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Reporting Summary

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Statistical parameters

When statistical analyses are reported, confirm that the following items are present in the relevant location (e.g. figure legend, table legend, main text, or Methods section).

n/a	Confirmed
☐	☒ The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒ An indication of whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒ The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☐	☒ A description of all covariates tested
☐	☒ A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒ A full description of the statistics including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒ For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐ For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐ For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☐	☒ Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated
☐	☒ Clearly defined error bars *State explicitly what error bars represent (e.g. SD, SE, CI)*

Our web collection on statistics for biologists may be useful.

Software and code

Policy information about availability of computer code

Data collection	Compare Methods and Supplementary Methods: Stimuli were generated on a windows PC using custom made scripts under "Cogent Graphics" (developed by John Romaya at the LON at the Wellcome Department of Imaging Neuroscience) in combination with Matlab 7.5. Eye movements of participants were monitored during fMRI using an MRI-compatible eye-camera and the ViewPoint Eye Tracker software. Brain Imaging was performed on a Siemens Trio Scanner, as is further specified below.
Data analysis	Compare Methods and Supplementary Methods: Brain imaging data were analysed using SPM5 in combination with Matlab 7.5 (including the SPM2 Volumes Toolbox Code to extract Raw data from image files, such as beta values and signal intensity values for fMRI signal time courses). Eye movement analysis was performed based on previously established scripts in Matlab 7.5. Statistical analyses were performed using Matlab 7.5 and the Measures of Effect Size (MES) Toolbox V1.6, SPM 5, and SPSS 24.

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors/reviewers upon request. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Research guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A list of figures that have associated raw data
- A description of any restrictions on data availability

Data availability. The data that support the findings of this study as well as the data underlying our power calculation are available from the corresponding author upon reasonable request. Un-thresholded statistical maps of our main fMRI-results will be made available at NeuroVault.org.

Field-specific reporting

Please select the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☒ Life sciences ☐ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/authors/policies/ReportingSummary-flat.pdf

Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size	Compare Supplementary Methods: Sample Size. Sample size was guided by our previous behavioural study on choice overload7 and built on a power-analysis (alpha=0.05, power=0.8) performed on amount rating data obtained on a scale equivalent to ours (Fig. 1c). Namely, it builds on the results from a previously published study which found that satisfaction from choice followed an inverted-U shape pattern with the highest satisfaction experienced by subjects when choosing from intermediate-sized sets (vs larger or smaller sets7). In that study 120 subjects were choosing a gift box to pack a present for their friends from different sized sets of boxes containing either 5, 10, 15 or 30 alternatives. Specifically, in our power-analysis we considered the rating difference between the small choice set [5 items, M = 4.17, SD = 1.80, N=30] and an intermediate choice set [10 items = twice the size of the small set, M = 5.53, SD = 1.57, N=30] and the difference between an intermediate choice set [15 items, M = 4.90, SD = 2.25, N=30] and the large choice set [30 items = twice the size of the intermediate set, M = 6.77, SD = 1.87, N=30] (results from7). Note that the effective sensitivity of the current study should be even higher due to our within-subject design and due to task repetitions (as compared to the between-subjects design and the lack of repetitions7). Both our current study and study7 used visual stimuli. However, as study7 suggests, the definition of "optimal", "too small", and "too large" choice set should depend on the costs and benefits of each choice setting and is different in varying environments.
Data exclusions	Compare Methods: Initially we recruited 20 subjects. One subject reported verbally that he was indifferent about landscape images, was not interested in choosing any of them, and even rejected the customized item as a reward at the end of the experiment. His ratings of the landscape indicated the same: there was no variability in the liking ratings of different images that he reported. Over 84% of images were given a rating of "0" (meaning, the subject did not like the images at all), and the rest 16% of ratings were distributed between 0 and 1.8 on the 11-point scale (M = 0.1, SD = 0.28). The data clearly indicated that the task was not engaging for that particular subject. Therefore, the data from that subject were not included in further analysis (behavioural or fMRI).
Replication	No replication tests were performed. Yet, in our study an array of independent conditions had to be fulfilled (task-related activity, inverted-u shaped activity, CF>NF, and less quadratic response in FO than in NF), only then a brain area would be considered to contribute to a representation of choice set value. The use of multiple independent criteria should increase the robustness of our findings.
Randomization	Our study used a within-subject design and subjects were not allocated to different treatment groups. All experimental conditions were presented randomly interleaved.
Blinding	Our within-subject design and our standardized computer-based analyses (which were the same for all individuals) did not require blinding.

Reporting for specific materials, systems and methods

Materials & experimental systems

n/a	Involved in the study
☒	☐ Unique biological materials
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology
☒	☐ Animals and other organisms
☐	☒ Human research participants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☐	☒ MRI-based neuroimaging

Human research participants

Policy information about studies involving human research participants

Population characteristics	Nineteen individuals (12 males; mean age 26.2 years +/- 4.9 SD) completed the study. All subjects were right-handed and had normal or corrected to normal vision.
Recruitment	Participants were recruited through mailing lists. Recruitment should not have an impact on the results of our within-subject study.

Magnetic resonance imaging

Experimental design

Design type	event-related task-design
Design specifications	Each subjects completed four runs with 18 trials each (three randomly interleaved choice conditions [CF,NF,FO] x three choice set sizes [6,12,24]). Trial duration: ~27sec. Baseline: ~13.5sec.
Behavioral performance measures	Measures: Preference ratings, choice [action sequence], reaction time, eye movements. Detailed statistical analyses of all respective measures are provided in the results section to characterize subjects' engagement in our task. In addition, eye movement measures and preference ratings entered our fMRI analyses.

Acquisition

Imaging type(s)	T1-weighted MP-rage, T2*-weighted gradient-echo planar imaging
Field strength	3 Tesla (Siemens Trio)
Sequence & imaging parameters	T1: '176 slices, slice thickness = 1 mm, gap = 0 mm, in-plane voxel size = 1x1 mm, TR = 1500 ms, TE = 3.05 ms, FOV = 256x256, resolution = 256x256'; EPI: 'EPIs: slice thickness = 3.5 mm, gap = 0 mm, in-plane voxel size = 3x3 mm, TR = 2000 ms, TE = 30 ms, flip angle = 90°, FOV = 192x192, resolution = 64x64, 32 axial slices'
Area of acquisition	Compare Supplementary Methods: The EPI volume provided an almost entire coverage of the cerebral cortex and of most sub-cortical structures: only the posterior part of the cerebellum was not covered, and there were signal dropouts in orbito-frontal cortex and inferior aspects of temporal cortex (see Figure 4a for additional information about the actual volume covered).

Diffusion MRI ☐ Used ☒ Not used

Preprocessing

Preprocessing software	SPM 5 (Wellcome Department of Cognitive Neurology, London). We spatially smoothed the normalized functional images using a Gaussian kernel (7x7x7 mm³ full-width at half-maximum). Furthermore, we applied a high pass filter (cut-off period 128 ms).
Normalization	All images of each subject were realigned to the first scan of the first run. Next, we co-registered the mean image of the realigned functional scans to the anatomical image. The latter was then normalized to the SPM T1-template in MNI space (Montreal Neurological Institute, mean brain). The resulting non-linear 3D-transformation was applied to all EPI images.
Normalization template	SPM 5 T1 template image (MNI space)
Noise and artifact removal	n.a.
Volume censoring	n.a.

Statistical modeling & inference

Model type and settings	Compare Methods:

Model type and settings

fMRI-analyses were first performed at the individual- and then at the group- level. On the individual level we used two different models.
In model 1, nine experimental conditions were modeled separately [three tasks (CF, NF, and FO choice) x 3 task stages (exposure and mask, delay, and response periods)] in the general linear model (GLMs) for a given subject. Each model also included 6 motion correction parameters obtained from a rigid-body transformation during image realignment, as well as three further parameters which served as additional parametric modulators for each of the 3x3 condition-by-stage regressors of the GLMs: (i) a linear predictor, (ii) a quadratic predictor (orthogonalized to the linear term), as well as (iii) the liking rating of the chosen item. Parametric modulators are explained in more detail in the results section. Thus, there were a total of 6 motion regressors and 27 parametrically modulated condition-by-stage regressors (3x3x3 = 3 tasks x 3 task stages x 3 parametric modulators).
In model 2 the individual subjects' GLMs included regressors for each of our 3x3 experimental conditions [3 tasks (CF, NF, and FO choices) x 3 choice sets S (6-, 12-, and 24-item sets)] and for each stage of the task (exposure and mask, delay, and response period), amounting to 27 regressors per session. As in model 1, the 6 motion correction parameters obtained from the rigid-body transformations during realignment were included as additional regressors in order to capture any residual movement artifacts.

Effect(s) tested

Compare Methods: For analysing model 1 on the group-level, we restricted our calculations to task-related areas (across-subject activity increases in the exposure phase in either of the choice conditions, CF or NF, at $P < 0.01$ uncorrected [one-tailed t-test; H0: $\mu>0$]). Then, contrast images for the various regressors of the exposure phase were analysed using one-tailed t-tests, allowing us to map brain regions which displayed an activity pattern in the pooled choice conditions NF & CF that was positively correlated with the quadratic predictor (H0: $\mu>0$; $P < 0.05$ FDR-corrected for multiple comparisons) or with the linear predictor ($P < 0.01$ uncorrected; note that this liberal threshold was chosen to ensure high sensitivity for detecting any additional presence of a positive linear signal component in "quadratic areas"). Areas revealed by the latter contrast were considered potential candidates for being a neural correlate of choice set value. The beta estimates revealed for these areas were further subjected to region of interest (ROI) analyses. [...] The respective beta estimates, which were assessed by model 2, were subjected to additional ROI analyses. Also compare 'ROI analyses' in our methods section.

Specify type of analysis: ☐ Whole brain ☐ ROI-based ☒ Both

Anatomical location(s)

Areas were functionally defined according to the procedure described above (compare effect(s) tested). Also compare chapter on ROI analyses in Methods: We used the SPM2 Volumes Toolbox V 1.21 by Volkmar Glauche to extract the normalized beta weights for the exposure-period regressors of both model 1 and model 2 for a 3mm-radius sphere that was centred on our functionally defined regions of interest.

Statistic type for inference
(See Eklund et al. 2016)

voxel-wise

Correction

FDR (main contrast: quadratic predictor>0; also see 'Effect(s) tested' above)

Models & analysis

n/a	Involved in the study
☒	☐ Functional and/or effective connectivity
☒	☐ Graph analysis
☒	☐ Multivariate modeling or predictive analysis