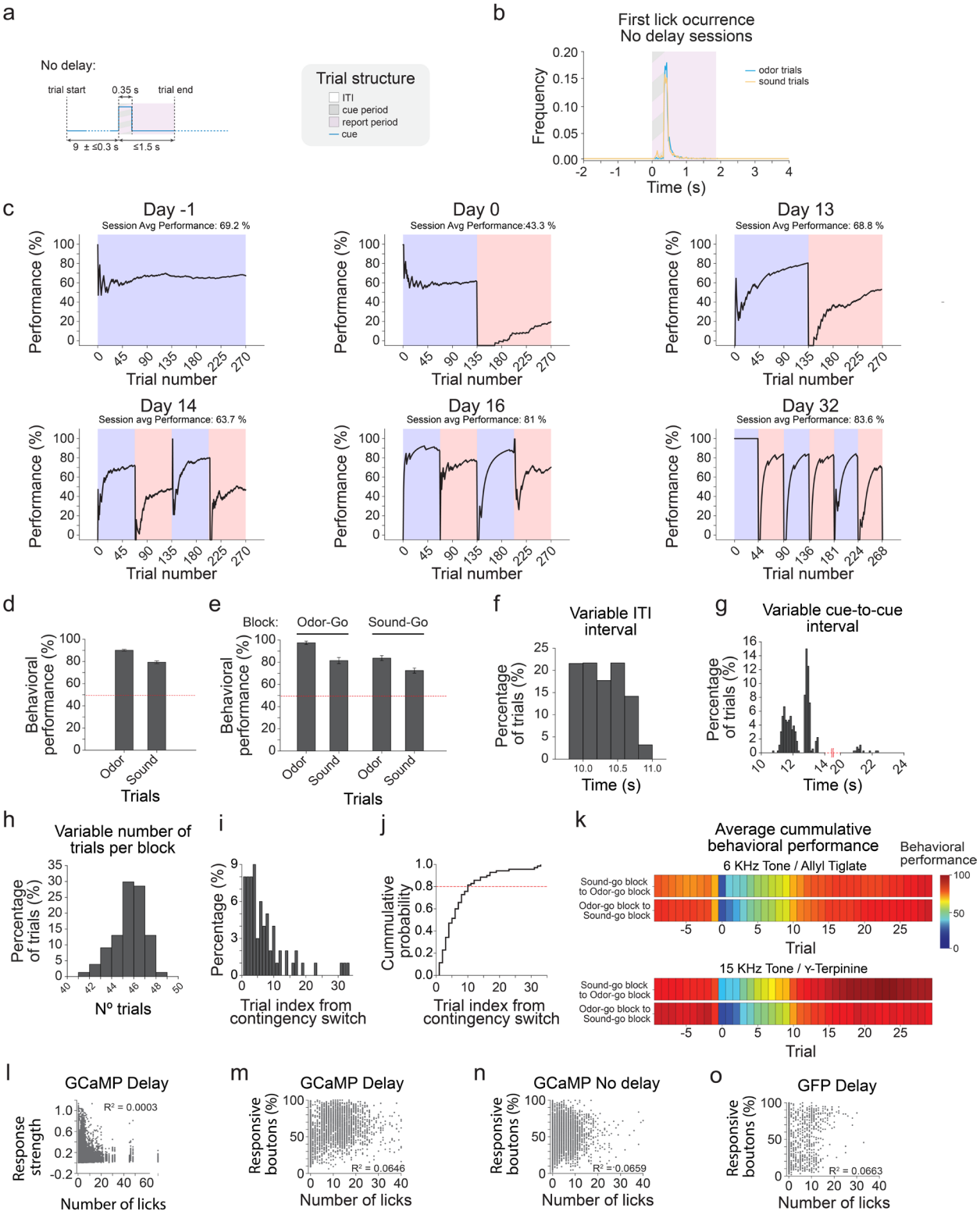
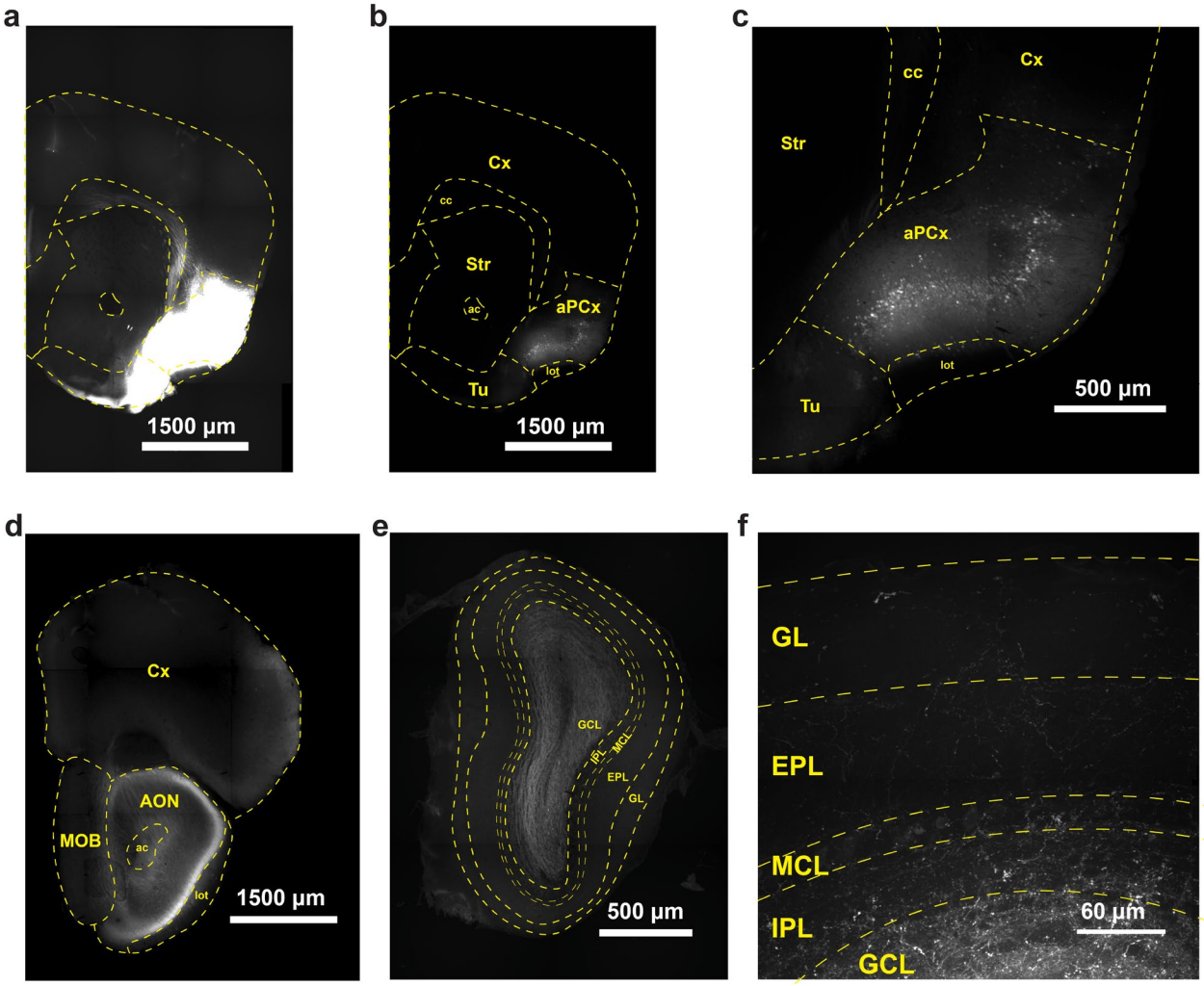
Supplementary Figure 1



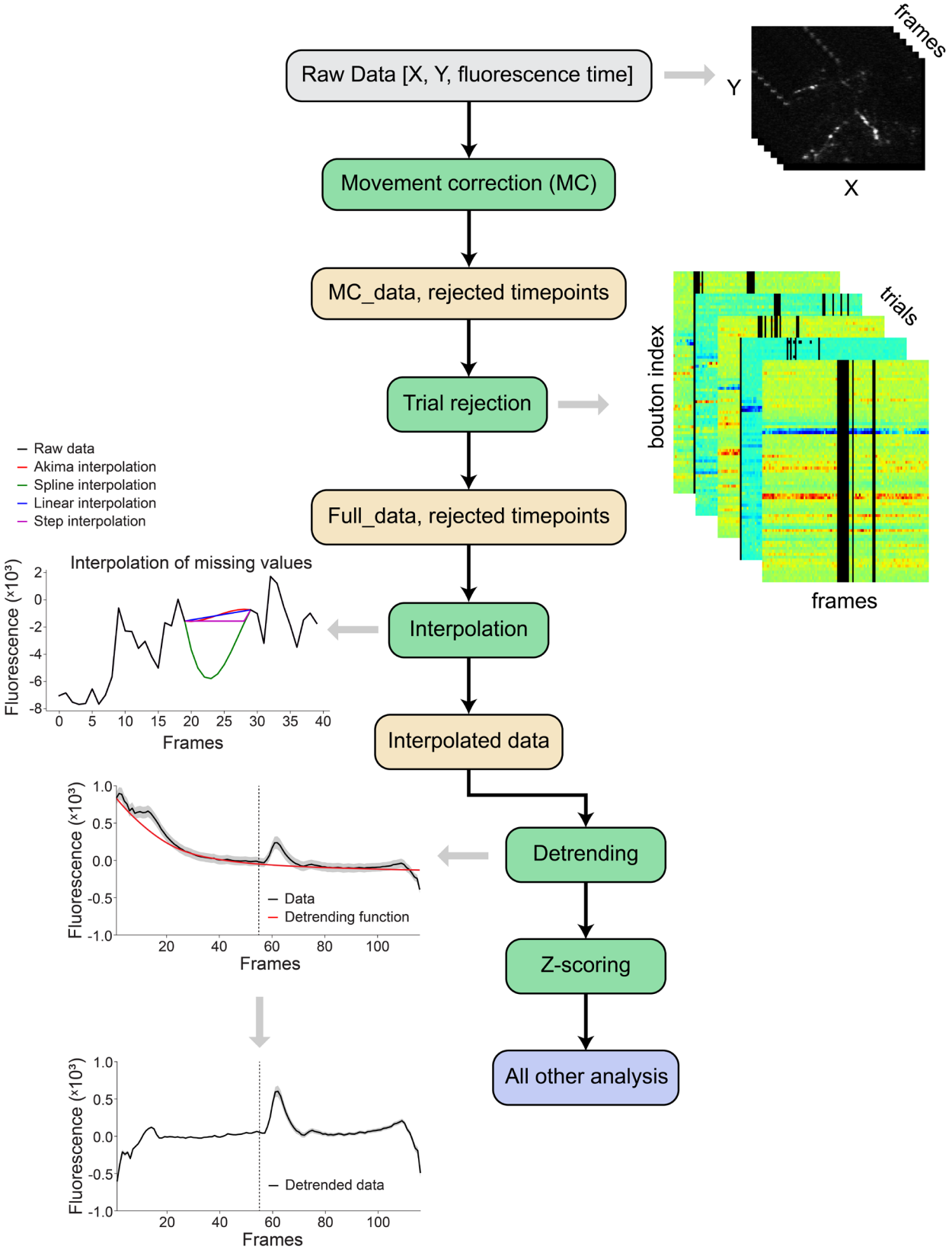
Supplementary Figure 1. (**a**) Structure of the 'no-delay' rule reversal task. A variable inter-trial interval (Methods) was followed by the delivery of a brief odor or sound cue (0.35 s) before the time when the reward became available. Mice were trained to report their decision (lick vs. no-lick) within a 1.5 s window from the cue offset. (**b**) Distributions of report latency (first-lick) from cue onset from all no-delay sessions parsed by cue identity (blue: odor; orange: sound trials). (**c**) Training progression of an example mouse in the delay version of the odor/sound reversal task. 'Day 0' corresponds to the first day the mouse experienced rule reversals within the same session. (**d**) Average session behavioral performance (Mean ± SEM) of odor and sound trials from mice trained in the delay task (N = 20 fields of view; 3 mice). (**e**) Average behavioral performance (Mean ± SEM) of the odor and sound trials from **d**, parsed by block type ('Odor-Go' and 'Sound-Go'). (**f**, **g**) Distribution of the variable duration (flat hazard-rate) inter-trial intervals, ITI (**f**) and cue-to-cue times for consecutive trials (**g**) for the delay version of the task (N = 20 fields of view, 3 mice). (**h**) Distribution of number of trials per block from expert behavior sessions used for the sniff analysis (n = 15 sessions; 3 mice). (**i**) Behavioral switch quantification: Percentage distribution of observing five consecutive correct trials starting at the switch (rule-reversal) trial (using a 5-trials sliding window). (**j**) Cumulative distribution of the histogram from **i**. (**k**) Average behavioral performance for block transitions from example expert mice trained with multiple sound and odor cue pairs. (**l**) Number of licks versus response strength ($\text{z-score}_{max} - \text{z-score}_{min}$) for GCaMP delay behavior sessions. $R^2 = 0.0003$. (**m**) Number of licks versus percentage of responsive boutons for GCaMP delay behavior sessions. $R^2 = 0.0646$. (**n**) Number of licks versus percentage of responsive boutons for GCaMP no-delay sessions. $R^2 = 0.0659$. (**o**) Number of licks versus percentage of responsive boutons for EGFP session. $R^2 = 0.0663$.

Supplementary Figure 2



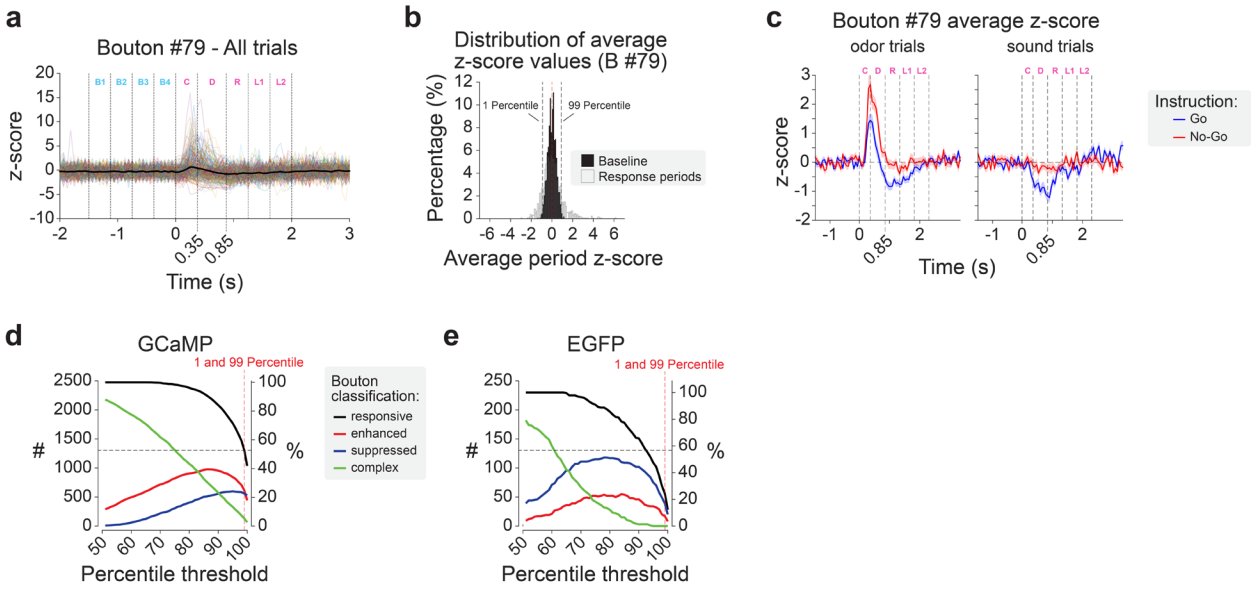
Supplementary Figure 2. **Coronal sections of a mouse brain injected with AAV in the anterior piriform cortex to express GCaMP in cortical bulbar feedback axons.** (**a-c**) Mice were injected with AAV-GCaMP (5 ot 7b) in the anterior piriform cortex, aPCx (Methods). (**a**) Brain section boundaries and areas (scale bar: 1500 μm). (**b**,**c**) Detail of GCaMP7b expression in aPCx neuronal cell bodies (scale bars: 1500 μm and 500 μm, respectively). Tu: olfactory tubercle; Str: striatum; Cx: other cortical structures; cc: corpus callosum; ac: anterior commissure; lot: lateral olfactory tract. (**d**) Detail of passing aPCx axons in the AON. Not lack of GCaMP expression in AON neuronal cell bodies (scale bar: 1500 μm). AON: anterior olfactory nucleus; MOB: main olfactory bulb. (**e**, **f**) Low and high magnification images of the olfactory bulb structure showing aPCx feedback axons innervating the MOB layers (scale bars: 500 and 60 μm, respectively). GL: glomerular layer; EPL: external plexiform layer; MCL: mitral cell layer; IPL: internal plexiform layer; GCL: granule cell layer.

Supplementary Figure 3



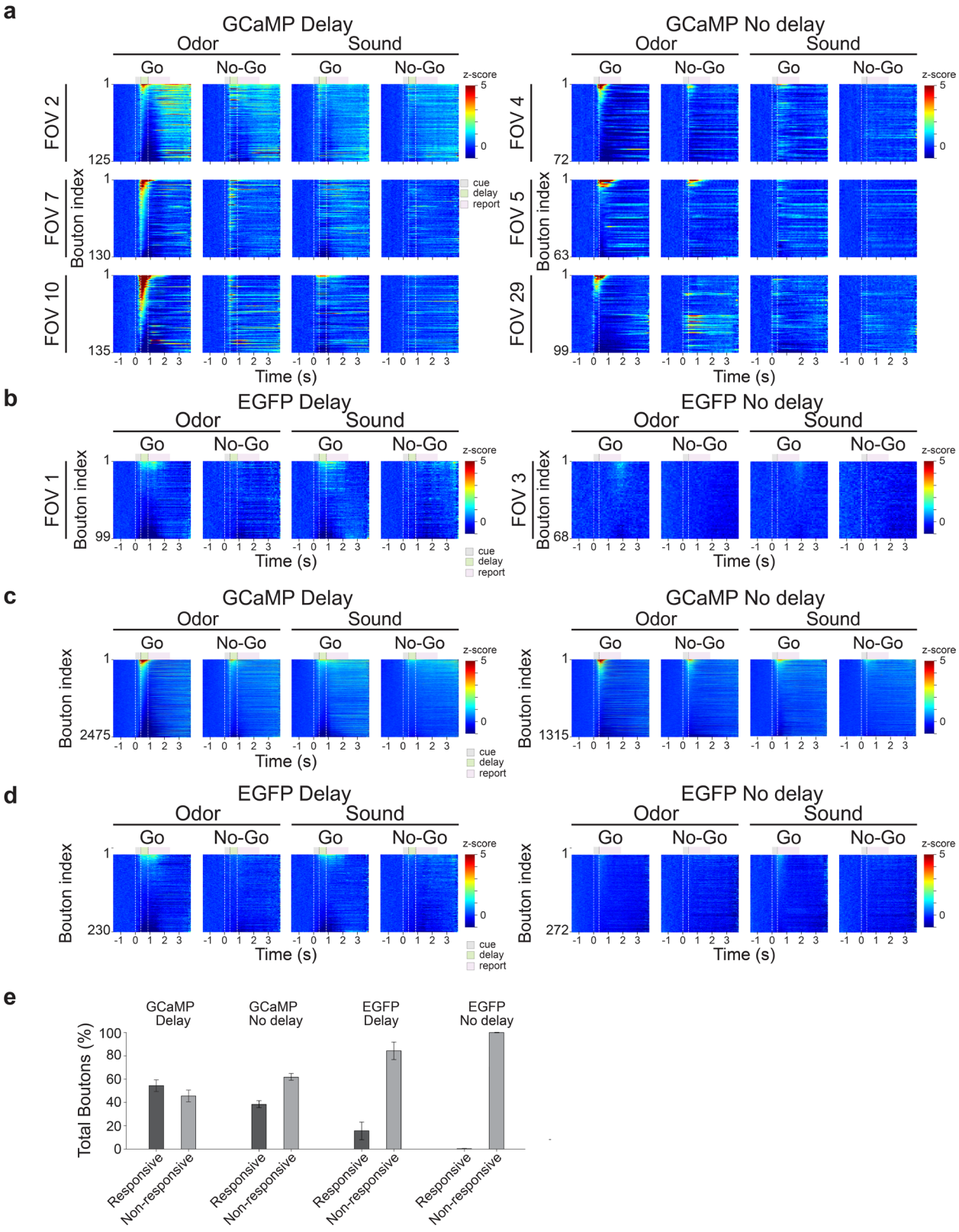
Supplementary Figure 3. **Outline of the data pre-processing pipeline**. The pre-processing pipeline includes the following steps: movement correction, region of interest (ROI) selection, trial rejection, interpolation, de-trending and z-scoring (Methods).

Supplementary Figure 4



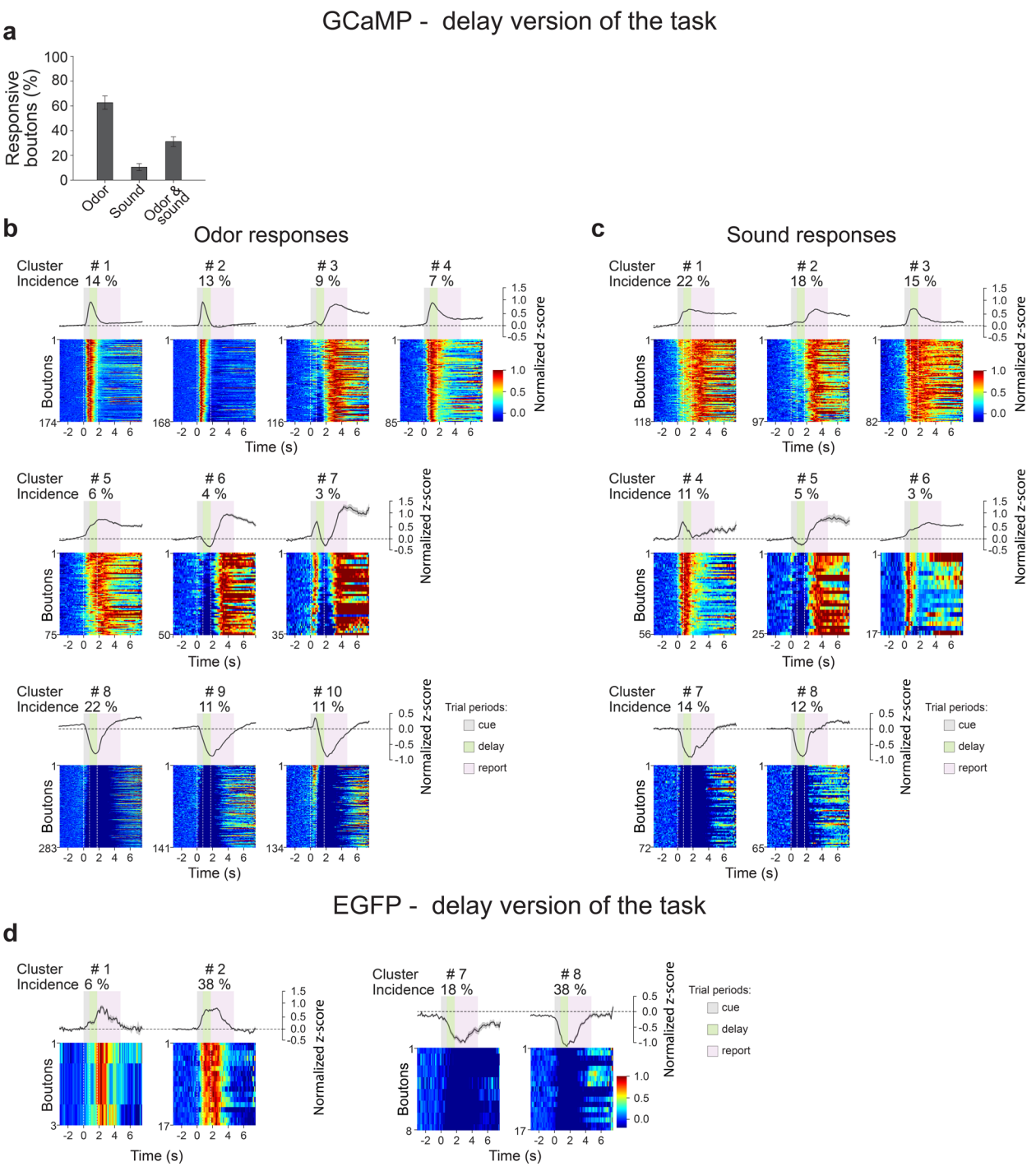
Supplementary Figure 4. **Quantifying bouton responsiveness**. (**a**) All trials (color) and average (black) responses of a single bouton from an example delay session. Baseline period was parsed in 6 frames chunks (B1-B4) that we used to compute fluorescence fluctuations. Further intervals mark different response periods throughout the trial including the cue (C), delay (D) and report (R, L1, L2). (**b**) Distribution of average z-score values. Vertical lines mark the 1 and 99 percentile of the distribution of baseline fluorescence fluctuations (black) which we used as thresholds to determine whether a bouton was responsive or not. Signals acquired during the later periods of the trial (C, D, R, L1, L2) were compared to these thresholds. A bouton was classified as responsive if the average signal during any of the later trial periods (D,D,R,L1,L2) was above 99 percentile (enhanced) of the baseline distribution or below 1 percentile (suppressed). (**c**) Average response time traces of the example bouton in **a** (Mean ± SEM), parsed by cue identity (Left: odor trials; Right: sound trials) and instruction (blue: Go; red: No-Go). (**d** and **e**) Distribution of the number of feedback boutons expressing GCaMP (**d**) or EGFP (**e**) that were classified as responsive (black) as a function of systematically varying the signal threshold (percentile) of the distribution of fluorescence fluctuations during the baseline. Color traces mark different types of responses: enhanced (red), suppressed (blue), and complex (green, which displayed both enhancement and suppression response periods). Note that across different signal thresholds, substantially more responsive boutons were identified in the GCaMP vs. EGFP boutons.

Supplementary Figure 5



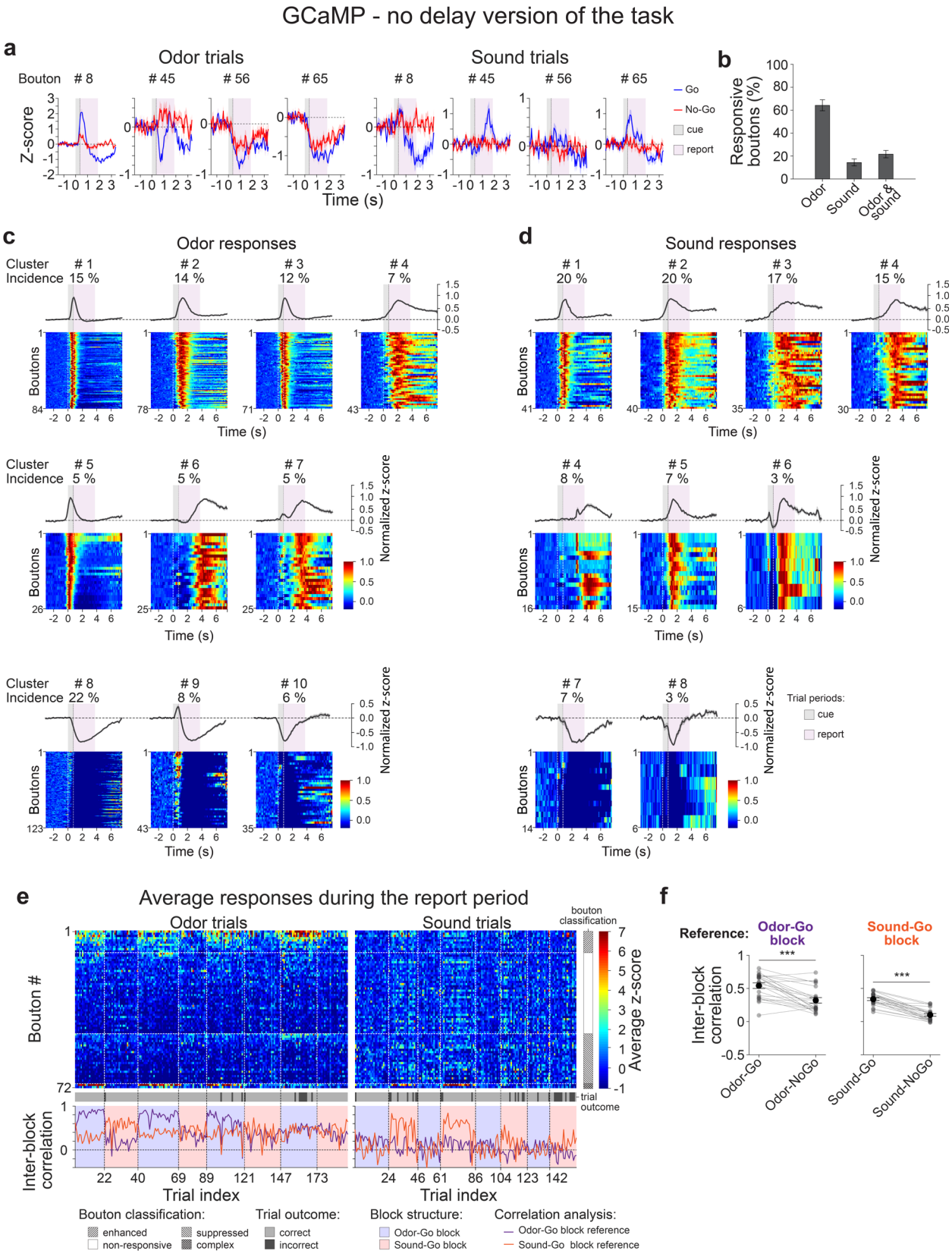
Supplementary Figure 5. (**a**) Example trial-averaged GCaMP5 bouton responses from 'delay' (Left) and 'no-delay' (Right) behavior and imaging sessions in expert mice, sorted by the cue identity (Odor and Sound) and instruction signals (Go and No-Go). (**b**) Same for example trial-averaged EGFP bouton fluctuations from delay (Left) and no-delay (Right) sessions. (**c**) Same as **a** for all boutons (GCaMP5) across all fields of view in the delay (Left; N = 20 sessions, 3 mice) and no-delay (Right; N = 23 sessions, 4 mice) versions of the task. (**d**) Same as **c** for the EGFP boutons (N = 10 sessions, 3 mice). (**e**) Percentage of boutons classified as 'Responsive' or 'Non-responsive', from all GCaMP and EGFP imaging and behavior sessions in expert mice trained in both versions of the task (Methods). Error bars: ± SEM.

Supplementary Figure 6



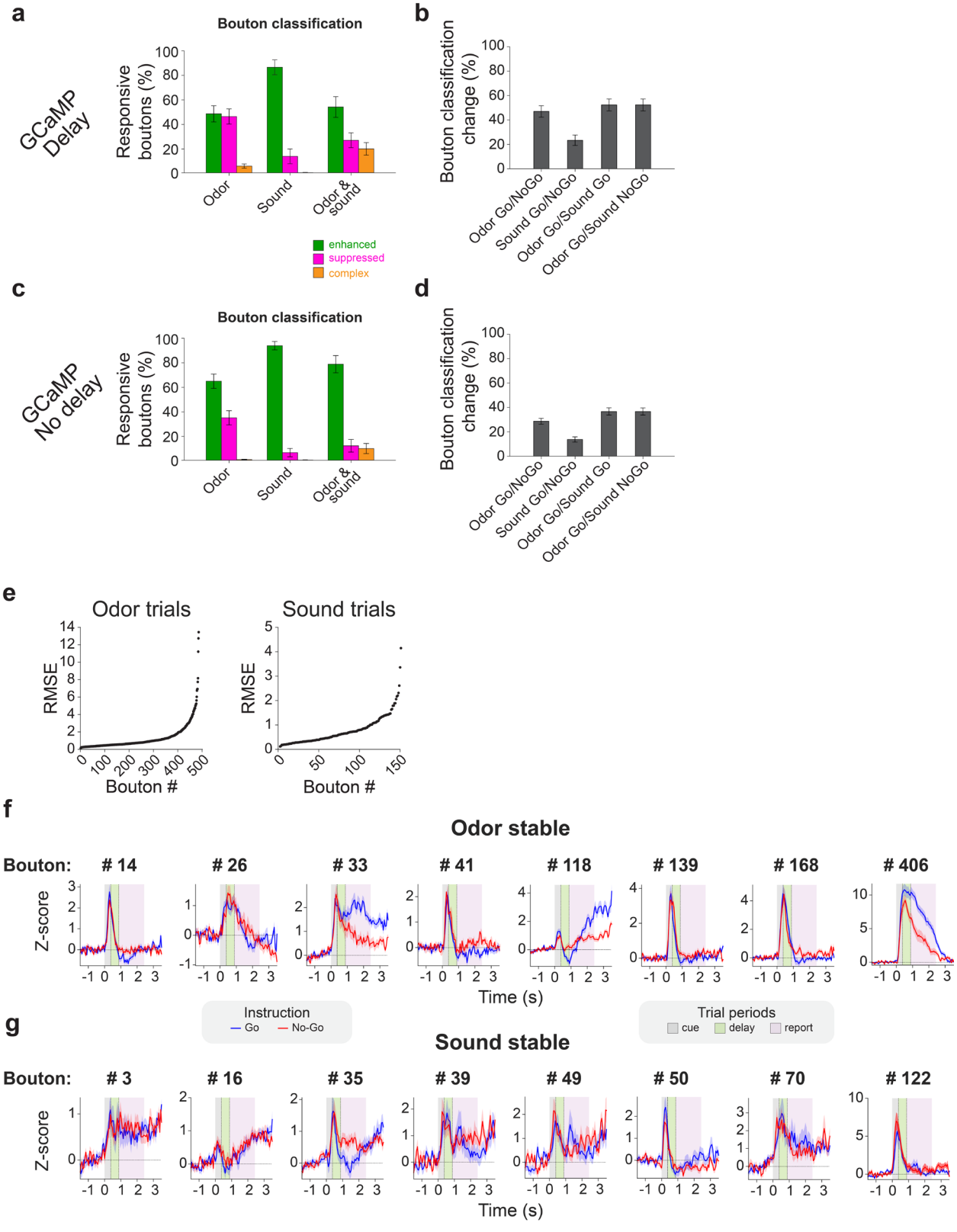
Supplementary Figure 6. (**a**) Percentage of responsive boutons to the odor, sound, or both cues across all fields of view in the delay version. (**b**, **c**) K-means clustering of bouton responses for odor trials (**b**) and sound trials (**c**) in the delay version of the task (GCaMP5). Average cluster waveform (enhanced, suppressed, complex) and cluster incidence (Top) and individual bouton response (Bottom) for each cluster. Note the diversity of time courses across clusters, spanning different periods of the task. Trial periods (cue, delay, report) are marked by vertical lines and colored areas (gray: cue; green: delay; pink: report). (**d**) K-means clustering of bouton EGFP fluorescence dynamics from animals trained in the delay version of the task. All panels error bars: ± SEM.

Supplementary Figure 7



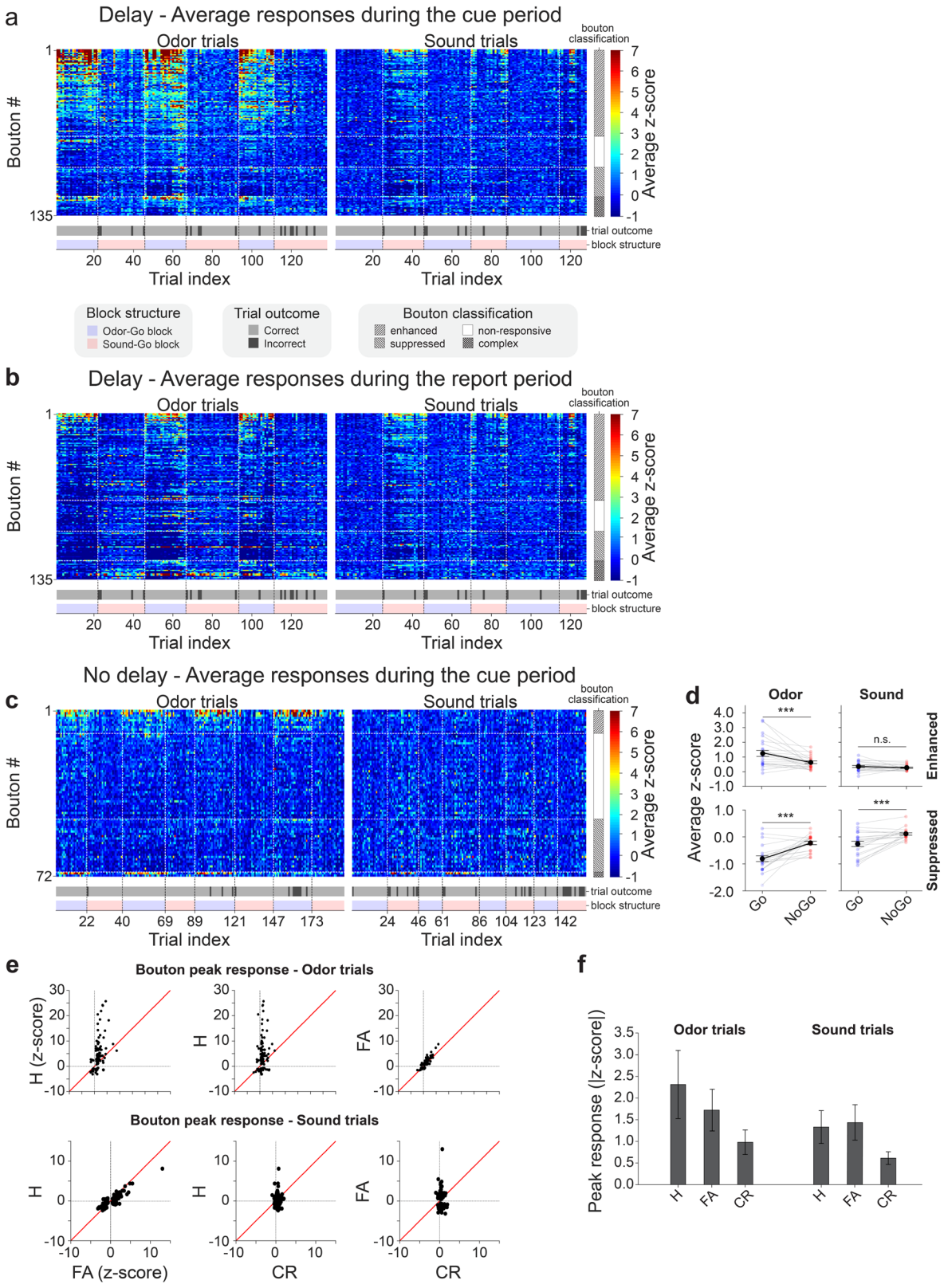
Supplementary Figure 7. GCaMP no-delay sessions: (**a**) Example average bouton responses to odor (Left) and sound (Right) cues sorted by instruction signals (Go, blue and No-Go, red). Trial periods are marked by colored areas (light gray: cue; light pink: report). (**b**) Percentage of responsive boutons to the odor, sound, or both cues. (**c**,**d**) K-means clustering of GCaMP responses in no-delay sessions for odor (**c**) and sound trials (**d**). Average cluster waveform (enhanced, suppressed, complex) and cluster incidence (Top) and individual bouton response (Bottom) for each cluster. Trial periods are marked by vertical lines and colored areas. (**e**) Activity maps (Top): Average responses (z-scored) during the report period for all identified boutons from an example behavior and imaging session across trials. Odor trials (Left) are parsed from sound trials (Right). Bouton classification: Bouton responses are grouped depending on their responsiveness and polarity and classified as enhanced (right oblique pattern), suppressed (left oblique pattern), or complex (cross pattern). A subset of boutons was classified as unresponsive (no pattern). Color scale bar: Average z-score values. Bottom bar represents the outcome of each trial. Correct trials (hits and correct rejections) are shown in light gray. Incorrect trials (misses and false alarms) shown in dark gray. Bottom plots: Average correlation coefficient between an average bouton ensemble response vector (Methods) of the first 'Odor-Go block' (purple trace) or first 'Sound-Go block' (orange trace) in the session, and the ensemble bouton response vector of each trial parsed by cue identity. Block structure: 'Odor-Go blocks': light purple; 'Sound-Go blocks': pink. (**f**) Average inter-block correlation coefficients for all fields of view (no-delay version) using the 'Odor-Go block' (Left) or 'Sound-Go block' (Right) as reference for the ensemble bouton responses during the odor and sound trials and for both types of instructions. Student's t-test: *** = $p < 0.0001$; n.s.: non-significant. All panels error bars: ± SEM.

Supplementary Figure 8



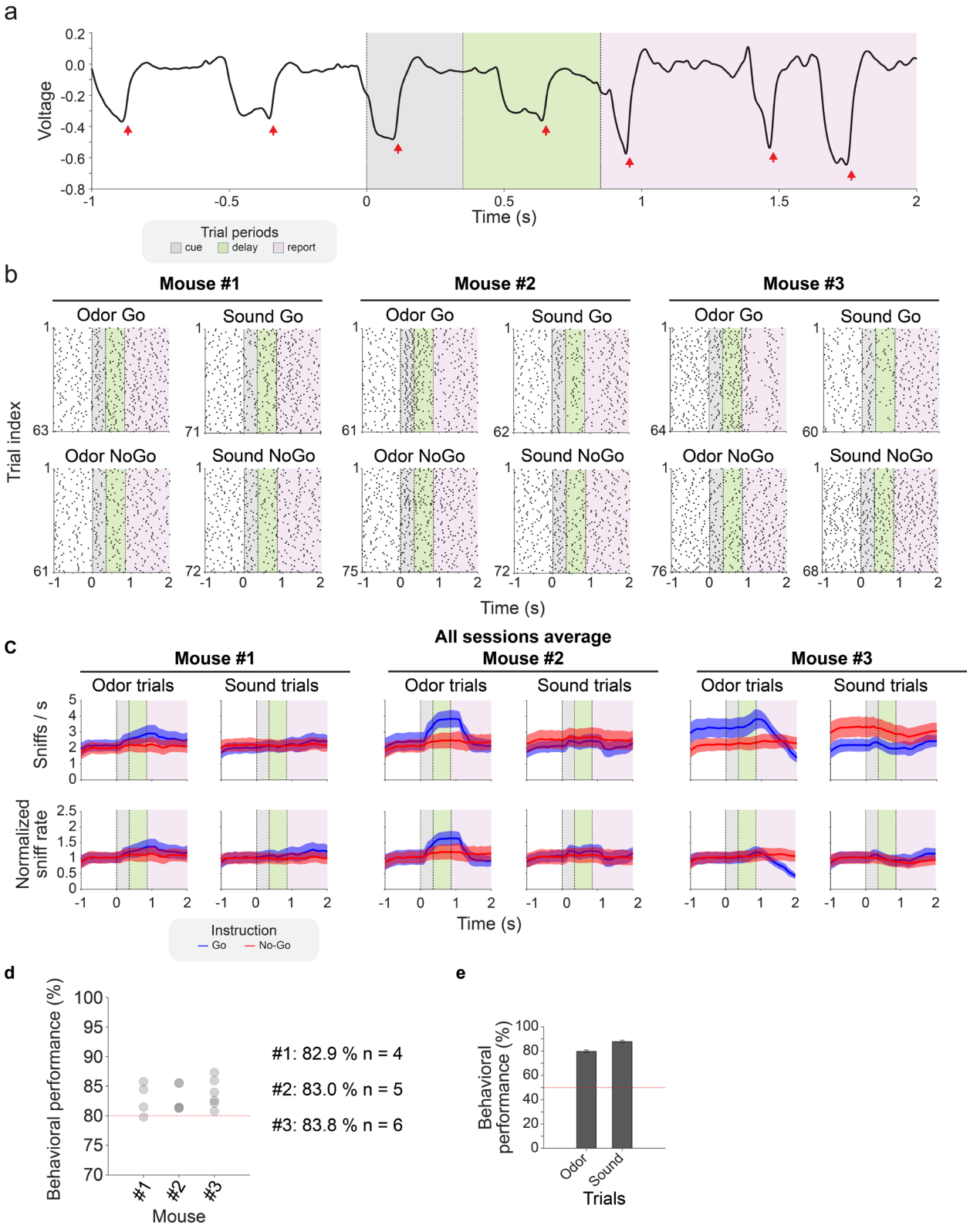
Supplementary Figure 8: (**a**,**c**) Percentage of GCaMP labeled boutons classified as enhanced (green), suppressed (magenta) or complex (orange) for the delay (**a**) and no-delay (**c**) versions of the task. (**b**,**d**) Percentage of boutons that changed class (e.g. from unresponsive to enhanced, enhanced to suppressed, etc.) in delay (**b**) and no-delay (**d**) when comparing responses to the same sensory cue for different instructions (Go vs. No-Go) and to different cues (odor or sound) for the same instruction. (**e**) Root mean square errors (RMSE) between average responses of individual boutons (during the cue and delay periods) in Go versus No-Go trials for same sensory stimulus; shown are RMSE for boutons that did not substantially change their response waveform across conditions (i.e. Pearson correlation coefficient between individual bouton response waveforms in the Go vs. No-Go trials for the same sensory cue was within the 90% percentile of the distribution of trial-to-trial correlations for the Go trials). RMSE were sorted by increasing magnitude for odor responsive (Left) and sound responsive (Right) boutons that passed the criterion. (**f**,**g**) Example odor (**f**) and sound (**g**) responses of boutons across signal instructions (Go vs. No-Go) from the distributions shown in (**e**). Numbers (#) represent indices of the corresponding boutons in the RMSE distributions. All panels error bars: ± SEM.

Supplementary Figure 9



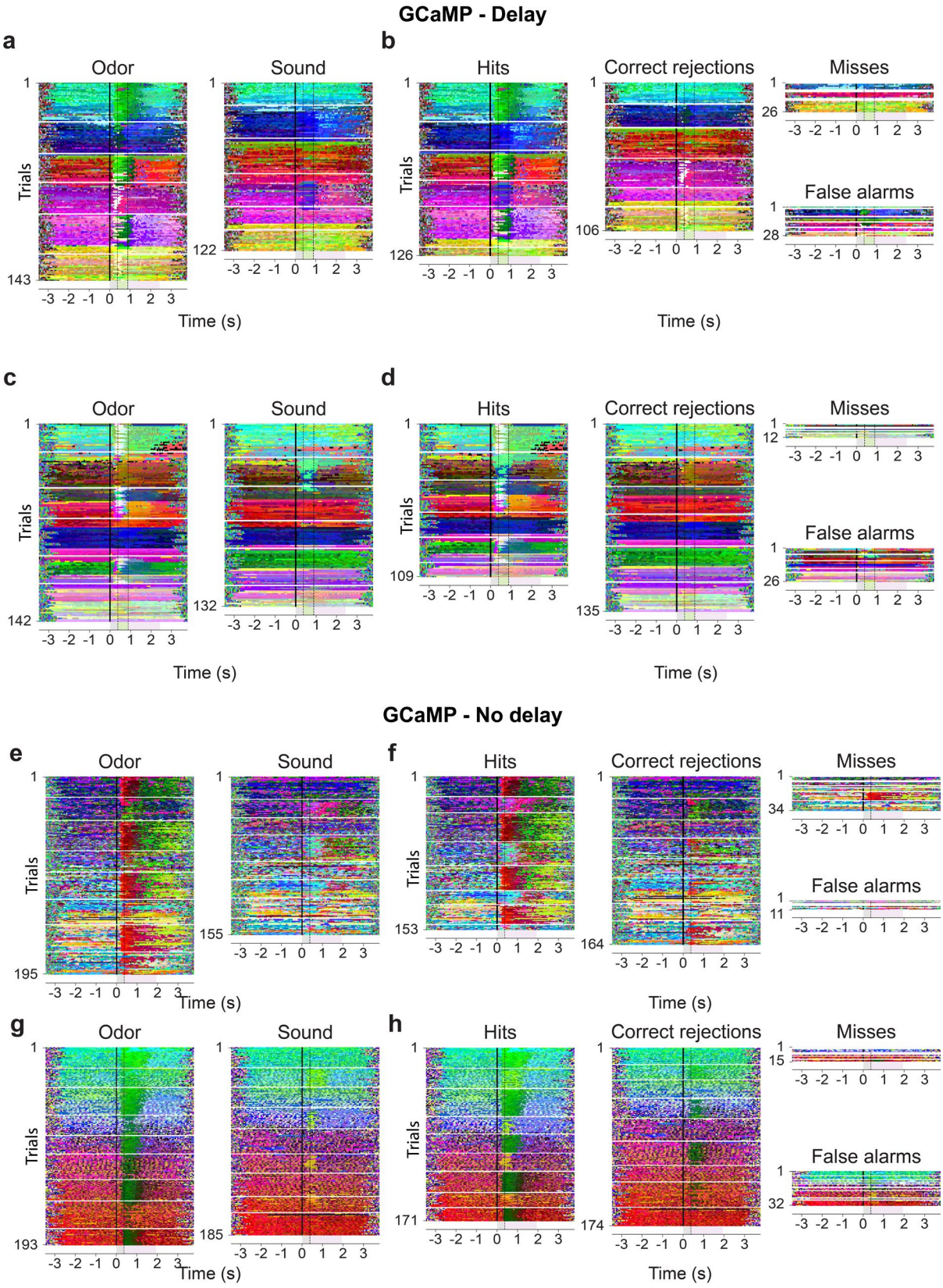
Supplementary Figure 9. (**a**,**b**) Activity maps for the same field of view shown in **Figs. 2d,e** representing average responses (z-scored) during cue (**a**) and report periods (**b**). (**c**) Activity map along trials of average responses (z-scored) during the cue period in a no-delay example session. (**d**) Average z-scored response values during the cue period (no-delay sessions) parsed by cue (Odor or Sound) and instruction (Go or No-Go) for the responsive boutons sampled. Each pair of connected dots represents average z-scored response values computed across boutons from one behavior session. Black dots represent average z-scored ensemble bouton response across sessions. (**e**) Peak responses (z-scored) across different behavioral contingencies (Hits vs. False alarms, Hits vs. Correct rejections and False alarms vs. Correct rejections) of all responsive boutons in an example field of view. Each dot corresponds to a bouton. (**f**) Average peak responses (z-scored) across different behavioral contingencies (Hits, H, False alarms, FA, Correct rejections, CR) across fields of view (delay sessions) for Odor (Left) and Sound (Right) trials. Student's t-test: *** = $p < 0.0001$; n.s.: non-significant. All panels error bars: ± SEM.

Supplementary Figure 10



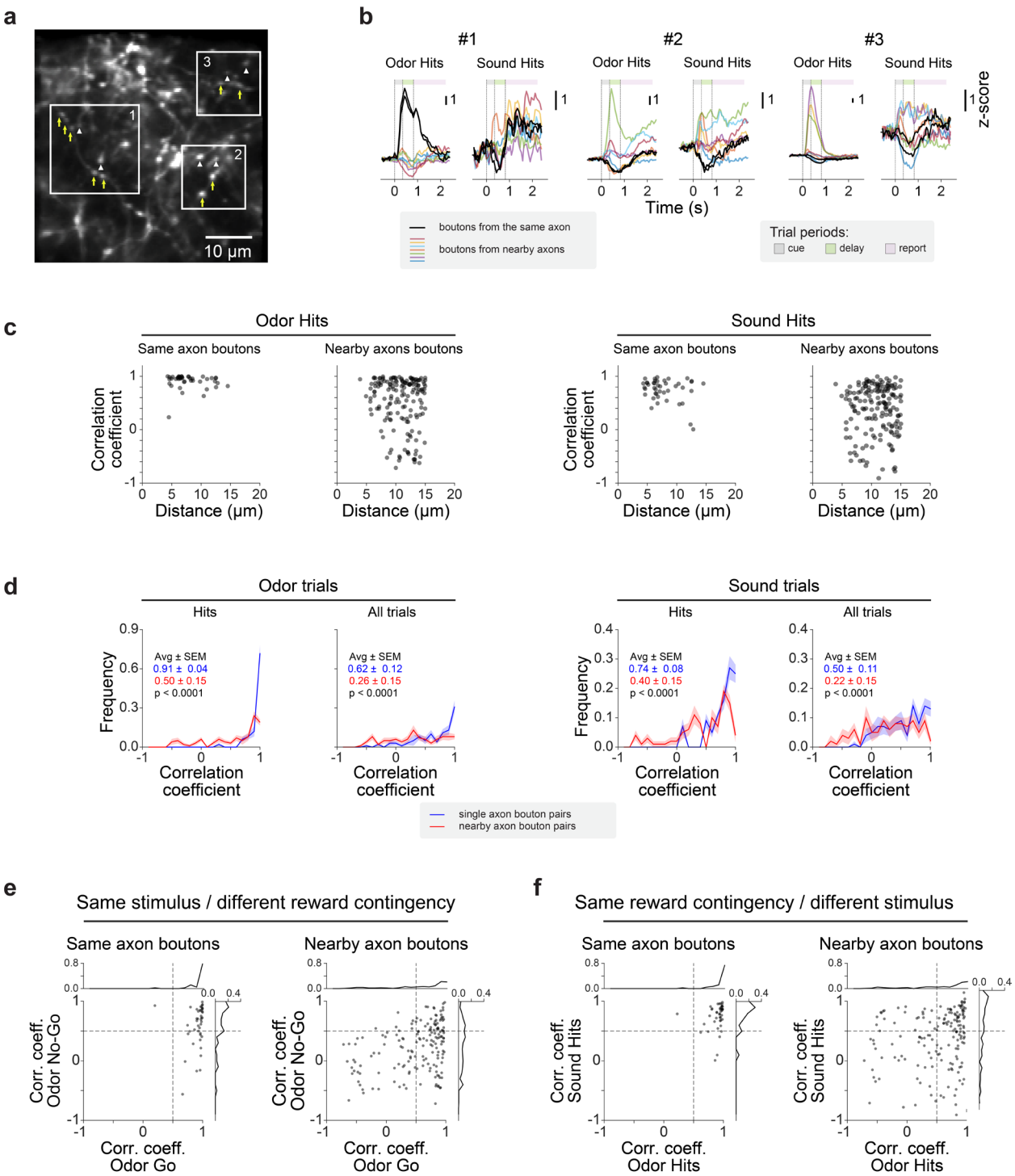
Supplementary Figure 10. **Sniff patterns in control expert mice performing the delay version of the rule-reversal task.** (**a**) Example sniff pattern during one trial in an expert mouse. Sniffing was measured using a flow sensor placed in front of the animal's snout (Methods). Arrows correspond to inhalation start. (**b**,**c**) Sniff monitoring across trials in example behavior sessions. For each mouse, trials are sorted by cue identity (Odor vs. Sound) and instruction signal (Go vs. No-Go). (**b**) Each dot represents an inhalation start identified as shown in **a** (Methods). Colored areas represent different trial periods (gray: cue; green: delay; pink: report). (**c**) Average sniff rate (Top) and normalized average sniff rate (Bottom, with respect to pre-cue air baseline) across all sampled behavior sessions (4-6 sessions per mouse). (**d**) Average behavior performance of the mice shown in (**b**,**c**) (Mouse 1 - 82.9%, N = 4 sessions; Mouse 2 - 83.0%, N = 5 sessions; Mouse 3 - 83.8%, N = 6 sessions). Across mice and sessions, sniff rate for a given cue was either unaffected or changed slightly based on the instruction signal. Instruction-dependent changes in sniff rate varied across animals and did not appear to correlate with the behavioral performance. (**e**) Average session behavioral performance (Mean ± SEM) of odor and sound trials in expert mice (N = 15 sessions; 3 mice). Panels **c** and **e** error bars: ± SEM.

Supplementary Figure 11



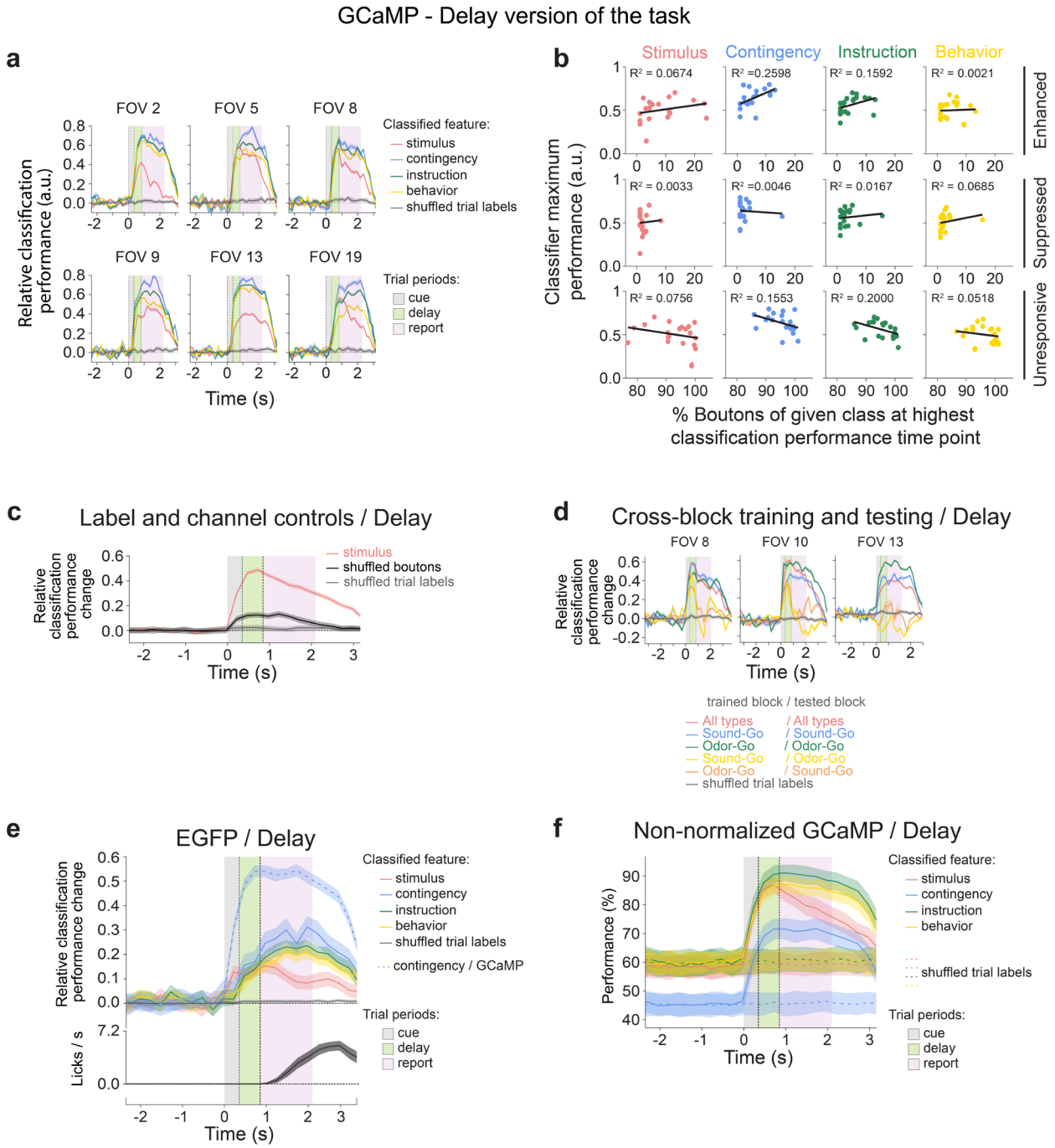
Supplementary Figure 11. Kohonen response maps of example 'delay' (**a-d**) sessions. (**a**,**c**) Example fields of view #7 (**a**) and #10 (**c**) parsed by cue (Odor vs. Sound). (**b**,**d**) Example fields of view #7 (**b**) and #10 (**d**) parsed by trial contingency (H, FA, CR). (**g-h**) Same analysis for example fields of view in the 'no-delay' version of the task. Trial periods are detailed at the bottom of each panel (gray: cue; green: delay; pink: report).

Supplementary Figure 12



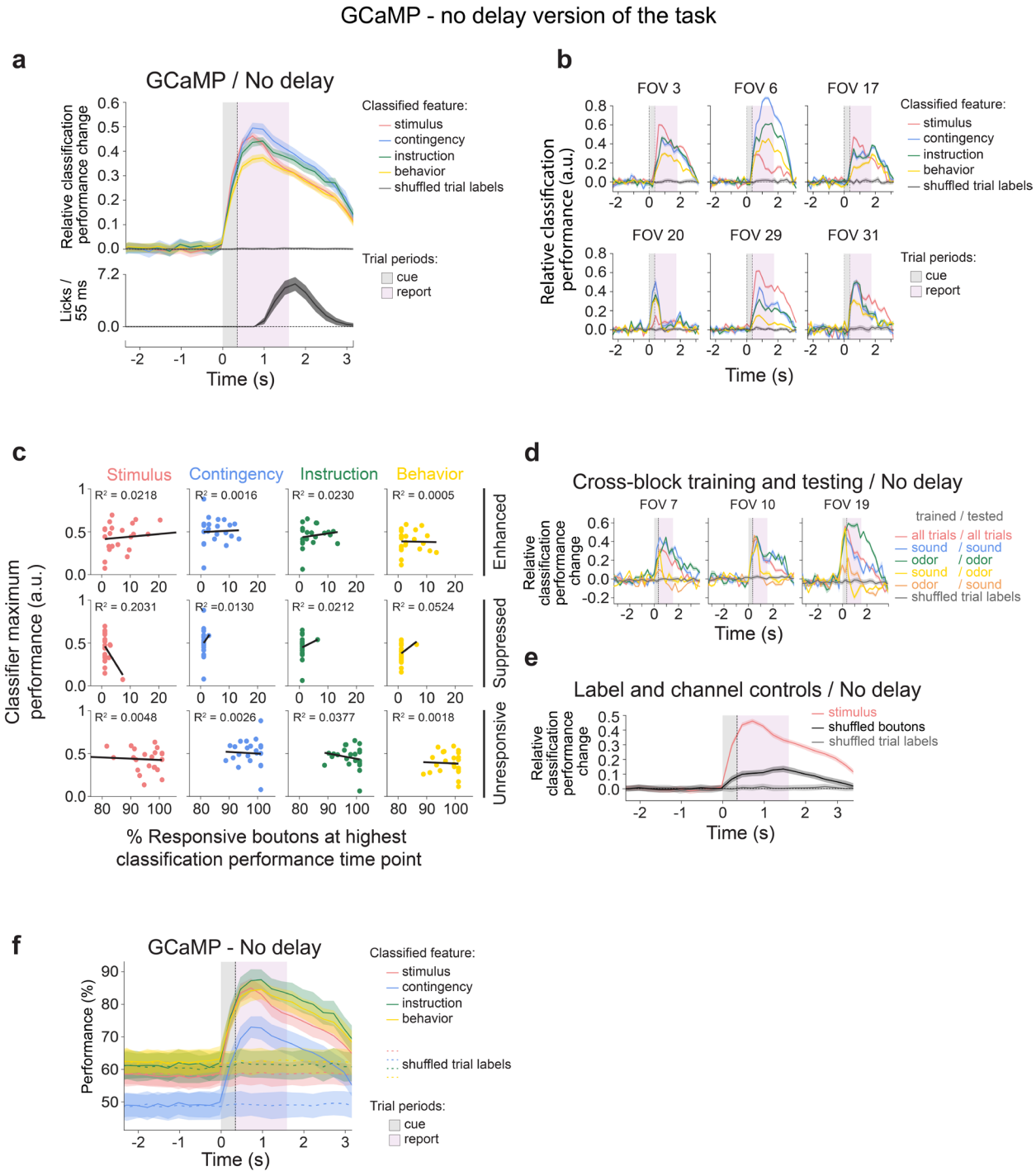
Supplementary Figure 12. Boutons on the same cortical feedback axon are highly correlated in their responses to the same cue across reward contingencies and to the same reward contingency across cues. (**a**) Example field of view (48 x 48 μm, ~200-300 μm below the olfactory bulb surface); cortical bulbar feedback axons expressing GCaMP5: several axonal branches were visually identified; yellow arrows mark example boutons on the same axon; white arrows mark neighboring boutons from potentially different feedback axons. (**b**) Example trial-averaged responses of boutons to Odor Hit (**Left**) vs. Sound Hit trials (Right) across three example subfields (**#1**, **#2**, **#3**) in **a**. Vertical lines mark different trial periods (light-gray: cue; green: delay; pink: report). Responses of boutons on the same axon are shown in black (two examples per panel are included). Color traces correspond to the responses of neighboring boutons. In a given subfield, the response of the same bouton across Odor vs. Sound Hit trials is shown in the same color. (**c**) Pairwise bouton response correlation as a function of distance for boutons on the same axon or nearby axons for odor (Left) and sound (Right) trials. (**d**) Left**:** Histograms of average response pairwise correlations for boutons on same (blue) or different, nearby (red) axons in odor hit trials (**Hits**) and across all types of odor trials (All trials). Bouton pairs were selected to be at most 15 μm apart. Note that boutons on the same axon were substantially more similar in response than boutons on different axons. Right: Same as a for sound trials hit trials (Hits) and all sound trials (All trials). Pairwise bouton analysis included 46 pairs of boutons on the same axon and 400 bouton pairs across axons; $p < 0.0001$, Wilcoxon sum-rank test. (**e**) Scatter plots of pairwise bouton response correlations to the same sensory stimulus (Odor) across blocks (Odor No-Go vs. Odor Go). (**f**) Scatter plots of pairwise bouton response correlations to the same reward contingency (Hit trials) across different cues (Odor Hits vs. Sound Hits). (**e**,**f**) (Left) Bouton pairs on the same axon; (Right) Neighboring bouton pairs on different axons. Each dot represents the response correlation for one bouton pair. Marginal distributions are histograms of pairwise correlation values for each condition. Bouton pairs within 15 um apart were included in the analysis.

Supplementary Figure 13



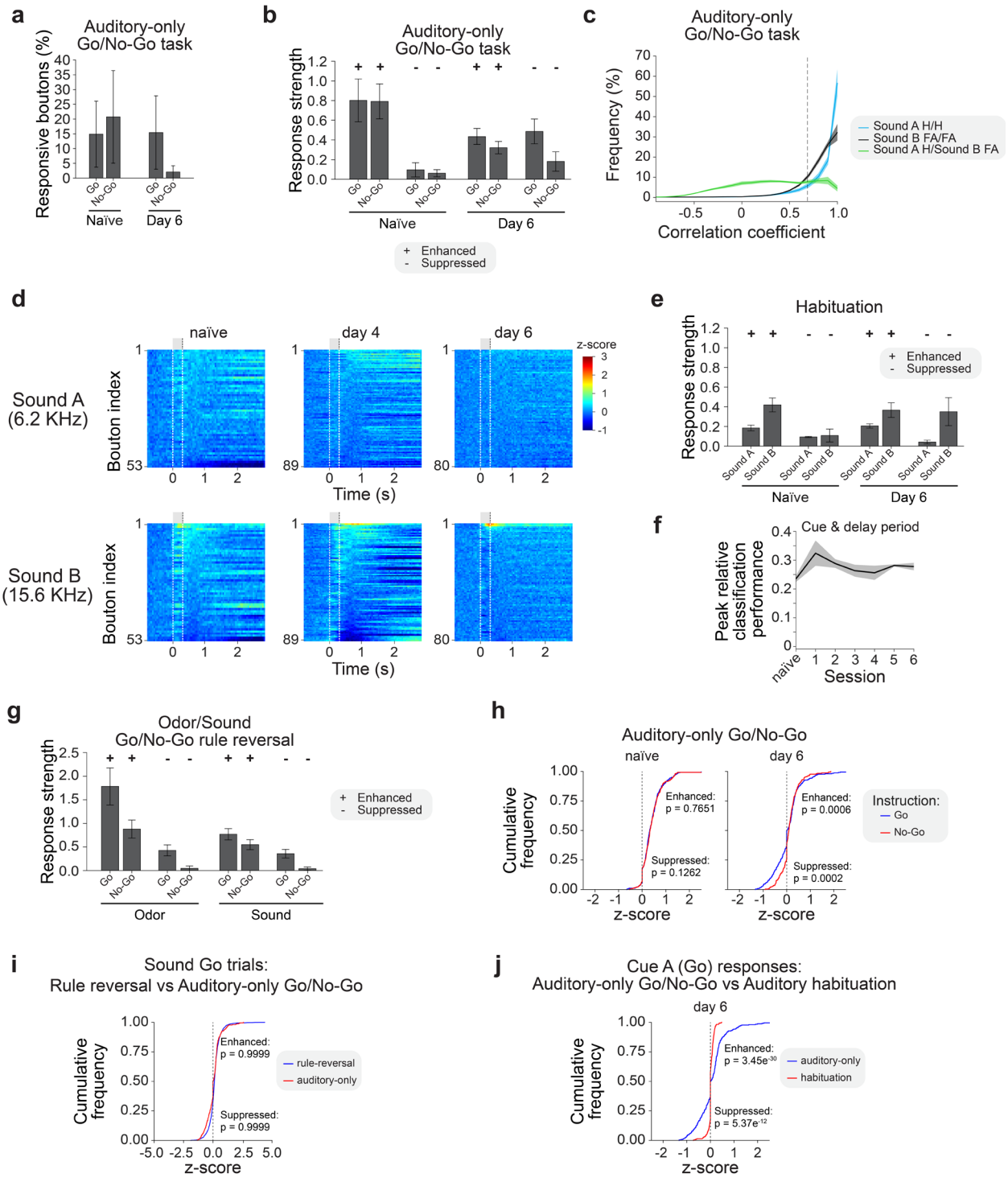
Supplementary Figure 13. **GCaMP delay sessions**: (**a**) Performance of multilayer-perceptron classifiers (MLP, **Fig. 3d**) for example individual fields of view. MLP were trained to decode stimulus identity (odor or sound), behavioral contingency (H, FA, CR), trial instruction (Go or No-Go), and behavior (lick or no-lick). When shuffling trial labels on the training data, the average classifier performance was 0. (**b**) Pearson correlation analysis between the percentages of boutons classified as enhanced (Top), suppressed (Middle), or unresponsive (Bottom) and the maximum performance of the multilayer-perceptrons (**Fig. 3d**). (**c**) Multilayer-perceptron classifier performance for stimulus classification substantially decreases when shuffling the bouton indexes or the trial labels of each trial. (**d**) Cross-block training and testing: Multilayer-perceptron performance for classifying cue identity (Odor vs. Sound) when training using Odor-Go and Sound-Go block trials, Odor-Go block trials only, or Sound-Go block trials only. Performance is tested either on same type of block as training or across block types (e.g. train on Odor-Go block trials and test on Odor-Go block trials; train on Odor-Go blocks trials only and test on Sound-Go trials, etc.) (**e**) Multilayer-perceptron performance for classifying stimulus, contingency, instruction and behavioral outcome, using boutons expressing EGFP in the cortical-bulbar feedback instead of GCaMP. GCaMP classifier performance at predicting trial contingency (H, FA, CR) is shown as reference (light blue line). When shuffling trial labels on the training data, average classifier performance was 0. (Bottom) Distribution of number of licks per second across all sessions. (**f**) Un-normalized version of the multilayer-perceptron performance for classifying stimulus, contingency, instruction and behavioral outcome (GCaMP – delay version of the task) for comparison to the normalized version shown in **Fig. 3d**.

Supplementary Figure 14



Supplementary Figure 14. GCaMP no-delay sessions. (**a**) Multi-layer perceptrons were trained to decode stimulus identity (Odor or Sound), behavioral contingency (Hit, FA, CR, or Miss), trial instruction (Go or No-Go), and behavior (lick or no-lick). **Top**: Cross-sessions average classifier performance normalized relative to the baseline. Shuffling the labels on the training data results in baseline performance of the classifier. (Bottom) Frequency distributions of licks per second for all acquired sessions. (**b**) Multilayer-perceptron performance for example fields of view. (**c**) Pearson correlation analysis between the percentage of boutons classified in a field of view as enhanced (Top), suppressed (Middle), or unresponsive (Bottom) and the maximum performance of the multilayer-perceptrons from **a**. (**d**) Cross-block training and testing: Multilayer-perceptron performance for classifying cue identity (Odor vs. Sound) when training using Odor-Go and Sound-Go block trials, Odor-Go block trials only, or Sound-Go block trials only. Performance is tested either on same type of block as training, or across block types (e.g. train on Odor-Go block trials and test on Odor-Go block trials; train on Odor-Go blocks trials only and test on Sound-Go trials, etc.) (**e**) Multilayer-perceptron performance for stimulus classification when shuffling the bouton channel indexes and the labels of each trial. (**f**) An un-normalized version of the multilayer-perceptron performance shown in **a**. Panels **a**, **b**, **d** to **e** error bars: ± SEM.

Supplementary Figure 15



Supplementary Figure 15. **Auditory-only Go/No-Go task and auditory habituation sessions:** (**a**) Percentage of responsive boutons in Go and No-Go trials in naïve sessions and after six days of training. (**b**) Average response strength in naïve sessions and after six days of training in the auditory-only Go/No-Go task. (**c**) Histogram of individual bouton response correlation values across trials as a function of trial contingency (Hits, H vs. false alarms, FA) in the auditory-only Go/No-Go task. Bouton responses were sampled between cue onset and the end of delay period (before licking) for each of the two sound cues (A and B). (**d**) Average cortical feedback bouton responses in example fields of view parsed by cue ('Sound A' or 'Sound B') and across days of habituation (naïve, day 4, and day 6). (**e**) Average response strength in the sound habituation experiments. (**f**) Peak performance of the classifier across sound habituation sessions. (**g**) Response strength differences to odor- and sound-evoked responses in the Odor/Sound rule reversal task. For **b**,**e** and **g**, we quantified response strength using the average z-score during the delay period, sampling in each field of view the top 20 responsive boutons. +/- mark enhanced and suppressed bouton responses. (**h**) Cumulative distributions of response strength (peak amplitude during delay period) for naïve (Left; Wilcoxon rank-sum test, enhanced and suppressed: n.s.) and task-engaged (day 6, Right; Wilcoxon rank-sum test, enhanced: $p = 0.0006$; suppressed: $p = 0.0002$) mice performing the auditory-only Go/No-Go task. Go responses are shown in blue; No-Go responses in red. (**i**) Cumulative distributions of response strength for expert mice engaged in the odor/sound rule-reversal task (blue) and auditory-only Go/No-Go task (day 6, red). Wilcoxon rank-sum test, enhanced and suppressed: n.s. (**j**) Cumulative distributions of response strength to Sound A for day 6 in mice performing the auditory-only Go/No-Go task (Go cue, blue) or passively exposed to the same sound cue (habituation, red). Wilcoxon rank-sum test, enhanced: $p = 3.45e^{-30}$; suppressed: $p = 5.37e^{-12}$. All panels error bars: ± SEM.

Supplementary Data Part 1

Supplementary Table 1

Figure	Test	n	Degrees of freedom (n-1)	mice	groups	mean				SD				SE				Significance	p-value	F-statistic	R^2	Post hoc test	p-value						Significance					
																							1//2	1//3	1//4	2//3	2//4	3//4	1//2	1//3	1//4	2//3	2//4	3//4
Figure 2 (f) Odor/Enhanced	Student's t-test	20	19	3	2	1.06	0.44	-	-	1.01	0.38	-	-	0.23	0.09	-	-	***	4.69E-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Figure 2 (f) Odor/Suppressed	Student's t-test	20	19	3	2	0.54	0.42	-	-	0.40	0.23	-	-	0.09	0.05	-	-	***	5.73E-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Figure 2 (f) Sound/Enhanced	Student's t-test	20	19	3	2	-1.15	-0.19	-	-	0.31	0.20	-	-	0.07	0.05	-	-	n.s	9.63E-02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Figure 2 (f) Sound/Suppressed	Student's t-test	20	19	3	2	-0.55	-0.04	-	-	0.39	0.13	-	-	0.09	0.03	-	-	***	6.50E-06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Figure 2 (g) Odor-Go Block	Student's t-test	20	19	3	2	0.43	0.14	-	-	0.18	0.11	-	-	0.04	0.03	-	-	***	4.39E-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Figure 2 (g) Sound-Go Block	Student's t-test	20	19	3	2	0.29	0.12	-	-	0.11	0.12	-	-	0.03	0.03	-	-	***	1.02E-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Figure 2 (h) Odor-Go Block	One-way Anova	20	19	3	4	0.43	0.13	0.21	0.14	0.28	0.12	0.17	0.12	0.06	0.03	0.04	0.03	***	9.59E-17	30.900	-	Multiple comparisons of means	7.65E-08	2.35E-04	3.07E-07	1.90E-01	9.88E-01	3.36E-01	***	***	***	n.s.	n.s.	n.s.
Figure 2 (h) Sound-Go Block	One-way Anova	20	19	3	4	0.28	0.11	0.38	0.22	0.22	0.12	0.15	0.08	0.05	0.03	0.03	0.02	***	1.21E-10	22.840	-	Multiple comparisons of means	7.28E-06	3.88E-02	1.58E-01	6.56E-11	1.20E-02	3.89E-05	***	*	n.s.	***	*	***
Figure 3 (a) Odor trials	One-way Anova	20	19	3	4	90.00	56.71	67.79	53.91	0.00	19.00	12.90	18.22	0.00	10.97	7.45	10.52	*	8.11E-11	24.360	-	Multiple comparisons of means	2.98E-09	1.27E-04	1.52E-09	1.14E-01	9.39E-01	4.19E-02	*	*	*	n.s.	n.s.	n.s.
Figure 3 (a) Sound trials	One-way Anova	20	19	3	4	90.00	52.73	72.48	47.37	0.00	22.71	14.24	22.07	0.00	13.11	8.22	12.74	*	1.12E-10	23.916	-	Multiple comparisons of means	1.60E-08	1.75E-02	1.71E-09	5.72E-03	7.90E-01	5.84E-04	*	*	*	n.s.	n.s.	n.s.
Figure 3 (b) Lick trials	One-way Anova	20	19	3	4	90.00	63.43	67.79	44.03	0.00	18.95	12.90	20.91	0.00	10.94	7.45	12.07	*	3.38E-11	26.103	-	Multiple comparisons of means	2.62E-06	2.18E-04	1.38E-11	8.21E-01	3.01E-03	3.97E-04	*	*	*	n.s.	n.s.	n.s.
Figure 5 (e) performance vs neuro-l distance	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	***	1.27E-05	62.876	0.86	-	-	-	-	-	-	-	-	-	-	-	-	-
Figure 5 (g) odor trials	One-way Anova	3	2	3	4	0.81	0.64	0.79	0.79	0.06	0.09	0.05	0.08	0.01	0.03	0.01	0.02	***	1.32E-06	12.593	-	Multiple comparisons of means	1.15E-06	8.11E-01	8.54E-01	1.12E-05	2.76E-05	1.00E+00	***	n.s.	n.s.	***	***	n.s.
Figure 5 (g) sound trials	One-way Anova	3	2	3	4	0.80	0.61	0.78	0.84	0.07	0.14	0.05	0.12	0.02	0.05	0.01	0.03	***	1.07E-06	12.823	-	Multiple comparisons of means	1.05E-05	8.56E-01	7.58E-01	7.43E-05	7.80E-07	2.93E-01	***	n.s.	n.s.	***	***	n.s.
Supp Fig. 1 (l) Response strength GCaMP	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	1.03E-01	2.664	8.95E-06	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 1 (m) % Responsive boutons GCaMP	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	***	7.27E-69	318.142	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 1 (n) % Responsive boutons EGFP	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	***	1.22E-14	61.628	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 7 (f) left Odor-Go Block	Student's t-test	23	22	4	2	0.54	0.31	-	-	0.18	0.18	-	-	0.04	0.04	-	-	***	1.43E-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 7 (f) right Sound-Go Block	Student's t-test	23	22	4	2	0.34	0.10	-	-	0.09	0.09	-	-	0.02	0.02	-	-	***	1.21E-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 9 (d) top left Odor/Enhanced	Student's t-test	23	22	4	2	1.49	0.72	-	-	0.96	0.43	-	-	0.21	0.09	-	-	***	8.84E-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 9 (d) Sound/Enhanced	Student's t-test	23	22	4	2	0.75	0.43	-	-	0.45	0.26	-	-	0.10	0.06	-	-	***	1.55E-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 9 (d) Odor/Suppressed	Student's t-test	23	22	4	2	-0.97	-0.31	-	-	0.42	0.30	-	-	0.09	0.06	-	-	***	6.09E-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 9 (d) Sound/Suppressed	Student's t-test	23	22	4	2	-0.45	0.00	-	-	0.32	0.15	-	-	0.07	0.03	-	-	***	2.96E-05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 12 (d) Odor Hit trials	Wilcoxon rank sum test	100	99	3	2	0.92	0.52	-	-	0.10	0.45	-	-	0.03	0.15	-	-	***	4.47E-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 12 (d) All odor trials	Wilcoxon rank sum test	100	99	3	2	0.64	0.22	-	-	0.34	0.47	-	-	0.11	0.16	-	-	***	2.86E-07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 12 (d) Sound Hit trials	Wilcoxon rank sum test	100	99	3	2	0.73	0.39	-	-	0.25	0.48	-	-	0.08	0.16	-	-	***	1.88E-13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 12 (d) All sound trials	Wilcoxon rank sum test	100	99	3	2	0.57	0.27	-	-	0.38	0.39	-	-	0.13	0.13	-	-	***	3.22E-08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Supplementary Table 2

Supplementary Data Part 2																																			
																								p-value									Significance				
Figure	Test	n	Degrees of freedom (n-1)	mice	groups	mean				SD				SE				Significance	p-value	F-statistic	R^2	Post hoc test	1//2	1//3	1//4	2//3	2//4	3//4	1//2	1//3	1//4	2//3	2//4	3//4
Supp Fig. 13 (b) Enhanced - Stimulus	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	2.14E-01	1.659	0.0844	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 13 (b) Enhanced - Contingency	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	*	2.31E-02	6.165	0.2551	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 13 (b) Enhanced - Instruction	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	8.56E-02	3.307	0.1552	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 13 (b) Enhanced - Behavior	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	8.66E-01	0.029	0.0016	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 13 (b) Suppressed - Stimulus	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	8.67E-01	0.029	0.0016	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 13 (b) Suppressed - Contingency	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	4.08E-01	0.718	0.0383	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 13 (b) Suppressed - Instruction	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	5.29E-01	0.412	0.0224	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 13 (b) Suppressed - Behavior	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	*	2.31E-02	6.164	0.2551	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 13 (b) Unresponsive - Stimulus	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	8.79E-02	3.255	0.1532	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 13 (b) Unresponsive - Contingency	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	1.05E-01	2.912	0.1393	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 13 (b) Unresponsive - Instruction	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	*	2.05E-01	1.731	0.0877	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 13 (b) Unresponsive - Behavior	Pearson's correlation	20	19	3	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	7.80E-01	0.080	0.0045	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Enhanced - Stimulus	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	5.61E-01	0.350	0.0164	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Enhanced - Contingency	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	8.56E-01	0.034	0.0016	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Enhanced - Instruction	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	4.90E-01	0.494	0.0230	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Enhanced - Behavior	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	9.18E-01	0.011	0.0005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Suppressed - Stimulus	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	*	3.09E-02	5.351	0.2031	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Suppressed - Contingency	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	6.04E-01	0.277	0.0130	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Suppressed - Instruction	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	5.08E-01	0.455	0.0212	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Suppressed - Behavior	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	2.94E-01	1.160	0.0524	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Unresponsive - Stimulus	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	3.70E-01	0.841	0.0385	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Unresponsive - Contingency	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	4.34E-01	0.637	0.0294	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Unresponsive - Instruction	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	3.20E-01	1.037	0.0471	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 14 (c) Unresponsive - Behavior	Pearson's correlation	23	22	4	1	-	-	-	-	-	-	-	-	-	-	-	-	n.s.	2.48E-01	1.412	0.0630	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 15 (h) AO S-Go -naïve vs AO S-NoGo - naïve / Enhanced	Wilcoxon rank sum test	3	-	3	2	0.501	0.521	-	-	0.394	0.398	-	-	0.278	0.281	-	-	n.s.	7.65E-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 15 (h) AO S-Go -naïve vs AO S-NoGo - naïve / Suppressed	Wilcoxon rank sum test	3	-	3	2	-0.234	-0.173	-	-	0.201	0.158	-	-	0.142	0.112	-	-	n.s.	1.26E-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 15 (h) AO S-Go day 6 vs AO S-NoGo day 6 / Enhanced	Wilcoxon rank sum test	3	-	3	2	0.464	0.331	-	-	0.465	0.334	-	-	0.329	0.236	-	-	***	5.56E-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 15 (h) AO S-Go day 6 vs AO S-NoGo day 6 / Suppressed	Wilcoxon rank sum test	3	-	3	2	-0.471	-0.287	-	-	0.335	0.220	-	-	0.237	0.155	-	-	***	2.41E-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 15 (i) RR S-Go vs AO S-Go day 6 / Enhanced	Wilcoxon rank sum test	20/3	-	3	2	0.359	0.464	-	-	0.399	0.465	-	-	0.092	0.329	-	-	n.s.	1.00E+00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 15 (i) RR S-Go vs AO S-Go day 6 / Suppressed	Wilcoxon rank sum test	20/3	-	3	2	-0.324	-0.471	-	-	0.319	0.335	-	-	0.073	0.237	-	-	n.s.	1.00E+00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 15 (j) AO S-Go day 6 vs HAB CueA day 6 / Enhanced	Wilcoxon rank sum test	3	-	3	2	0.464	0.107	-	-	0.465	0.085	-	-	0.329	0.060	-	-	***	3.45E-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supp Fig. 15 (j) AO S-Go day 6 vs HAB CueA day 6 / Suppressed	Wilcoxon rank sum test	3	-	3	2	-0.471	-0.143	-	-	0.335	0.169	-	-	0.237	0.119	-	-	***	5.37E-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-