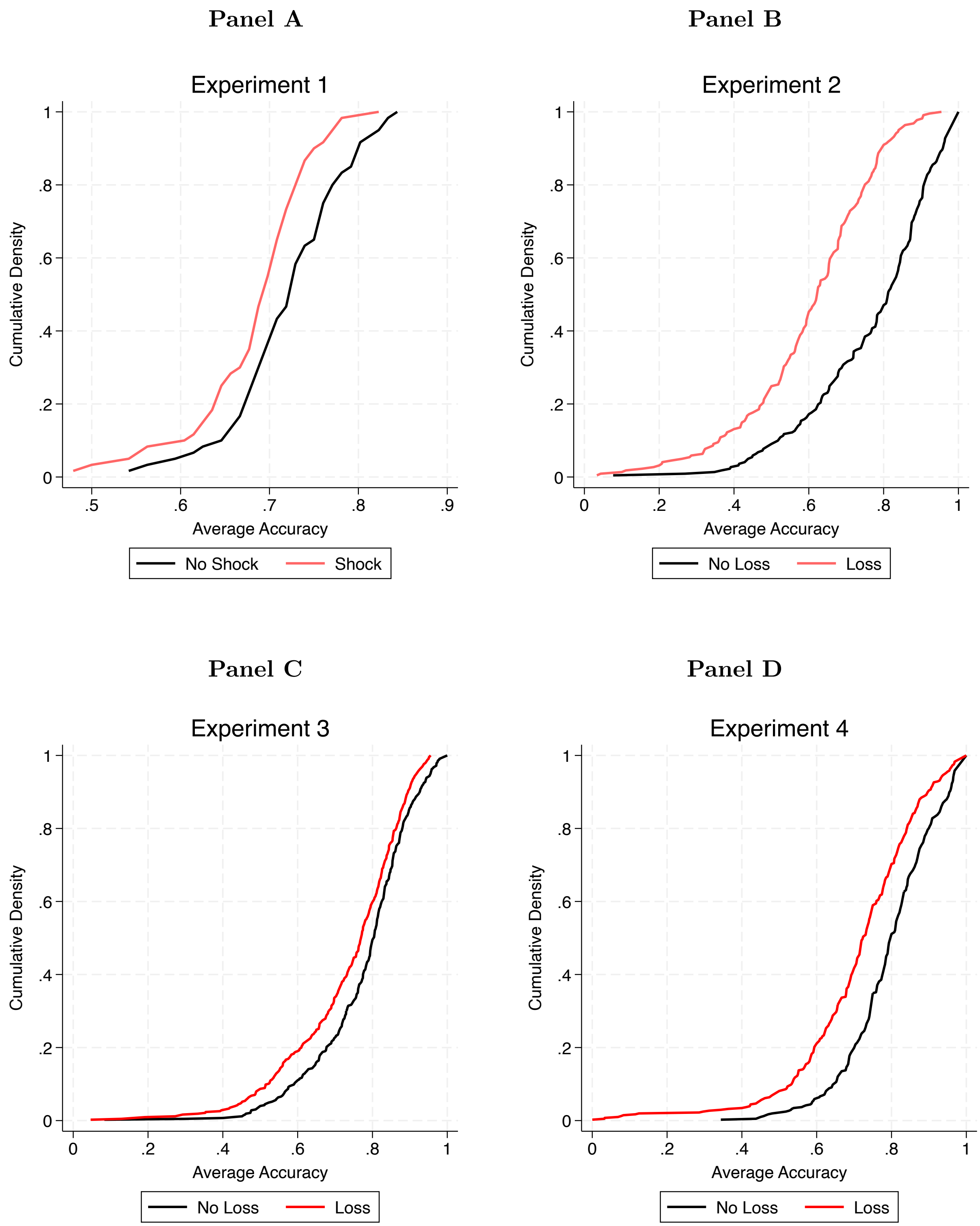


Figure A.4: CDFs of participants' average accuracy in each experiment, split by shock/loss and no-shock/no-loss patterns. Each observation is the average accuracy of all trials of an individual participant in that category.

G Robustness

Table A.16: Accuracy and treatment effect in selected samples

	(1) Accuracy	(2) Accuracy	(3) Accuracy	(4) Accuracy	(5) Accuracy	(6) Accuracy	(7) Accuracy
Shock pattern	-7.210	-5.966	-7.005	-6.849	-6.654	-6.390	-6.975
	(0.738)	(0.851)	(0.937)	(0.826)	(0.725)	(0.820)	(0.819)
High accuracy bonus (HAB)	0.695	0.992	0.838	0.976	0.735	0.626	1.306
	(0.508)	(0.632)	(0.685)	(0.595)	(0.534)	(0.575)	(0.593)
Difficult pattern (DP)	-7.996	-8.264	-8.190	-7.903	-8.222	-7.901	-7.987
	(0.347)	(0.416)	(0.453)	(0.383)	(0.350)	(0.393)	(0.385)
Shock pattern x HAB	0.745	0.716	1.418	0.338	1.029	1.034	0.0338
	(0.782)	(0.967)	(1.067)	(0.934)	(0.825)	(0.872)	(0.906)
Shock pattern x DP	-1.328	-1.530	-1.457	-1.656	-1.423	-1.318	-1.188
	(0.481)	(0.571)	(0.633)	(0.533)	(0.474)	(0.523)	(0.533)
Constant	82.21	77.23	77.12	76.31	82.60	81.53	75.80
	(0.740)	(1.227)	(1.328)	(1.109)	(0.665)	(0.845)	(1.100)
Restrictions	None	Difficult Instructions < 4 out of 7	Hard to recall conditions < 5 out of 7	Total no. of mistakes on control q. < 3	Average accuracy > 60 percent	Trust in experimenters > 2 out of 5	Answer does not cause shock
ID clustered S.E.	✓	✓	✓	✓	✓	✓	✓
Experiment fixed effects	✓	✓	✓	✓	✓	✓	✓
Observations	12397	8388	7388	9710	11204	9663	9717
R^2	0.134	0.138	0.135	0.135	0.149	0.130	0.132

OLS regressions of accuracy on treatments across experiments. An observation is the average accuracy per treatment and individual. All regressions include experiment fixed effects and standard errors clustered at the individual level. “Shock pattern” is a dummy representing the pattern is associated with a shock (Experiment 1) or loss (Experiments 2-4). “High accuracy bonus” is a dummy that represents a high accuracy bonus, while “Difficult pattern” is a categorical variable that measures the difficulty of the perceptual task, (see 1 for exact specification by experiment). Column 2 excludes participants with one of the three highest scores on the question “How difficult did you find it to follow the instructions of this experiment?” measured on a 7-point Likert scale. Column 3 excludes participants with one of the three highest scores on the question ““How difficult did you find it to keep in mind information about the potential losses and bonuses associated with trials” measured on a 7-point Likert scale. Column 4 excludes participants who wrongly answered more than two control questions at the beginning of the experiment. Column 5 excludes participants whose average accuracy in the experiment is below 60 percent. Column 6 excludes participants with the three lowest agreement scores with the statement “During the experiment, I never thought that I was deceived by the experimenters about my possible gains or losses” measured on a 5 point Likert scale. Column 7 excludes participants who wrongly answered a multiple choice question about the determinants of the shock. Data in column 2, 3, 4 and 7 exclude Experiment 1, where the relevant measure was not collected.

Table A.17: Accuracy and treatment effect in selected samples, panel regressions

	(1) Accuracy	(2) Accuracy	(3) Accuracy	(4) Accuracy	(5) Accuracy	(6) Accuracy	(7) Accuracy
Shock pattern	-5.989	-5.009	-5.799	-5.799	-5.229	-5.025	-6.202
	(0.679)	(0.785)	(0.861)	(0.757)	(0.631)	(0.748)	(0.758)
High accuracy bonus (HAB)	0.561	0.880	0.678	0.755	0.738	0.629	0.919
	(0.413)	(0.510)	(0.546)	(0.477)	(0.434)	(0.469)	(0.479)
Difficult pattern (DP)	-9.412	-9.815	-9.812	-8.690	-8.929	-9.406	-9.517
	(0.345)	(0.438)	(0.476)	(0.384)	(0.321)	(0.395)	(0.403)
Shock pattern x HAB	0.726	0.911	1.512	0.376	0.811	0.709	0.326
	(0.599)	(0.729)	(0.779)	(0.705)	(0.625)	(0.663)	(0.701)
Shock pattern x DP	-1.842	-2.173	-2.186	-2.314	-1.946	-1.827	-1.778
	(0.435)	(0.531)	(0.591)	(0.499)	(0.422)	(0.475)	(0.502)
Constant	85.14	86.77	87.25	86.17	87.85	85.06	86.55
	(0.424)	(0.510)	(0.549)	(0.553)	(0.421)	(0.481)	(0.483)
Restrictions	None	Difficult Instructions < 4 out of 7	Hard to recall conditions < 4 out of 7	Total no. of mistakes on control q. < 3	Average accuracy > 60 percent	Trust in experimenters > 2 out of 5	Answer does not cause shock
ID clustered S.E.	✓	✓	✓	✓	✓	✓	✓
Individual fixed effects	✓	✓	✓	✓	✓	✓	✓
Observations	77537	47486	42017	55054	68774	61235	53357
R^2	0.040	0.047	0.048			0.039	0.046

Linear regressions of accuracy on treatments across experiments. We use a panel data structure where each observation is a single trial, and regressions include individual fixed effects and standard errors clustered at the individual level. "Shock pattern" is a dummy if the pattern is associated with a shock (Experiment 1) or loss (Experiments 2-4). "High accuracy bonus" is a dummy that represents a high accuracy bonus, while "Difficult pattern" is a categorical variable that measures the difficulty of the perceptual task, (see 1 for exact specification by experiment). Column 2 excludes participants with one of the three highest scores on the question "How difficult did you find it to follow the instructions of this experiment?" measured on a 7-point Likert scale. Column 3 excludes participants with one of the three highest scores on the question ""How difficult did you find it to keep in mind information about the potential losses and bonuses associated with trials" measured on a 7-point Likert scale. Column 4 excludes participants who wrongly answered more than two control questions at the beginning of the experiment. Column 5 excludes participants whose average accuracy in the experiment is below 60 percent. Column 6 excludes participants with the three lowest agreement scores with the statement "During the experiment, I never thought that I was deceived by the experimenters about my possible gains or losses" measured on a 5 point Likert scale. Column 7 excludes participants who wrongly answered a multiple choice question about the determinants of the shock. Data in column 2, 3, 4 and 7 exclude Experiment 1, where the relevant measure was not collected.

Table A.18: Comparison of accuracy of neutral, loss and no-loss patterns

	(1) Accuracy	(2) Accuracy
Loss pattern	-0.110	-0.0449
	(-8.83)	(-5.43)
No-loss pattern	0.0586	0.0398
	(6.52)	(6.35)
Constant	0.712	0.757
	(70.05)	(145.67)
	Experiment 2	Experiment 4
Observations	1105	1221
R^2	0.140	0.065

OLS regression of accuracy on neutral, loss and no-loss patterns in Experiment 2 and 4. Baseline are neutral patterns where no shock was administered present. Each observation is average accuracy per treatment and individual. Standard errors clustered at the participant level in parentheses.

B Heterogeneity

Figure B.1 depicts the histograms of individual-level wishful thinking in experiments 1 through 4. Table B.1 reports half-split correlations. For this exercise we split trials into odd and even numbered trials, trials with easy and trials with difficult patterns, trials in the first half and trials in the second half of the experiment and, for Experiment 2, trials with high stakes and trials with low stakes. Calculating such half-split correlations is common in psychology, where they are used to assess the reliability of individual measures derived from cognitive tasks (for example, see Pronk et al. 2021).[29]

Columns 1 through 3 of Table B.1 report the half-split correlations of wishful thinking.[30] Correlations are around 0.5, with some fluctuations depending on how we split the data, indicating that heterogeneity in wishful thinking reflects individual differences. Moreover, our measure of wishful thinking is only slightly less reliable or stable than participants' skill in the pattern recognition tasks, as shown by the half split correlations in accuracy that we report in columns 4 through 6 of Table B.1. To further show that our results are not driven by a few outliers, Figure B.2 shows the scatterplots pertaining to the odd-even trial splits in Table B.1.

[29] In the same vein, our results here also help us assess how reliably our experimental design identifies wishful thinking.

[30] We exclude Experiment 1 because there we recalibrated both the strength of the shock and the difficulty of the patterns during the experiment. This confounds the half-split correlations of wishful thinking and accuracy.

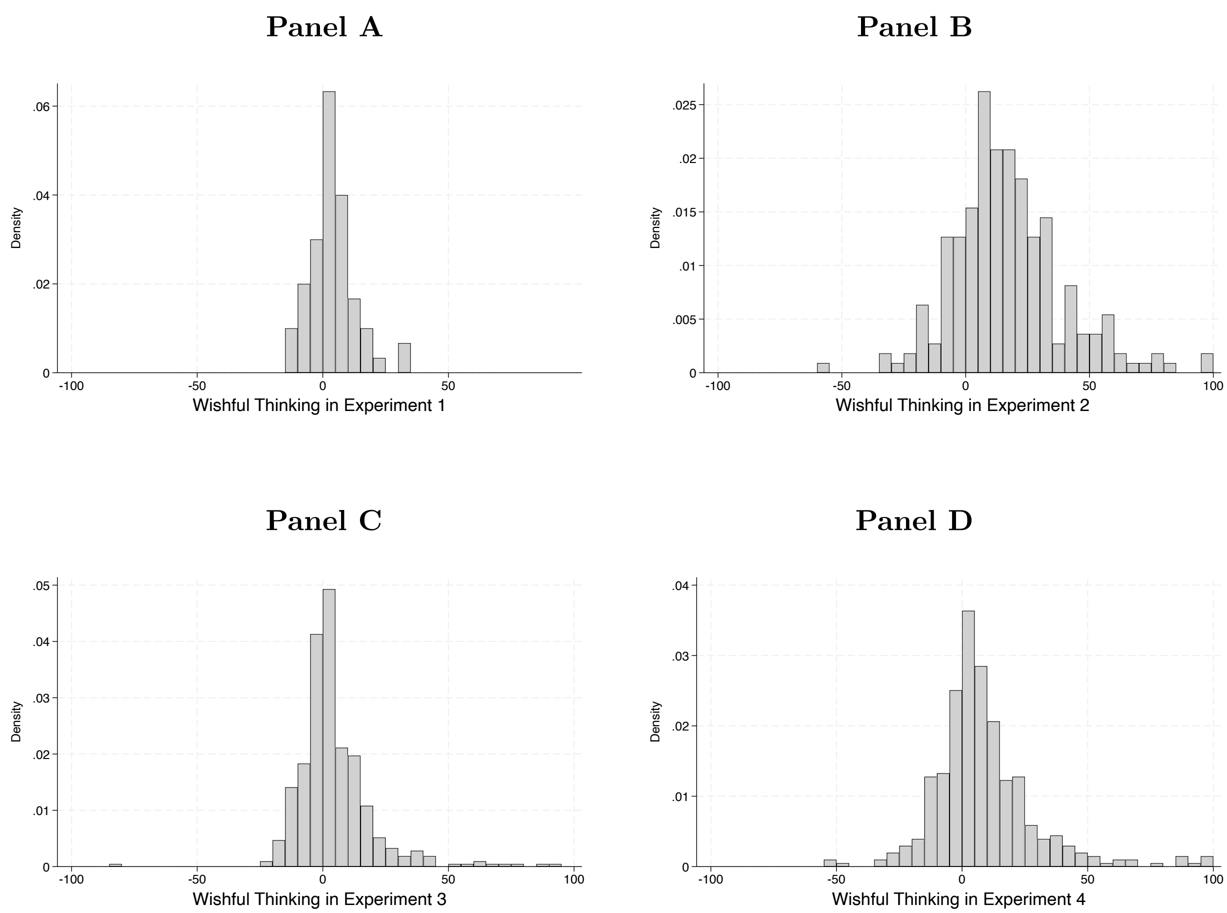


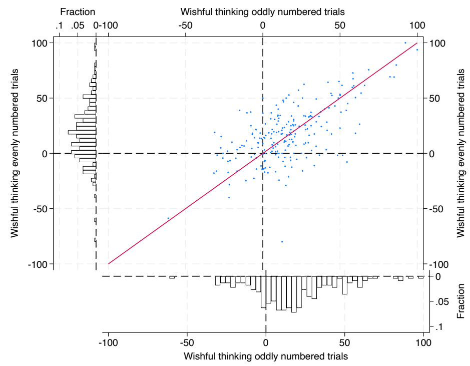
Figure B.1: Histograms of participants' wishful thinking in each experiment. Wishful thinking is defined as an individual's accuracy for shock patterns minus their accuracy for no shock patterns.

Table B.1: Half-split correlations

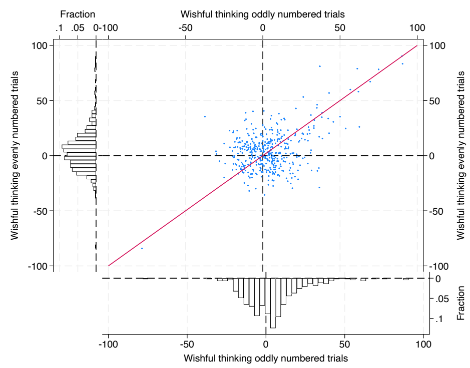
	Wishful thinking			Accuracy		
	(1)	(2)	(3)	(4)	(5)	(6)
X/Y	Exp. 2	Exp. 3	Exp. 4	Exp. 2	Exp. 3	Exp. 4
Odd/even trials	0.641	0.461	0.570	0.592	0.730	0.476
Difficult/easy patterns	0.573	0.526	0.457	0.575	0.497	0.563
First/second half	0.441	0.435	0.350	0.663	0.568	0.478
Low/high losses	0.460	-	-	0.589	-	-

Correlations between individual participants' wishful thinking or accuracy as measured in X and Y trials. X and Y correspond to odd and even, difficult and easy, first and second half, and low and high loss trials respectively.

A - Experiment 2



B - Experiment 3



C - Experiment 4

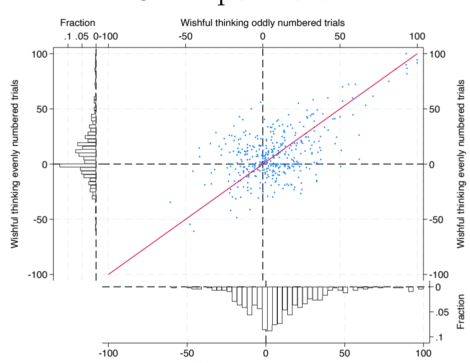


Figure B.2: Scatterplot of participants' wishful thinking in odd and even trials in each experiment. Wishful thinking is defined as an individual's accuracy for shock patterns minus their accuracy for no-shock patterns. Each plot includes the 45 degree line as well as projected histograms for odd and even trials.

C Replication Experiment 1

Before conducting Experiment 1, we ran an experiment with an almost identical design, which was also preregistered on aspredicted.org (preregistration is here). There were some small differences. First, the experiment also featured some neutral trial blocks in which subjects did not face the threat of a shock. Second, while we used the same visual patterns for the task, subjects had to indicate whether they were vertically or horizontally oriented (rather than choosing the closest diagonal), and there were four difficulty levels. Third, incentives were constant across the experiment. Finally, the experimental code exhibited a small bug which meant that the ambiguity levels were not equally calibrated across the Shock and No-shock condition. While we are able to control for the ambiguity level (see below), the imperfect randomization ultimately caused us to rerun this experiment, resulting in Experiment 1. For our purposes, two aspects of the precursor experiment are of interest. First, we investigate whether our main treatment effect obtains also in this study. The experiment replicates our main results with very similar effect sizes (μ) between shock and no-shock patterns (Accuracy: $\mu = 0.047$, $s.d. = 0.103$, $p = 0.0024$; Belief: $\mu = 0.031$, $s.d. = 0.069$, $p = 0.0022$). Table C.1 shows the result of an OLS regression of Accuracy and Belief, averaged by subject and condition, on treatment dummies. Because pattern difficulty was not well balanced between the Shock and No-Shock conditions, we control for difficulty in Table C.1. This shows similar results, with a highly significant effect of the Shock condition which is 0.037 for Accuracy and 0.029 for Belief, closely mirroring the magnitudes in our main experiment.

Second, the presence of "Neutral" trials without the threat of shocks allows us to investigate the "noise explanation" elaborated in Section VII.C, where we inspect how the presence of a shock-threat affects Accuracy and Beliefs. We find that the Accuracy and Belief in the Neutral patterns are substantially worse than in the No-Shock patterns. This shows that the presence of a shock does not necessarily reduce performance, reinforcing our confidence that wishful thinking is driving our main result.

	(1) Accuracy	(2) Belief
Shock Pattern	-3.734	-2.854
	(1.521)	(1.034)
Neutral Pattern	-3.392	-3.714
	(1.140)	(0.736)
Difficulty	-3.490	-2.553
	(0.497)	(0.411)
Constant	90.38	80.98
	(1.323)	(1.268)
Observations	600	600
R^2	0.098	0.087

Table C.1: OLS regressions of Accuracy and Belief on the experimental conditions. Standard errors in parentheses clustered at subject level.

D Theory extensions

A Anticipatory utility from accuracy incentives

In the following, we suppose that the agent also obtains utility from her anticipation of incentives for accuracy. Her utility then takes the following form.

$$
\begin{aligned}
U = \; & \frac{1}{2}\left(1 + 2p\hat{p} - \hat{p}^2\right) M + \sigma_m \frac{1}{2}\left(1 + \hat{p}^2\right) M \\
& - (r_z p + (1 - r_z)(1 - p))qZ - \sigma_z (r_z \hat{p} + (1 - r_z)(1 - \hat{p}))qZ \\
& - \lambda(s)(p - \hat{p})^2,
\end{aligned}
$$

where σ_m captures the agent's propensity to savor future payoffs from the accuracy incentives and is distinct from the anxiety of being shocked or losing money, which is still parameterized by σ_z. Note that the agent's anticipatory utility from expecting future accuracy payoffs depends only on her chosen belief $\hat{p}$ and not on the undistorted or true probability of the pattern being right-tilted p.

Maximizing the agent's utility then yields the following optimal beliefs

$$
\hat{p}^* = \frac{M + 2\lambda(s)}{(1 - \sigma_m)M + 2\lambda(s)} p(s, r_\theta) - \frac{\sigma_z (2r_z - 1)qZ}{(1 - \sigma_m)M + 2\lambda(s)},
$$

and wishful thinking is given by

$$
W := \hat{p}^*(r_z = 0) - \hat{p}^*(r_z = 1) = \frac{2\sigma_z qZ}{(1 - \sigma_m)M + 2\lambda(s)}.
$$

We see that an anticipatory utility motive stemming from the savoring of accuracy incentives does not change qualitative predictions regarding the drivers of anxiety-induced wishful thinking. In particular, the comparative statics of wishful thinking in M, s and Z have the same sign they had in the main model. However, wishful thinking is now increasing in the savoring parameter σ_m because the higher σ_m, the more the agent cares about her perceived rather than her actual receipt of accuracy incentives, and the former is not decreasing in the amount of belief distortion.

B Defensive pessimism and bracing

To capture defensive pessimism or bracing we suppose that the agent maximizes the following utility function.[31]

$$\begin{aligned} U = \; & \frac{1}{2}\left(1 + 2p\hat{p} - \hat{p}^2\right) M \\ & - (r_z p + (1 - r_z)(1 - p))q(Z - b\hat{p}Z) - \sigma_z(r_z\hat{p} + (1 - r_z)(1 - \hat{p}))q(Z - b\hat{p}Z) \\ & - \lambda(s)(p - \hat{p})^2. \end{aligned}$$

Here, parameter b captures the benefit of bracing or the extent to which defensive pessimism can soften the blow of a shock or loss. If $b = 0$, pessimistic beliefs do not lessen the impact of a shock. In the other extreme, $b = 1$, the agent can fully negate the shock's impact by being maximally pessimistic. The agent's optimal beliefs are then given by

$$\begin{aligned} \hat{p}^*(r_z = 1) &= \frac{M + 2\lambda(s) + bZ}{M + 2\lambda(s) - 2\sigma_z qbZ}p - \frac{\sigma_z qZ}{M + 2\lambda(s) - 2\sigma_z qbZ} \\ \hat{p}^*(r_z = 0) &= \frac{M + 2\lambda(s) - bZ}{M + 2\lambda(s) + 2\sigma_z qbZ}p + \frac{\sigma_z qZ}{M + 2\lambda(s) + 2\sigma_z qbZ}. \end{aligned}$$

We can check that $\frac{d\hat{p}^*(r_z=1)}{db} > 0$ and $\frac{d\hat{p}^*(r_z=0)}{db} < 0$. So the bracing motive decreases apparent wishful thinking, which is defined as $W := \hat{p}^*(r_z = 0) - \hat{p}^*(r_z = 1)$. Furthermore, it is easy to verify that there is wishful thinking, i.e. $\hat{p}^*(r_z = 1) < p$ and $\hat{p}^*(r_z = 0) > p$, only if the following inequality holds

$$b < \frac{\sigma_z q}{1 + 2\sigma_z q}.$$

This inequality is satisfied for small b and large σ_z. Therefore, if we detect wishful thinking in our average participant, then we provide evidence not just for wishful thinking but for the fact that the anticipatory anxiety motive dominates the defensive pessimism or bracing motive.

C The correlation between anxiety and wishful thinking

The agent's utility function contains a term that captures her experienced anxiety conditional on her (optimal) belief and the tilt of the shock pattern. Since the shock pattern is right-tilted 50

[31] We take "bracing" to mean any action or investment that can reduce the impact (physical or otherwise) of negative news or events. Defensive pessimism is a more specific concept and form of bracing. It is a cognitive strategy that allows one to deal with the psychological impact of negative events by holding negative expectations (Norem and Cantor, 1986).

percent of the time and left-tilted 50 percent of the time, average experienced anxiety is given by

$$A = \frac{1}{2}\sigma_z \hat{p}^*_{r_z=1} qZ + \frac{1}{2}\sigma_z(1 - \hat{p}^*_{r_z=0})qZ$$

Substituting into this term her respective optimal beliefs $\hat{p}^*_{r_z=1}$ and $\hat{p}^*_{r_z=0}$ from the main model yields

$$A = \frac{1}{2}\sigma_z qZ - \frac{\sigma_z^2 q^2 Z^2}{M + 2\lambda}.$$

Next, we turn to the comparative statics of A in λ and σ_z. Comparing these with the comparative statics of W in λ and σ_z, will allow us to see how heterogeneities in λ and σ_z map into correlations between experienced anxiety and wishful thinking.

It is easy to see that $\frac{dA}{d\lambda} > 0$, so that experienced anxiety is increasing in the cognitive costs of self-deception. How A varies with σ_z is more subtle. We can show that $\frac{dA}{d\sigma_z} > 0$ if and only if

$$\sigma_z < \frac{4q^2Z^2}{M + 2\lambda}, \tag{C.1}$$

and $\frac{dA}{d\sigma_z} \leq 0$ otherwise. So experienced anxiety A is increasing in innate anxiety σ_z for small levels of innate anxiety and decreasing for higher levels. To see why experienced anxiety must eventually decrease in innate anxiety note that for very high levels of innate anxiety the agent will engage in sufficient wishful thinking to put zero subjective probability on the negative outcome, leaving her with no experienced anxiety.

We can use our experimental results to get a sense of where in the parameter space participants are likely to be located. To this end, note that inequality C.1 can be rewritten to state that $\frac{dA}{d\sigma_z} > 0$ if and only if

$$W < \frac{1}{2}$$

Clearly, average wishful thinking is well below 50 percentage points in all experiments. Going forward we therefore assume that inequality C.1 is satisfied.

Putting together the comparative statics on σ_z and λ, we now consider two scenarios.

Secenario A (heterogeneity in λ). Suppose there are two groups of participants (group 1 and group 2) that differ only in λ, their cognitive costs of self-deception. In particular, suppose that $\lambda_1 < \lambda_2$, where the subscript is the group label. Based on how W and A vary with λ, it will then be the case that $W_1 > W_2$ and $A_1 < A_2$. Therefore, in this scenario, wishful thinking and experienced anxiety are negatively correlated, as those with low cost of self-deception have higher wishful thinking and hence lower experienced anxiety.

Secenario B (heterogeneity in σ_z). Now suppose there are two groups of participants (group 1 and group 2) that differ only in σ_z, their innate anxiety. In particular, suppose that $\sigma_{z1} < \sigma_{z2}$, where the subscript is the group label. Based on how W and A vary with σ_z, it will then be the case that $W_1 < W_2$ and $A_1 < A_2$. Therefore, in this scenario, wishful thinking and experienced anxiety are positively correlated, as high innate anxiety leads to the higher experienced anxiety, despite a partial offset by higher wishful thinking.

Considering these two scenarios allows us to conclude that, according to the model, whether measures of experienced anxiety and wishful thinking are positively, negatively, or not correlated is ambiguous. More specifically, it will depend on whether there is a dominant heterogeneity and whether this heterogeneity is in participants' ability to self-deceive σ_z (negative correlation) or in their innate anxiety λ (positive correlation).

D Optimal beliefs with a hard cognitive constraint

In this section we describe a model that better captures the statistical relationships we see in the data. We will add two elements to the model. First, self-deception is constrained to some maximum amount or hard cognitive constraint. One interpretation, closest to our original model and developed below in more detail, is that this is a binding constraint on an optimizing agent who chooses optimal beliefs. A second interpretation is that self-deception is an "automatic" or "system 1" process, where a certain amount of self-deception occurs automatically without an agent's cognitive influence. The second new element is that the constraint on self-deception depends on the signal strength, which is determined by the agent's investment in signal precision or information-gathering.

Thus, we suppose that the agent first invests in signal precision at time $t = 0$ and then distorts her mental representation of the signal at time $t = 1$. To solve the agent's problem, we first look at $t = 1$.

D.1 Belief choice conditional on the signal at $t = 1$

Consider the following maximization problem.

$$
\begin{aligned}
Max \quad U_1 = \quad & \frac{1}{2}\left(1 + 2p\hat{p} - \hat{p}^2\right) M \\
& - (r_z p + (1 - r_z)(1 - p))qZ - \sigma_z(r_z\hat{p} + (1 - r_z)(1 - \hat{p}))qZ \\
\text{such that} \quad & |p - \hat{p}| \leq \lambda(s)
\end{aligned}
$$

So self-deception is cognitively costless up to a point and then becomes impossible. In line with our results, we further assume that the maximum distance between true and distorted beliefs is decreasing in s, the signal precision, i.e. $\lambda'(s) < 0$.

Solving this maximization problem yields the following optimal beliefs.

$$
\hat{p}^* = \begin{cases} \max(p - \frac{\sigma_z qZ}{M}, p - \lambda(s)) & \text{if} \quad r_z = 1 \\ \min(p + \frac{\sigma_z qZ}{M}, p + \lambda(s)) & \text{if} \quad r_z = 0 \end{cases}
$$

Our results in Experiments 1 to 3 indicate that ex-post signal distortion responds to s, but not to M or Z. In other words, the cognitive constraint is binding for all values of M and Z and optimal beliefs are given by $p - \lambda(s)$ for right-tilted patterns and by $p + \lambda(s)$ for left-tilted patterns. In this case, wishful thinking is given by $W = 2\lambda(s)$, which is decreasing in signal precision s.

In a next step we look the an agent's investment in signal precision.

D.2 Investment in signal precision at $t = 0$

The agent decides on her investment in signal precision knowing whether shocks are associated with left or with right-tilted patterns and anticipating the effect of signal precision on her payments from the BDM mechanism and her ability to self-deceive. At the point of deciding on the cognitive effort she spends on identifying the pattern, she does not know the actual tilt of the pattern and merely has a 50:50 prior over whether the pattern is left- or right-tilted. Her choice of signal precision s maximizes the following function.

$$
\begin{aligned}
U_0 = \quad & \frac{1}{2}\left(\hat{p}_{r_t=1}M + (1 - \hat{p}_{r_t=1})\frac{1 + \hat{p}_{r_t=1}}{2}M\right) + \frac{1}{2}\left((1 - \hat{p}_{r_t=0})\frac{1 + \hat{p}_{r_t=0}}{2}M\right) \\
& - \frac{1}{2}\sigma_Z(r_z\hat{p}_{r_t=1} + (1 - r_z)(1 - \hat{p}_{r_t=1}))qZ - \frac{1}{2}\sigma_Z(r_z\hat{p}_{r_t=0} + (1 - r_z)(1 - \hat{p}_{r_t=0}))qZ \\
& - \frac{1}{2}qZ - c(s),
\end{aligned} \tag{C.2}
$$

where $c(s)$ is the cognitive cost associated with generating more precise representations of the signal. Moreover, $\hat{p}_{r_t=\{0,1\}}$ are the agent's optimal $t = 1$ beliefs, conditional on the true pattern, that depend on $p_{r_t=\{0,1\}}$, her undistorted belief, which in turn depends on $s \in [0.5, 1]$.

For simplicity, we assume that undistorted beliefs are $p_{r_t=1} = s$ and $p_{r_t=0} = 1 - s$. So as s increases, the agent becomes more accurate in identifying both right- and left-tilted patterns. Furthermore, we assume that $\lambda(s) = \epsilon(1 - s)$ and that $c(s) = cs^2$.

We consider the case of $r_z = 1$ so that $\hat{p}_{r_t} = p_{r_t} - \lambda(s)$. Then, substituting the expressions for $p_{r_t=\{0,1\}}$, $\lambda(s)$ and $c(s) = cs^2$ into C.2 and simplifying yields

$$\begin{aligned} U_0 = \quad & \frac{1}{2}M\left(\frac{1}{2} + 2s - s^2 - \frac{1}{2}\epsilon^2(1 - s)\right) \\ & - \frac{1}{2}\sigma_Z(1 - \epsilon + \epsilon s)qZ \\ & - \frac{1}{2}qZ - cs^2 \end{aligned}$$

The s that maximizes this ex ante utility is given by

$$s^* = \frac{\frac{1}{2}M(2 + \epsilon^2) - \frac{1}{2}\sigma_z \epsilon qZ}{\frac{1}{2}M(2 + \epsilon^2) + 2c} \tag{C.3}$$

Taking the first derivative yields that $\frac{ds^*}{dM} > 0$. So an increase in accuracy incentives increases signal precision. Then, because $\lambda'(s) < 0$ and wishful thinking is decreasing in λ, we have that $\frac{dW}{dM} < 0$.

Note that this chain of reasoning depends on the agent being *able* to increase her signal precision, i.e. $\frac{ds^*}{dM} > 0$. Across our experiment, only dot counters in experiment 4 were able to increase their accuracy in pattern recognition (a proxy for signal precision) in response to an increase in incentives.

Hypothesis C.1 (Incentives) *If signal precision and hence, accuracy, is increasing in accuracy incentives* $\frac{ds^*}{dM} > 0$*, then wishful thinking is decreasing in accuracy incentives, i.e.* $\frac{dW}{dM} < 0$.

Naivite and sophistication. Here we assumed that the agent is sophisticated about the effect of her investment in s on her ability to self-deceive. An agent who is naive about the link between signal precision and her subsequent ability to self-deceive expects that $\lambda'(s) = 0$. The naive agent's optimal signal precision is then given by

$$s^*_n = \frac{M}{M + 2c} \tag{C.4}$$

For the naive it will therefore also be the case that $\frac{ds_n^*}{dM} > 0$. Because, in reality, $\lambda(s) > 0$ and $\lambda'(s) < 0$, a naive's wishful thinking will then also be decreasing in M. This implies that the result that wishful thinking is decreasing in M does not help us distinguish between naives and sophisticates. However, note that s^* but not s_n^* are increasing in Z, the size of the loss or shock. A positive effect of Z on wishful thinking is therefore suggestive of sophistication.

E IRB and Preregistration

UNIVERSITY OF AMSTERDAM

Ethics Committee Economics and Business (EBEC)
University of Amsterdam

Amsterdam Business School
Plantage Muidergracht 12
1012 TV Amsterdam
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To: van der Weele

Date	Our reference	
June 12, 2017	EC 20170510120541	
Contact	Telephone	E-Mail
Sophia de Jong	(31)20-5255311	secbs-abs@uva.nl
Subject		
EBEC approval		

Dear Joel van der Weele,

The Economics & Business Ethics Committee (University of Amsterdam) received your request nr 20170510120541 to approve your project "Anticipatory utility and probabilistic confidence".

We evaluated your proposed research in terms of potential impact of the research on the participants, the level and types of information and explanation provided to the participants at various stages of the research process, the team's expertise in conducting the proposed analyses and particularly in terms of restricted access to the data to guarantee optimal levels of anonymity to the participants.

The Ethics Committee approves of your request.

Best regards,
On behalf of the Ethics Committee Economics and Business,

Prof. Dr. J.H. Sonnemans
Chairman of the Committee

UNIVERSITY OF AMSTERDAM

Ethics Committee Economics and Business (EBEC)
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To: van der Weele

Date
February 02, 2021

Our reference
EC 20210202020244

Contact
Sophia de Jong

Telephone
(31)20-5255311

E-Mail
secbs-abs@uva.nl

Subject
EBEC approval

Dear Joel van der Weele,

The Economics & Business Ethics Committee (University of Amsterdam) received your request nr 20210202020244 to approve your project "Anticipatory anxiety from monetary losses and wishful thinking ".

We evaluated your proposed research in terms of potential impact of the research on the participants, the level and types of information and explanation provided to the participants at various stages of the research process, the team's expertise in conducting the proposed analyses and particularly in terms of restricted access to the data to guarantee optimal levels of anonymity to the participants.

The Ethics Committee approves of your request.

The information as filled in the form, can be found at
https://www.creedexperiment.nl/EBEC/showprojectAVG.php?nummer=20210202020244

Best regards,
On behalf of the Ethics Committee Economics and Business,

Prof. Dr. J.H. Sonnemans
Chairman of the Committee

Wishful thinking and anxiety in the laboratory (#15709)

Created: 10/29/2018 02:38 PM (PT)
Shared: 01/15/2019 11:37 AM (PT)

1) Have any data been collected for this study already?
No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?
1) If an uncertain outcome is associated with painful consequences, does that lead people to engage in wishful thinking by underestimating the probability of that outcome?
2) Can higher incentives for accuracy reduce wishful thinking?

3) Describe the key dependent variable(s) specifying how they will be measured.
There are two key dependent variables:
1) Accuracy: this is a binary variable (1:correct; 0:incorrect), indexing at each trial whether the participant correctly identified the displayed pattern.
2) Confidence: this is elicited trial-by-trial, as a number between 50% and 100%: after each choice participants are asked to report the probability that this answer is correct (50% is chance level, and 100% is certainty). On the basis of this we can construct a “belief” measure, which measures on a scale from 0 to 100% the belief of the subject about the orientation of the true pattern.

4) How many and which conditions will participants be assigned to?
In total, a participant sees 216 Gabor patches, and has to recognize whether these patterns are tilted to the right or left. After deciding between these two answers, the participant indicates his confidence in this decision in percentages. The participants are incentivized monetarily for providing accurate answers by a matching probability. At the start of the experiment, each participant is connected to an electric stimulation device that is personally calibrated to deliver mild but unpleasant shocks. Participants will receive an electric shock with a probability of 1/3 if the true answer is either right or left (depending on the condition).

This is a 2x2 design with 4 conditions. Each participant will participate in each condition (a within-subject design), and the pattern recognition tasks are equally divided over all conditions (54 in each condition). The two treatments dimensions are a) the incentives for accuracy (high and low), and b) whether the shock is associated with the left-leaning Gabor patch or the right-leaning Gabor patch.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
We are interested how the shock influences the accuracy and confidence of the participants. Specifically, we will test the following directional hypotheses:

1) Wishful thinking 1: Does the accuracy of identifying a given pattern go down if the potential shock is aligned with the true answer (the unpleasant true answer), relative to the case where the potential shock is not aligned with the answer? We use one-sided t-tests to evaluate the differences in the average accuracy and confidence between conditions, where each observation is the average of a subject’s answers in that condition.

2) Wishful thinking 2: Similarly, we will use one-sided t-tests to examine whether the confidence in the true answer decreases if the potential shock is aligned with the true answer.

3) Accuracy incentives: We will test use one-sided t-tests whether accuracy and confidence in the true answer are higher in the condition with high incentives for accuracy.

In addition to t-tests, we will also use multivariate linear regression analysis to test the effect of our treatments (accuracy incentives, shock alignment) as well as their interaction. Finally, we will use linear mixed effect models (with or without individual fixed effects) where we can control for trial characteristics and/or subject characteristics (see below).

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.
We calibrate the difficulty of the task in the beginning of the experiment, so that we expect participants to be accurate 75% of the time on average. The actual accuracy in the experiment may deviate from this, and we will exclude the participant if actual accuracy is outside the [60%-90%] range, as this may indicate that, despite the calibration, the task was either too easy or too hard to detect meaningful differences.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

We ran a previous study that we had to discard due to an error in the code but was very similar. On the basis this study, running the same tests as specified above, we calculated that we could achieve more than 80% power with a sample of 60 people, so we will invite 60 participants

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

We are likely to do some further exploratory analysis. For instance, we will see if the strength of the effect size differs by the difficulty of the task. We also look whether people who score higher on the trait anxiety, which we measure with a psychological questionnaire, are more affected by the shock, both in their accuracy and their beliefs. To investigate this, we will run mixed models which feature interactions between the shock treatment and the trait anxiety measured by the questionnaire.

Finally, we might explore how the effects of shocks play in typical models of confidence formation (inspired from signal-detection theory): confidence is known to be an increasing function of evidence for correct answers and decreasing for incorrect answers. We can test if the presence of shocks modulate the intercept of the slopes of this model (see e.g. Lebreton, et al. (2017) biorXiv for similar analysis)

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Anticipatory anxiety about monetary losses and wishful thinking 2021 (#57718)

Created: 02/08/2021 03:07 AM (PT)

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1) Have any data been collected for this study already?

No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?

Our main question is about "wishful thinking": If an ambiguous state-of-the-world is associated with monetary losses, does that lead people to be less likely to correctly identify that state?

Secondary hypotheses: Does wishful thinking increase with…

1)…lower incentives for accuracy?

2)…higher monetary losses?

3)…increased ambiguity of the evidence?

3) Describe the key dependent variable(s) specifying how they will be measured.

A participant sees up to 96 Gabor patches, and has to recognize whether these patterns are tilted to the right or left. The main dependent variable is based on their accuracy on this task in each trial, i.e. whether the participant correctly identified the displayed pattern. Wishful thinking is constructed as the difference in accuracy in recognizing patterns associated with monetary losses and those not associated with such losses.

4) How many and which conditions will participants be assigned to?

Participants are endowed with an amount of money. They can lose part of this endowment on each trial with a probability of 1/3 if the true state is either right or left (depending on the condition) – i.e. monetary losses are not associated with participants' answers, but with the Gabor actual tilt direction. Additionally, participants are rewarded monetarily for providing accurate answers on the perception task.

There are 4 treatment dimensions. Each participant will participate in each condition (a within-subject design), and the pattern recognition tasks are equally divided over all treatments. The treatments dimensions are a) monetary loss is associated with the left-leaning Gabor patch or the right-leaning Gabor patch, b) the size of those losses (zero, low, or high), (c) the incentives for accuracy (high and low), and d) the ambiguity of the pattern (easy versus hard to discriminate).

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.

We are interested how the losses influences the accuracy and confidence of the participants. Specifically, we will test the following directional hypotheses:

1) Wishful thinking (main hypothesis): Does the accuracy of identifying a given pattern go down if the potential loss is aligned with the Gabor patch reflecting the correct answer, relative to the case where the potential shock is not aligned with the answer? We use a t-test to evaluate the differences in the average accuracy and confidence between conditions, where each observation is the average of a subject's answers in that condition.

2) Secondary hypotheses: We will test use t-tests to assess whether wishful thinking is higher in the conditions with (a) low incentives for accuracy, (b) higher ambiguity of the pattern, and (c) higher potential losses.

In addition to t-tests, we will also use multivariate linear regression analysis to test the effect of our treatments (accuracy incentives, loss alignment) as well as their interaction. We will use linear mixed effect models where we can control for trial characteristics and/or subject characteristics. Finally, we will study the effect of incentives for accuracy on accuracy in the task.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

Our experiment takes place on prolific. We will exclude participants who fail to answer simple attention checks at the beginning and throughout the experiment.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

We will recruit 220 subjects to the experiment.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

More exploratory analysis will correlate wishful thinking with questionnaire items related to the self-reported anxiety of subjects about losing money, as well as other questionnaire responses that include trait anxiety and emotion regulation.

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Anticipatory anxiety about monetary losses, wishful thinking, and the effe (#83830)

Created: 12/21/2021 10:06 AM (PT)

1) Have any data been collected for this study already?

No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?

In previous experiments we have found evidence for "wishful thinking". If a state of the world is associated with aversive outcomes, then subjects are less likely to correctly identify that state. Here, we will test whether wishful thinking is motivated by the threat of monetary losses. However, the main directional hypothesis we test is whether wishful thinking decreases with higher incentives for accuracy.

3) Describe the key dependent variable(s) specifying how they will be measured.

A participant sees several short sequences of Gabor patches, and is asked to recognize whether these sequences are more right- or more left-tilted. The main dependent variable is based on their accuracy on this task in each trial, i.e., whether the participant correctly identified the displayed patterns. Wishful thinking is constructed as the difference in accuracy in recognizing patterns not associated with monetary losses and patterns associated with such losses. Our paradigm expands on an earlier experiment, which focused on the accurate recognition of the tilt of a single Gabor patch.

4) How many and which conditions will participants be assigned to?

Participants are endowed with an amount of money. They can lose part of this endowment on each trial with a probability of 1/3 if the true state is either right or left tilted (depending on the condition) – i.e., these monetary losses are not associated with participants' answers, but with the actual tilt of the sequence. In addition, participants are rewarded with a monetary bonus for correctly identifying sequences.

There are 3 treatment dimensions. Each participant will participate in each condition (a within-subject design) and the pattern recognition tasks are equally divided across treatments. The treatment dimensions are a) monetary loss is associated with a left-leaning sequence of Gabor patches or the right-leaning sequence, b) the incentives for accuracy are high or low, and c) the ambiguity of the sequences of patterns is high or low. Our measure for ambiguity derives from a continuous variable of pattern difficulty that we dichotomize. The experimental uses a 2 x 2 x 2 within-subjects design with the factors loss pattern (aligned, not aligned with loss), incentives (high, low) and ambiguity (high, low).

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.

We will run a linear regression of correct answers on the following variables
- [loss pattern]: a dummy for whether the pattern is associated with a loss.
- [high incentives]: a dummy for the high incentive condition.
- [interaction]: a dummy for the interaction of the two conditions.

We cluster standard errors at the individual level. We run regressions where each observation is the individual average over trials in that condition, as well as regressions where we use all data points.

We test for
- wishful thinking by testing whether the first coefficient is positive and stat. significant.
- the effect of incentives on overall task performance by testing whether the second coefficient is positive and stat. significant.
- the interaction (our main hypothesis), by testing whether the third coefficient is positive and stat. significant.

For patterns associated with a loss, incentives should raise performance both because of the overall effect and because of a reduction in wishful thinking. To test this joint effect, we conduct an additional t-test assessing whether high accuracy incentives improve performance on loss patterns only.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

We conduct our online experiment on Prolific. We will exclude participants who fail to answer simple attention checks at the beginning and throughout the experiment.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

400

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

We will test whether self-reported concentration responds to incentives, as a manipulation check.
We will test our secondary hypothesis that wishful thinking increases with the ambiguity of the evidence.
Leveraging our within subject identification of wishful thinking, we will also study the heterogeneity of wishful thinking across subjects, correlating it with responses from the exit questionnaire.
We will test the robustness of our results if we exclude participants whose average accuracy is worse than chance.

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Anticipatory anxiety, wishful thinking, and the effect of accuracy incentives in a dot-task. (#89876)

Created: 03/04/2022 02:58 AM (PT)

1) Have any data been collected for this study already?
No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?
In previous experiments we have found evidence for "wishful thinking". If a state of the world is associated with aversive outcomes, then subjects are less likely to correctly identify that state.
Here, we will test whether wishful thinking is motivated by the threat of monetary losses in a task we have not previously used. However, the main directional hypothesis we test is whether wishful thinking decreases with higher incentives for accuracy.

3) Describe the key dependent variable(s) specifying how they will be measured.
On each trial, a participant sees an array of 100 blue and red dots, and is asked to recognize whether there are more blue or red dots. The main dependent variable is based on their accuracy on this task in each trial, i.e., whether the participant correctly identified the displayed patterns. Wishful thinking is constructed as the difference in accuracy in recognizing patterns not associated with monetary losses and patterns associated with such losses.

Our paradigm expands on an earlier experiment, which focused on the accurate recognition of the tilt of Gabor patches.

4) How many and which conditions will participants be assigned to?
Participants are endowed with an amount of money. They can lose part of this endowment on each trial with a probability of 1/3 if the true state is either right or left tilted (depending on the condition) – i.e., these monetary losses are not associated with participants' answers, but with the actual tilt of the sequence. In addition, participants are rewarded with a monetary bonus for correctly identifying sequences.

There are 3 treatment dimensions. Each participant will participate in each condition (a within-subject design) and the pattern recognition tasks are equally divided across treatments. The treatment dimensions are a) monetary loss is absent or present, and when it is present, it associated with patterns with a majority of red dots, or with a majority of blue dots, b) the incentives for accuracy are high or low, and c) the asymmetry in the number of blue and red dots differs. Our measure for ambiguity derives from a continuous variable of pattern difficulty that we dichotomize. The experiment uses a 3 x 2 x 4 within-subjects design with the factors loss pattern (no losses, associated with blue patterns, associated with red patterns), incentives (high, low) and ambiguity (high, medium high, medium low, low).

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
We will run a linear regression of correct answers on the following variables
1.[loss pattern]: a dummy for whether the pattern is associated with a loss. A t-test on the coefficient tests our hypothesis on wishful thinking.
2.[high incentives1]: a dummy for the high incentive condition when there is no possibility of monetary losses. A t-test on the coefficient tests for the effect of high incentives in the absence of losses.
3.[high incentives2]: a dummy for the high incentive condition when there is a possibility of monetary losses. A t-test on the coefficient tests for the effect of high incentives when losses are present.
4.[interaction]: restricting ourselves to the pattern with losses, we will look at a dummy for the interaction of the loss patterns with the high incentive condition. A t-test on the coefficient for the interaction term tests whether the incentives reduce wishful thinking.
We cluster standard errors at the individual level. We run regressions where each observation is the individual average over trials in that condition, as well as regressions where we use all data points.

For patterns associated with a loss, incentives should raise performance both because of the overall effect and because of a reduction in wishful thinking. To test this joint effect, we conduct an additional t-test assessing whether high accuracy incentives improve performance on loss patterns only.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.
We conduct our online experiment on Prolific. We will exclude participants who fail to answer simple attention checks at the beginning and throughout the experiment.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.
We will recruit 400 subjects to complete the experiment.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

We will test whether self-reported concentration responds to incentives, as a manipulation check.
We will test whether self-reported anxiety responds to the presence of losses, as a manipulation check.

We will test our secondary hypothesis that wishful thinking increases with the ambiguity of the evidence.
Leveraging our within subject identification of wishful thinking, we will also study the heterogeneity of wishful thinking across subjects, correlating it with responses from the exit questionnaire.
We will test the robustness of our results if we exclude participants whose average accuracy is worse than chance.

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Wishful thinking in the gain and in the loss domain (#124703)

Created: 03/10/2023 12:33 PM (PT)

1) Have any data been collected for this study already?
No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?
In previous experiments we have found evidence for "wishful thinking". If a state of the world is associated with aversive outcomes, then subjects are less likely to correctly identify that state. Here, we will test whether wishful thinking is affected by the framing of the outcomes as (foregone) gains or losses.

3) Describe the key dependent variable(s) specifying how they will be measured.
Participants face 32 trials where they see a Gabor patch, and are asked to recognize whether it is tilted to the left or right. The main dependent variable is the accuracy on this task in each trial, i.e., whether the participant correctly identified the displayed patterns.

In particular, some patterns are associated with favorable and some with unfavorable outcomes. We are interested in "wishful thinking", defined as the difference in accuracy in recognizing patterns that result in favorable outcomes compared to the accuracy in recognizing patterns that result in unfavorable outcomes.

4) How many and which conditions will participants be assigned to?
We use a 2x2 mixed factorial design. The first treatment dimension varies which pattern (left- or right-tilted) results in a favorable outcome and which one results in an unfavorable outcome. This treatment varies within subjects: subjects face an equal number of trials where the left-titled pattern is favorable and where the right-tilted pattern is favorable.

The second treatment dimension varies the framing of the (un)favorable outcomes. In the loss treatment, participants are initially endowed with 16 pounds. On each trial, they incur a loss of 50 cents each time the unfavorable pattern occurs and incur no loss each time the favorable pattern occurs. In the gain treatment, participants are not endowed with money, but gain 50 cents each time the favorable pattern occurs and gain nothing each time the unfavorable pattern occurs. Note that these treatments result in an identical probability distribution over monetary outcomes. The frame treatment varies between subjects.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
We will run a linear regression where each trial is an observation. We regress a dummy for the correct answer (accuracy) on the following variables:

- Main effect of Wishful Thinking [unfavorable pattern]: a dummy for an unfavorable pattern (i.e. associated with a loss or absence of a gain). A t-test on the coefficient tests our hypothesis on wishful thinking in the gain frame (a negative coefficient indicates wishful thinking).

- Main effect of Loss Frame [Loss]: a dummy for the loss frame (relative to gain frame). A t-test on the coefficient tests our hypothesis that average accuracy differs across the two frames.

- Interaction between WT and Loss Frame [unfavorable pattern as loss]: a dummy for an unfavorable answer in the loss frame (i.e. associated with a loss). A t-test on the coefficient tests for the increase in wishful thinking in the loss vs. gain frame.

We cluster standard errors at the individual level. As robustness, we will run regressions where each observation is the individual average over trials in that condition. Regressions will control for the level of tilt, which differs between trials.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.
We conduct our online experiment on Prolific. We will exclude participants who fail to answer simple attention checks at the beginning and throughout the experiment.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.
We will recruit 600 subjects to complete the experiment, 300 in each condition.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

We will test whether wishful thinking is mediated by self-reported anxiety and by self-reported excitement, elicited with questionnaires after blocks of trials. We expect the former to play a larger role in the loss treatment and to be a more important driver of wishful thinking.
We vary the ambiguity of the pattern within-subject by using two different levels of the tilt and test whether wishful thinking increases with the ambiguity of the evidence.
We will test the robustness of our results if we exclude participants whose average accuracy is worse than chance or who indicated they found the instructions complex.

F Instructions, attention checks and subject exclusion

Instructions for the different Experiments can be found as part of the replication package on OSF: https://doi.org/10.17605/OSF.IO/TZNPY.

All experiments included quiz questions to check participant understanding of the instructions. In Experiments 2-5, the quiz questions are presented intermixed with the instructions, separated in two sections. Each question is repeated upon a wrong answer, and each section is repeated up to 2 times if 3 or more mistakes are made within that section. In Experiment 2 the first section was repeated up to 3 times, though this rarely happened. Participants were excluded from the experiment if they made more than 4 mistakes in total.

Several attention checks (see screen captures on the Online Supplementary Material: https://doi.org/10.17605/OSF.IO/TZNPY) were used at the beginning of the task for Experiment 2-5. Each was repeated upon a wrong response, and the experiment stopped at two total wrong responses. The last attention check (pressing a key written on screen) appeared once again at the end of the first block, and the experiment ended if answered incorrectly four times.