SUPPLEMENTARY FIGURES

Molecular diversity of clustered protocadherin-α required for sensory integration and short-term memory in mice

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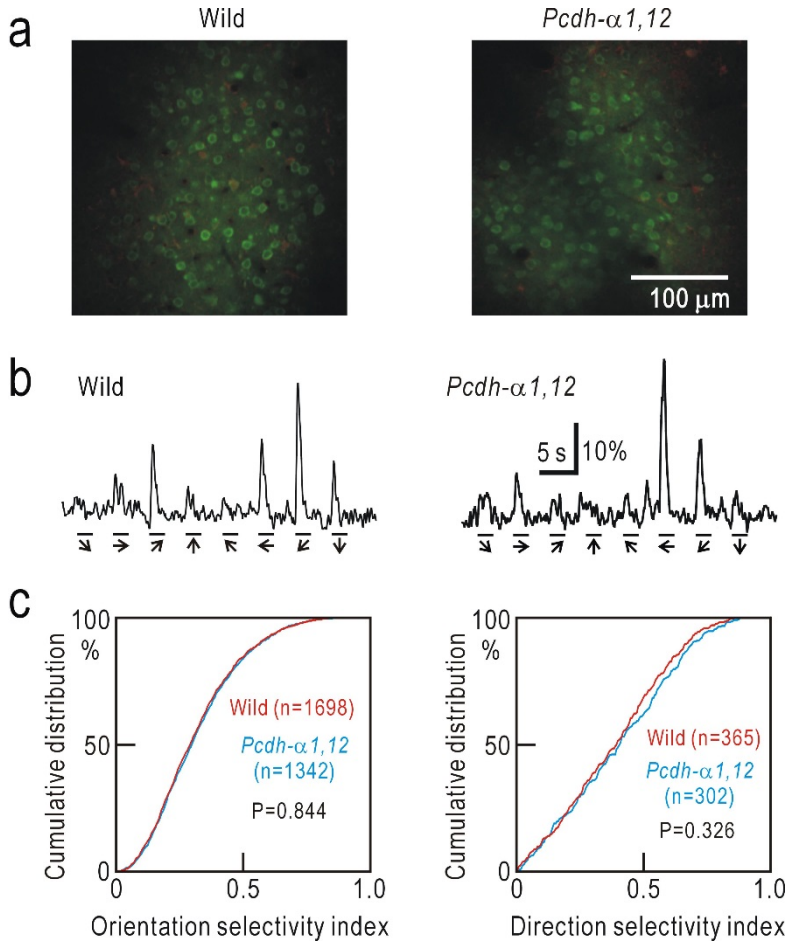
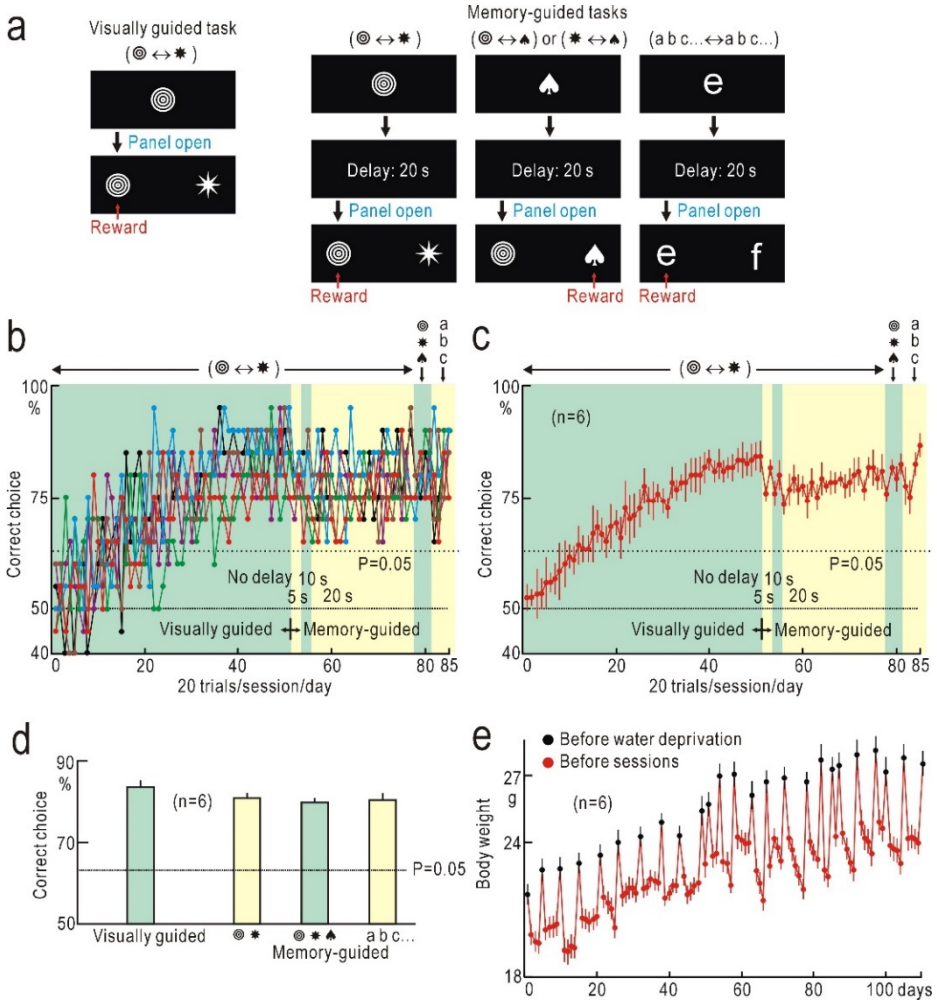


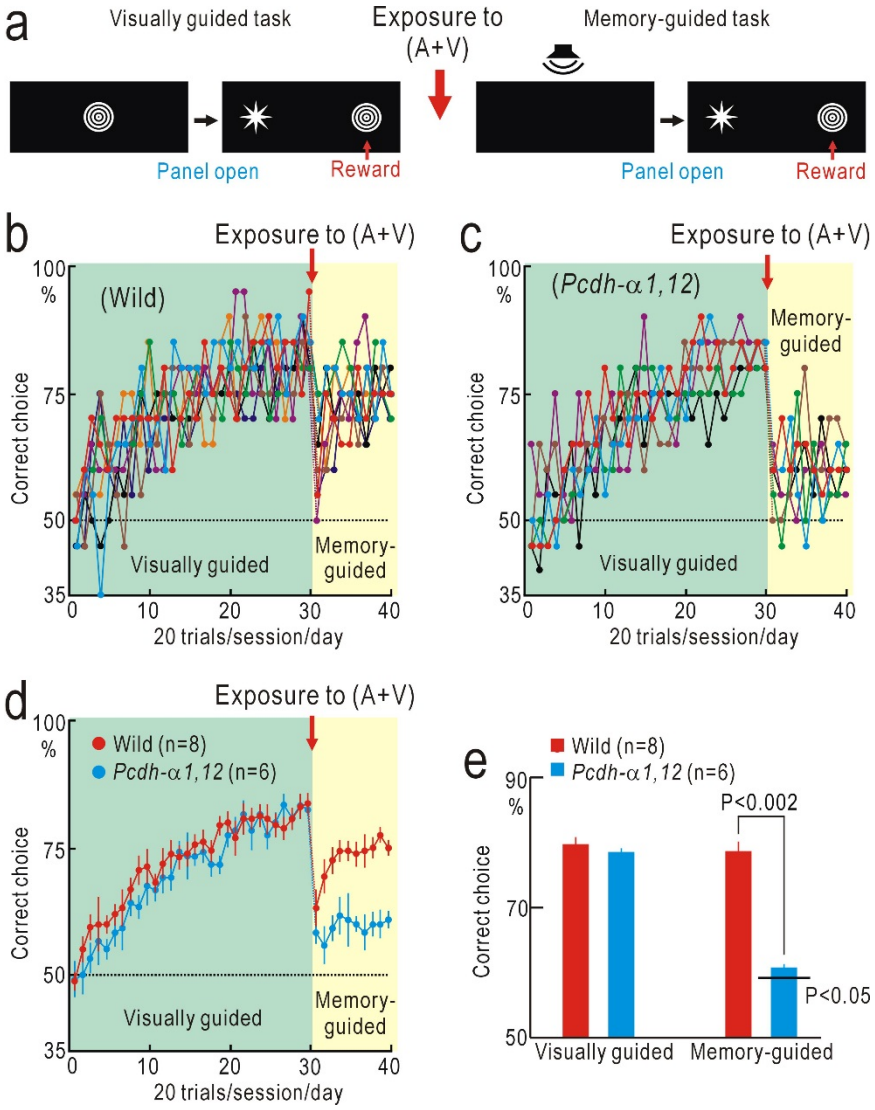
Supplementary Figure S1. Selectivity of V1 neurons.

a, Neurons stained with Cal-520 but not with SR-101 in the V1 of a wild-type mouse (left) and a *Pcdh-α1,12* mouse (right). The image was obtained using a two-photon microscope. **b,** Sample traces of neuronal calcium responses to moving grating patterns in eight directions (from -45° to 270° in 45° steps) for 2 s in a wild-type mouse (left) and a *Pcdh-α1,12* mouse (right). **c,** Cumulative distributions of the orientation selectivity index (OSI, left) and direction selectivity index (DSI, right) of neurons obtained from three wild-type mice and three *Pcdh-α1,12* mice. The OSI was obtained from1698 and 1342 neurons, respectively. The DSI was obtained from 365 and 302 neurons with an OSI > 0.45, respectively. There was no significant difference in the cumulative distribution of the OSI or DSI between wild-type and *Pcdh-α1,12* mice.



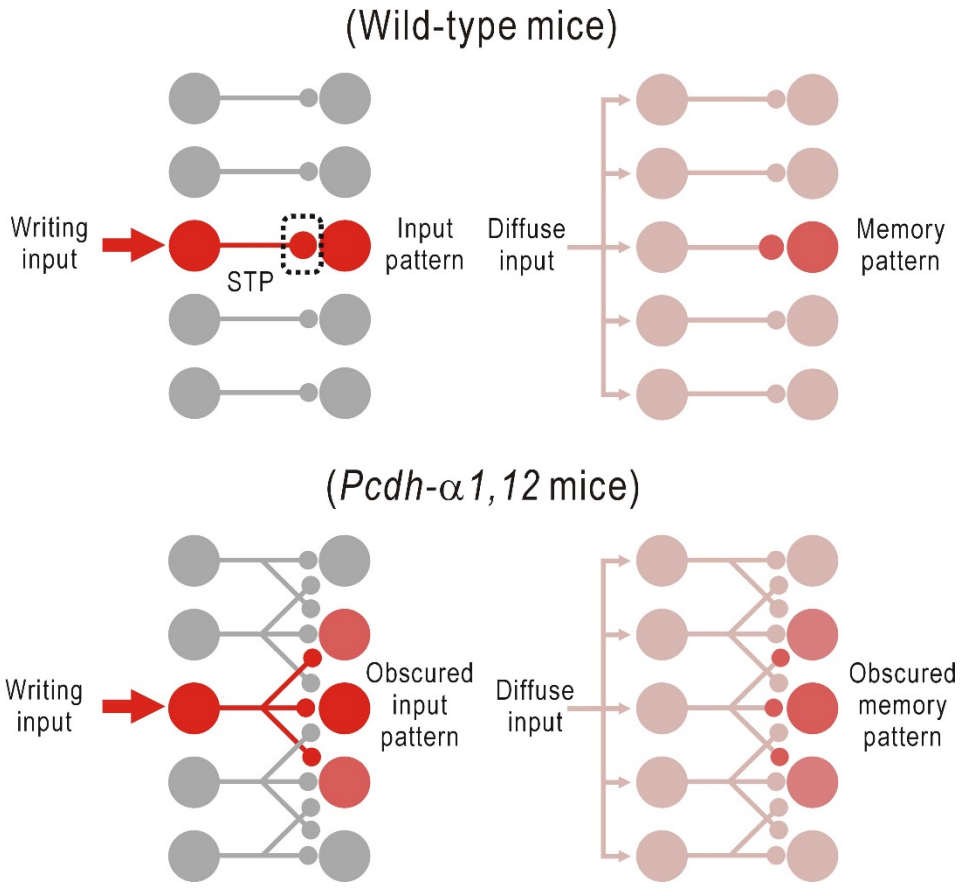
Supplementary Figure S2. Visual discrimination ability of mice.

a, Tasks in this experiment. Matching-to-sample tests with a delay of 0–20 s were used. After discrimination between circles and stars was completed, discrimination between circles and spades or stars and spades, and between alphabet pairs was tested. **b,** Performance in wild-type mice. Dotted line at approximately 63% performance shows a significant (P = 0.05) deviation of the averaged performance from chance level in four successive sessions. **c,** The mean and SEM of data shown in (**b**). **d,** Averaged performance in the visually guided task and memory-guided tasks with a delay of 20 s discriminating between circles and stars, between circles and spades or stars and spades, and between alphabets. **e,** Body weight change during the experiments. Black dots and bars represent data before water deprivation, and red dots and bars show data before each session.



Supplementary Figure S3. Audio-visual associative learning after passive exposure to audio-visual stimulation.

a, Visually guided and memory-guided tasks. Mice were exposed to audio-visual stimulation for 48 h between the two tasks. **b,** Performance of eight wild-type mice. In this experiment, sound cues were combined with visual stimuli only during passive exposure for 48 h between the two tasks. **c,** Performance of six *Pcdh-α1,12* mice. **d,** The mean and SEM. of data shown in (**b**) and (**c**). **e,** Averaged amplitudes of performance in the last five sessions of the visually guided and memory-guided tasks. The performance of *Pcdh-α1,12* mice in the memory-guided task was significantly worse than that of wild-type mice.



Supplementary Figure S4. Sparse circuit model of short-term memory.

In wild-type mice, localized writing input to the first layer produces short-term potentiation (STP) in the stimulated synapses. The information stored as STP can be converted to short-term memory by adding diffuse input to the first layer. In *Pcdh-α1,12* mice, the sparseness of the circuits is slightly deteriorated, thus the content in short-term memory is obscured.