How unrealistic optimism is maintained in the face of reality

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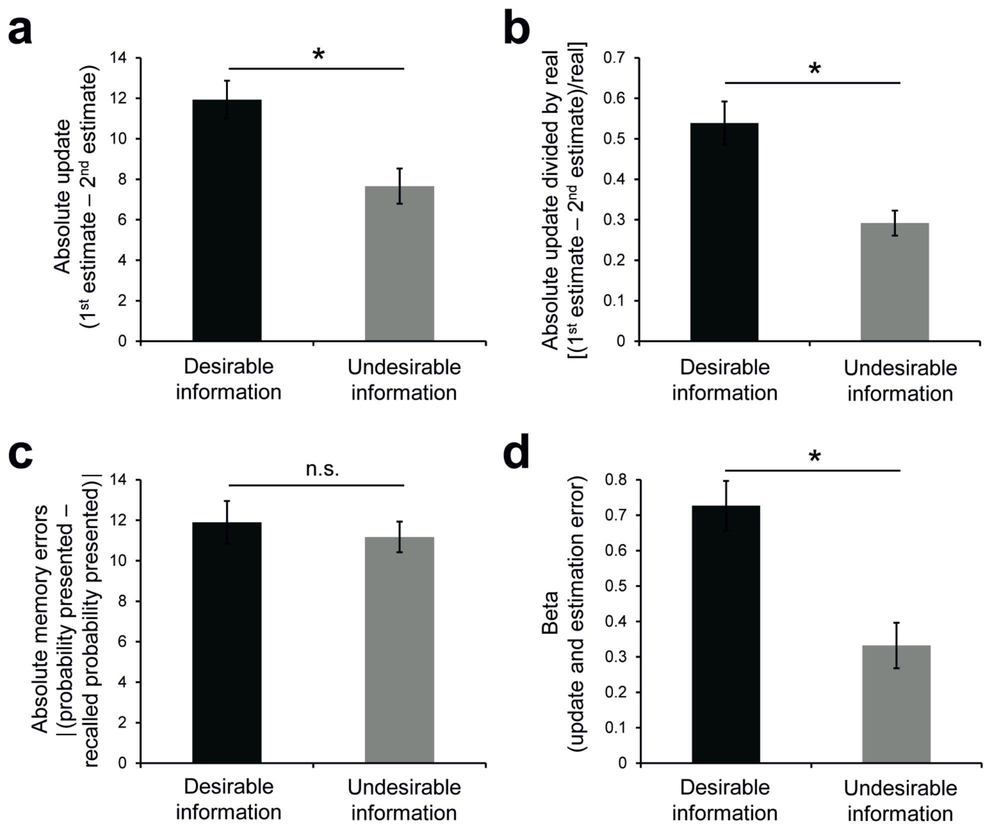
Supplementary Online Material



Supplementary Figure 1. Behaviorally observed bias.

All bars represent group means. (**a**) After receiving (desirable) information that presented an opportunity to adopt a more optimistic outlook, participants updated their estimations to a greater extent than after receiving (undesirable) information that called for a more pessimistic estimate. (**b**) This difference remained significant when updates (difference between first and second estimates**)** on each trial were divided by

Nature Neuroscience: doi:10.1038/nn.2949

the true probability of the respective event happening to an average person. (**c**) Memory performance tested post-scanning (calculated as the absolute difference between the statistical number presented for each event and the participants' recollection of that number) did not differ between desirable and undesirable information. (**d**) Betas indicating the association between update and estimation errors on an individual basis showed that estimation errors predicted update to a greater extent when participants received desirable information than when they received undesirable information.

Error bars (s.e.m.). * = $P < 0.05$, two-tailed paired sample t-test.

Supplementary Table 1 Regions throughout the brain that showed differential BOLD signal for different trial types during "thinking" period. Session 1& 3: contrasting activity during the time period participants were asked to think about encountering adverse events for the first time; Trials of stimuli for which participants will subsequently give an estimate lower than the average probability (i.e. will receive desirable information) versus trials of stimuli for which participants will subsequently give an estimate higher than the average probability (i.e. will receive undesirable information). Session 2& 4: contrasting activity during the time participants were asked to think about encountering adverse events for the second time; Trials of stimuli for which participants previously gave an estimate lower than the average probability (i.e. received desirable information) versus trials of stimuli for which participants gave an estimate higher than the average probability (i.e. received undesirable information) . $P < 0.001$, uncorrected; 10 > contiguous voxels.

Nature Neuroscience: doi:10.1038/nn.2949

Session 1&3					Sesion 2&4				
	X	Y	Z	R/L		X	Y	Z	R/L
Subsequent Underestimations>Subsequent Overestimations					Previouse Underestimations>Previouse Overestimations				
Precuneus, BA 7	28	-68	38	R	Superior Temporal Gyrus, BA 39	57	-63	22	R
Middle Temporal Gyrus, BA 21	-57	3	-12	L	Fusiform Gyrus, BA 20	-38	-40	-18	L
Precuneus, BA 31	-6	-73	26	L	Cerebellum	34	-63	-10	R
Inferior Occipital Gyrus, BA 19	44	-72	-5	R	Lingual Gyrus, BA 18	-14	-82	-8	L
Superior Frontal Gyrus, BA 11	16	56	-8	R	Parahippocampal Gyrus, BA 30	18	-46	6	R
Lingual Gyrus, BA 18	-16	-82	-9	L	Lingual Gyrus, BA 18	28	-76	-8	R
Inferior Occipital Gyrus, BA 18	-32	-84	-9	L	Middle Occipital Gyrus, BA 19	28	-82	21	R
Inferior Frontal Gyrus, BA 47	-44	23	-15	L	Cuneus, BA 19	12	-86	32	R
Lingual Gyrus, BA 19	-28	-74	0	L	Fusiform Gyrus, BA 37	-50	-55	-16	L
Inferior Frontal Gyrus, BA 46	36	33	8	R	Precuneus, BA 7	16	-44	43	R
Cerebellum	2	-52	-33	R	Inferior Occipital Gyrus, BA 18	38	-88	-4	R
Middle Occipital Gyrus, BA 19	-34	-83	4	L	Fusiform Gyrus, BA 20	34	-40	-17	R
Cerebellum	14	-80	-11	R					
Middle Temporal Gyrus, BA 19	38	-62	12	R					
Medial Frontal Gyrus, BA 8	-6	35	37	L					
Cuneus, BA 19	6	-84	34	R					
Cerebellum	-6	-71	-17	L					
Superior Temporal Gyrus, BA 22	-46	-26	-5	L					
Supramarginal Gyrus, BA 40	-55	-49	28	L					
Lateral Globus Pallidus	-20	0	-5	L					
Middle Frontal Gyrus, BA 8	-32	12	36	L					
Cuneus, BA 17	-8	-93	3	L					
Supramarginal Gyrus, BA 40	57	-45	30	R					
Paracentral Lobule, BA 5	14	-36	52	R					
Fusiform Gyrus, BA 37	-40	-59	-9	L					
Middle Temporal Gyrus, BA 21	51	-29	-2	R					
Middle Occipital Gyrus, BA 18	28	-91	8	R					
Inferior Frontal Gyrus, BA 9	36	11	23	R					
Cuneus, BA 17	14	-89	3	R					
Lingual Gyrus, BA 18	12	-54	5	R					
Subsequent Overestimations>Subsequent Underestimations					Previouse Overestimations>Previouse Underestimations				
					Caudate	-12	-11	19	L
					Medial Frontal Gyrus, BA 9	22	41	13	R
					Inferior Frontal Gyrus, BA 45	61	18	5	R
					Medial Frontal Gyrus, BA 9	-20	38	20	L

Nature Neuroscience: doi:10.1038/nn.2949

Supplementary List of Stimuli

fraud when buying something on the internet
theft from vehicle
card fraud
sport related accident
household accident
mouse/rat in house
knee osteoarthritis (causing knee pain and swelling)
being cheated by husband/wife
more than £30000 debts
miss a flight
hernia (rupture of internal tissue wall)
death before 80
witness a traumatising accident
domestic burglary
bone fracture
depression
heart failure
obesity
irritable bowel syndrome (disorder of the gut)
chronic high blood pressure
diabetes (type 2)
victim of violence by stranger
disease of spinal cord
serious hearing problems
infertility
car stolen
dementia
drug abuse
gallbladder stones
being convicted of crime
house vandalised

Nature Neuroscience: doi:10.1038/nn.2949

restless legs syndrome
gluten intolerance
appendicitis
age related blindness
genital warts
chronic ringing sound in ear (tinnitus)
death before 60
alcoholism
Parkinson's disease
back pain
computer crash with loss of important data
being fired
eye cataract (clouding of the lens of the eye)
skin burn
hospital stay longer than three weeks
bicycle theft
divorce
victim of bullying at work (nonphysical)
arteries hardening (narrowing of blood vessels)
theft from person
having fleas/lice
sexual dysfunction
hepatitis A or B
victim of violence with need to go to A&E
severe teeth problems when old
cancer (of digestive system/lung/prostate/breast/skin)
abnormal heart rhythm
victim of violence by acquaintance
herpes
migraine
having a stroke
victim of violence at home
severe insomnia

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osteoporosis (reduced bone density)

death before 70

severe injury due to accident (traffic or house)

autoimmune disease

artificial joint

victim of mugging

asthma

blood clot in vein

ulcer

kidney stones

Alzheimer's disease

anxiety disorder

limb amputation

epilepsy

liver disease

death by infection

Events used during the training sessions

dying before 90

glaucoma

post-traumatic stress disorder

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Supplementary Behavioural Study I – Testing memory after a single presentation of the actual probabilities

Rationale: In our fMRI study (reported in the main text) participants' memory for the information presented did not differ for desirable and undesirable information. We concluded that the selective updating observed in response to desirable and undesirable information was not driven by differential memory. A limitation here was that participants were presented twice with the actual likelihoods before their memory was tested. It is possible that after the first presentation of the statistical likelihoods (before the second update) participants' memory was biased, but not after the second presentation of the likelihoods.

Method: To exclude this possibility we tested ten additional subjects (age range 20–36, 7 females) on a similar behavioural task as utilized in the fMRI study with one critical difference – participants were not presented with the statistical probabilities in the second session. For simplicity we only asked participants to estimate their likelihood of encountering the adverse events (rather than estimate their likelihood of not encountering the adverse events) as our previous results showed no effect of how the question was worded. Analysis was conducted as before.

Results: First, we replicated our main behavioural results, showing greater update on trials when participants received desirable information relative to undesirable information ($t(9) = 3$; $P < 0.02$). Importantly, there was no difference in participants' memory for desirable and undesirable information after one presentation of the likelihoods ($t(9) = 0.3$, $P > 0.7$), suggesting that selective update was not driven by differential memory for desirable and undesirable information.

Nature Neuroscience: doi:10.1038/nn.2949

Supplementary Behavioural Study II – Testing memory before the second estimation of personal probabilities

Rationale: A limitation to the design employed above is that it had order confounding; memory was tested after receiving the second estimate from the participants. We thus tested whether the same pattern of results would emerge (i.e. a valence effect on update but not on memory) if memory was tested before second estimates were elicited.

Method: We tested twenty additional subjects (age range 20–30, 13 females) on a similar behavioural task as utilized in the study above with one critical difference – after completing the first session participants received the memory test and only then they were asked to estimates all probabilities again. For simplicity half of the participants were asked to estimate their likelihood of encountering the adverse events and half were asked to estimate their likelihood of not encountering the adverse event. Analysis was conducted as before.

Results: First, we replicated our main behavioural results, showing greater update on trials when participants received desirable information relative to undesirable information ($t(19) = 2.4$; $P < 0.05$). Importantly, there was no difference in participants' memory for desirable and undesirable information ($t(19) = 0.99$, $P > 0.3$), suggesting that the results reported in the main text were not due to memory being tested after the second estimates were elicited.

Supplementary Results

To control for the possibility that differential updating following desirable and undesirable information could be explained by differential processing of high and low numbers, participants were asked to estimate their likelihood of encountering the

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adverse event on half the trials, and to estimate their likelihood of not encountering the adverse event on the rest of the trials. A 2 by 2 ANOVA (wording of task: event happening / event not happening X information provided: desirable / undesirable) conducted on amount of update, did not reveal a significant interaction ($F(1, 18) = 0.208$, $P > 0.6$). Furthermore, the wording of the task did not affect any of the fMRI results reported in the main text.

Post-scanning questionnaire scores showed that participants found events for which they received desirable information as emotionally arousing and as negative as the events for which they received undesirable information ($t(18) = -0.3$, $P > 0.7$ and $t(18) = 1.3$, $P > 0.2$, respectively). Events for which participants received desirable information were imagined more vividly ($t(18) = -2.3$, $P < 0.05$), were more familiar ($t(18) = -2.2$, $P < 0.05$) and tended to be experienced more often in the past ($t(18) = -2.1$, $P < 0.01$) than events for which participants received undesirable information. In other words, events for which a change in update was more likely were more familiar indicating more, rather than less, prior knowledge. Importantly, these factors could not explain differential updating; the difference in absolute update for events for which participants received desirable and undesirable information remained significant even after entering all post-scanning scores as covariates ($F(1, 13) = 9.7$, $P < 0.01$).

As mentioned in the main text, the difference in updating for events for which participants received desirable and undesirable information remained significant even after entering the difference in true probabilities of the events as covariates ($F(1,17) = 6.04$, $P < 0.05$). Entering the true probabilities of the events as a regressor in the fMRI analysis did not reveal any differential effects for desirable and undesirable trials in any of the regions reported in the text.

Nature Neuroscience: doi:10.1038/nn.2949