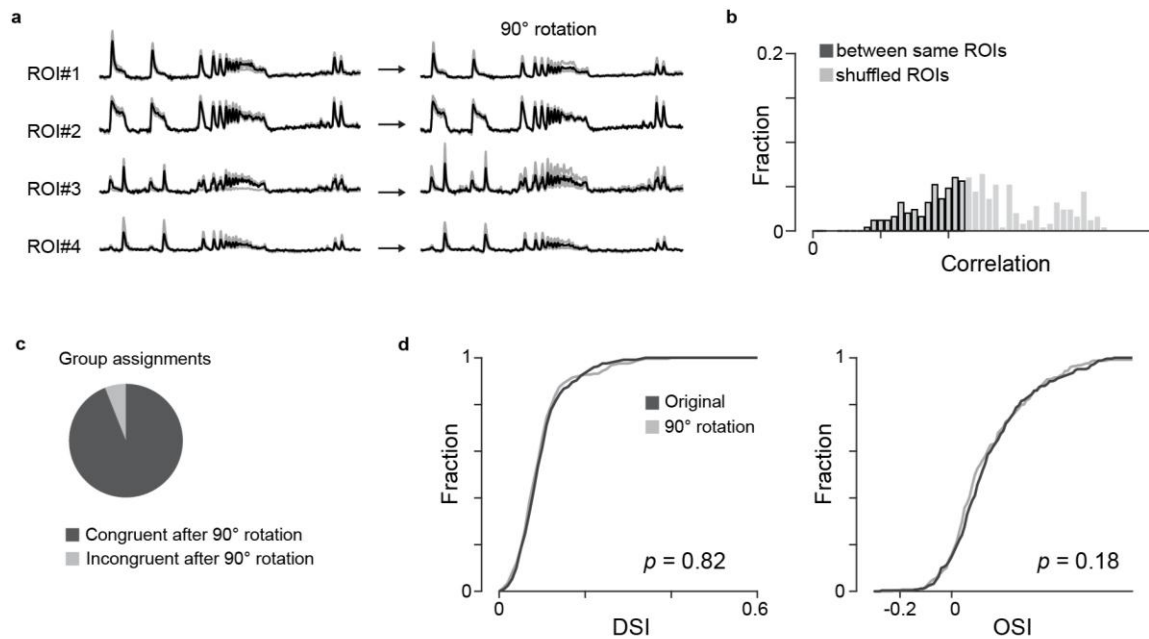


# Functionally distinct GABAergic amacrine cell types regulate spatiotemporal encoding in the mouse retina

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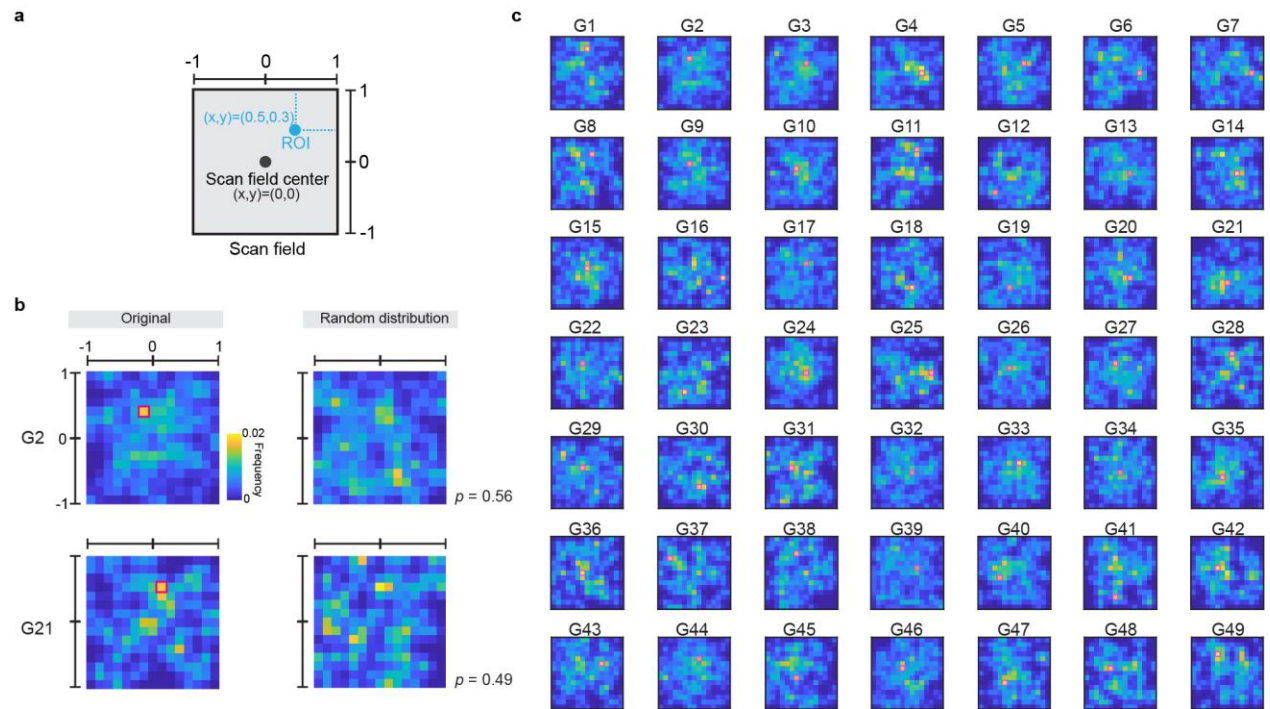
In the format provided by the  
authors and unedited

# Supplementary Figures:



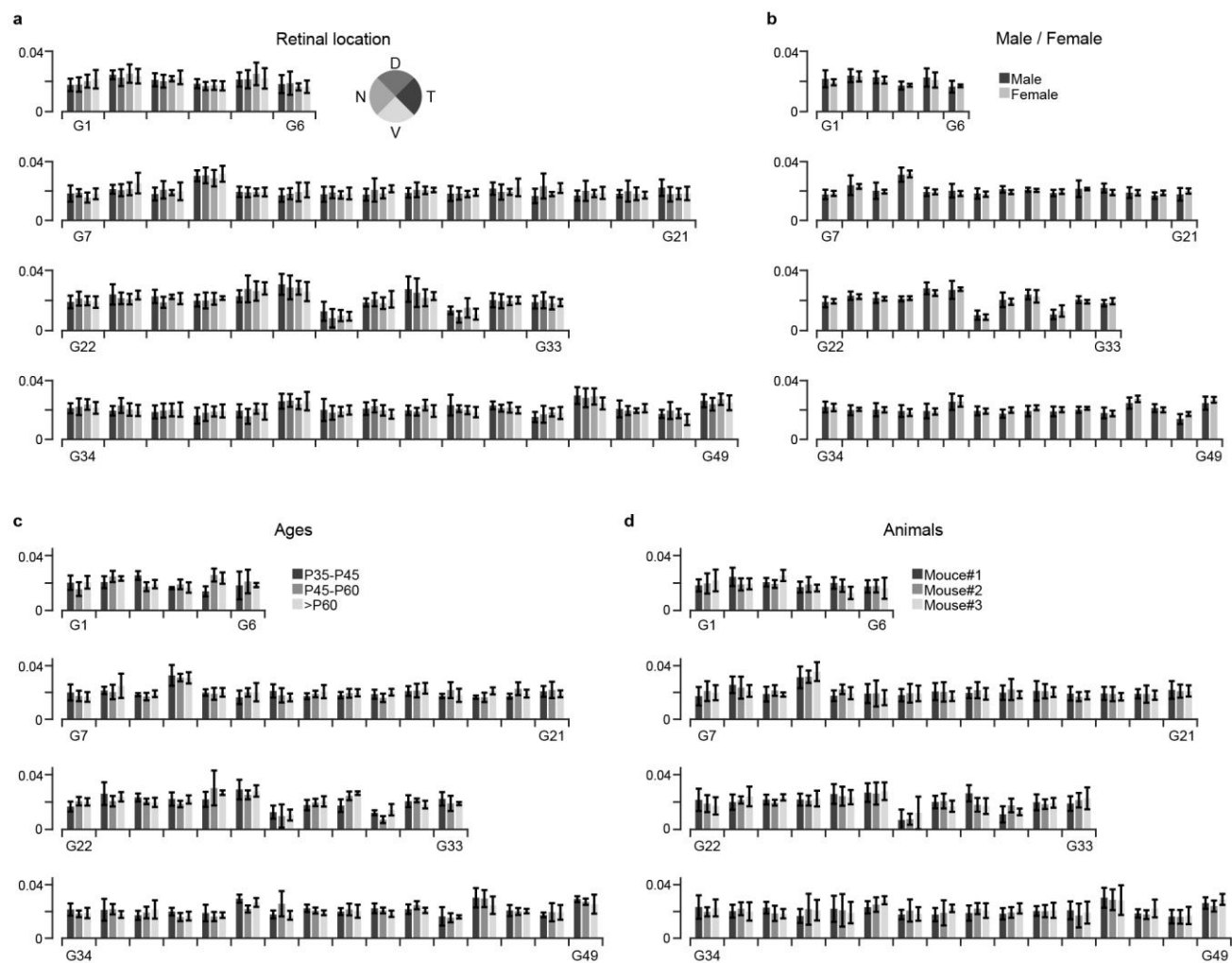
Supplementary Figure 1. 90° rotation of tissue does not affect results.

(a) GABA signal during light stimulus (modulating spot) in 4 example ROIs (left) and the signal of same ROIs after 90° rotation of tissue (right). Black and gray, average and each trial. (b) Correlation denoting similarity between ROIs before and after 90° rotation (black) and between shuffled ROIs (gray). Correlation was computed by cross-correlation. (c) Fraction of ROIs that were assigned to the same group after rotation (congruent) and ROIs that were assigned to a different group (incongruent). (d) Cumulative histogram of direction selective index (DSI, left) and orientation selective index (OSI, right) before (dark gray) and after (gray) rotation.



Supplementary Figure 2. ROI locations on FOVs.

(a) Normalization of ROI location relative to FOV center. (b) Frequency of normalized ROI location relative to FOV center for 49 groups. The most frequent location of ROIs is marked by pink squares. (c) Comparisons of the most frequent ROI locations in original (left) and random (right) frequency maps.



Supplementary Figure 3. Comparisons of fraction of 49 groups among different retinal locations (a; temporal (T), dorsal (D), nasal (N), and ventral (V)), male or female (b), ages (c), and animals (d).

## Supplementary Tables:

| ID  | Polarity | Latency | Kinetics  | DS | DS angle              | RF       | RF bias  | Contrast          | Encoding                             | PF                                        | Cell Identity?                              | NCorr         |
|-----|----------|---------|-----------|----|-----------------------|----------|----------|-------------------|--------------------------------------|-------------------------------------------|---------------------------------------------|---------------|
| #1  | dON      |         | Transient |    |                       | Small    | Oriented | Low-thresh,Non-L  |                                      |                                           |                                             |               |
| #2  | dON      |         | Transient |    |                       | s-Medium |          | Low-thresh,Non-L  | Contrast-invariant                   | Offset                                    |                                             | with G5       |
| #3  | dON      |         | Transient |    |                       | Large    | Oriented | Low-thresh,Non-L  | Contrast-invariant; TF-invariant     |                                           | Polyaxonal wide-field<br>(SST-1?)           |               |
| #4  | dON      |         |           | OS |                       | l-Medium |          |                   | OS; Contrast-invariant               | Larger PF; Directionally biased; Offset   |                                             |               |
| #5  | dON      |         | Sustained |    |                       | Small    |          |                   |                                      |                                           |                                             | with G2       |
| #6  | dON      |         | Sustained |    |                       |          | Oriented | L                 | Contrast-invariant; Motion-prefering | Orientationally biased                    |                                             |               |
| #7  | ON       |         | Transient | DS | vertical (ventral)    |          |          | Low-thresh        | DS; Contrast                         | Larger PF; Directionally biased; Offset   | Gating                                      |               |
| #8  | ON       |         | Transient |    |                       | s-Medium | Oriented | L                 |                                      | Smaller PF                                | Polyaxonal medium-field                     |               |
| #9  | ON       | Fast    | Transient | OS |                       | Small    |          | High-thresh,L     | Contrast-invariant; TF-invariant     | Directionally biased                      |                                             |               |
| #10 | ON       | Fast    | Transient | DS | cardinal              | s-Medium |          | High-thresh,Non-L | DS                                   | Larger PF; Offset                         | ON SAC                                      |               |
| #11 | ON       | Fast    | Transient | OS |                       | l-Medium |          | Low-thresh,Non-L  |                                      |                                           |                                             |               |
| #12 | ON       | Fast    | Transient |    |                       | s-Medium |          | Low-thresh,Non-L  |                                      |                                           |                                             | with G19, G21 |
| #13 | ON       |         |           |    |                       | s-Medium | Oriented | Low-thresh,L      |                                      | Larger PF; Orientationally biased; Offset |                                             |               |
| #14 | ON       |         | Sustained |    |                       | Small    |          | Low-thresh        | Contrast; TF                         | Smaller PF; Directionally biased          | CRH-1?                                      |               |
| #15 | ON       |         |           | OS |                       |          |          | L                 |                                      | Smaller PF; Directionally biased          |                                             |               |
| #16 | ON       |         | Sustained |    |                       |          | Oriented | L                 | Speed tuning; Motion-prefering       |                                           |                                             |               |
| #17 | ON       | Slow    | Sustained |    |                       | s-Medium |          | Low-thresh,L      |                                      | Larger PF; Orientationally biased; Offset | Polyaxonal medium-field                     |               |
| #18 | ON       | Slow    | Sustained |    |                       | l-Medium |          | Low-thresh,L      |                                      |                                           | A17?                                        |               |
| #19 | ON       | Slow    | Sustained |    |                       |          | Oriented | Low-thresh,L      | Motion-prefering                     | Smaller PF                                |                                             | with G12, G21 |
| #20 | ON       | Slow    | Sustained | DS | Horizontal            | Large    | Oriented | Low-thresh        | TF                                   | Orientationally biased                    | Polyaxonal wide-field                       |               |
| #21 | ON       | Slow    | Sustained |    |                       | s-Medium |          | L                 |                                      | Smaller PF                                |                                             | with G12, G19 |
| #22 | ON-OFF   | Fast    | Sustained |    |                       | l-Medium |          | High-thresh,L     | TF-invariant; Motion-prefering       | Larger PF                                 | TH2-cell?                                   |               |
| #23 | ON-OFF   | Fast    | Sustained |    |                       | Small    |          | L                 | TF-invariant                         | Larger PF; Orientationally biased; Offset |                                             |               |
| #24 | ON-OFF   |         | Sustained |    |                       | s-Medium |          | L                 | TF-invariant; Speed tuning           | Larger PF                                 | VIP-1?                                      |               |
| #25 | ON-OFF   |         | Sustained |    |                       | Small    | Oriented |                   |                                      | Orientationally biased                    |                                             |               |
| #26 | ON-OFF   | Fast    | Sustained |    |                       |          | Oriented |                   |                                      | Smaller PF                                |                                             |               |
| #27 | ON-OFF   |         | Transient | OS |                       | s-Medium |          | High-thresh,L     | Contrast; TF-invariant; Speed tuning | Directionally biased; Offset              | Polyaxonal medium-field                     |               |
| #28 | ON-OFF   |         | Transient |    |                       | Small    |          | High-thresh,L     | TF-invariant                         | Smaller PF                                |                                             |               |
| #29 | ON-OFF   |         | Transient |    |                       | Small    |          | L                 |                                      |                                           |                                             |               |
| #30 | ON-OFF   | Slow    | Transient | OS |                       | l-Medium | Oriented | L                 | OS                                   | Larger PF; Orientationally biased         | Polyaxonal medium-field (nNOS-2)            |               |
| #31 | ON-OFF   |         | Transient | DS | cardinal              | Large    | Oriented | Low-thresh,L      | DS; Flash-prefering                  | Larger PF; Offset                         | DS Polyaxonal wide-field (A1/CRH-2/nNOS-1?) |               |
| #32 | ON-OFF   | Slow    | Transient |    |                       | Large    | Oriented | Low-thresh,L      | Contrast-invariant; Motion-prefering | Offset                                    | Polyaxonal wide-field                       |               |
| #33 | ON-OFF   | Slow    | Transient |    |                       | l-Medium |          | High-thresh,Non-L |                                      | Directionally biased                      |                                             |               |
| #34 | OFF      | Fast    | Sustained | OS |                       | s-Medium |          | Low-thresh        | Flash-prefering                      | Larger PF; Orientationally biased         |                                             |               |
| #35 | OFF      | Fast    |           |    |                       | Small    |          | Low-thresh        |                                      | Smaller PF                                |                                             | with G42, G47 |
| #36 | OFF      | Fast    | Transient | OS |                       | l-Medium | Oriented | High-thresh       | OS                                   | Offset                                    |                                             |               |
| #37 | OFF      |         | Transient | DS | cardinal              | s-Medium |          | High-thresh,L     | DS                                   | Larger PF; Offset                         | OFF SAC                                     |               |
| #38 | OFF      |         |           | DS | cardinal              | l-Medium | Oriented | High-thresh,L     | DS; Speed tuning; Motion-prefering   | Larger PF; Offset                         | Polyaxonal medium-filed Gating              |               |
| #39 | OFF      | Slow    | Sustained |    |                       | s-Medium |          | High-thresh,L     |                                      | Larger PF; Directionally biased; Offset   | Polyaxonal medium-filed                     |               |
| #40 | OFF      | Slow    | Transient |    |                       | s-Medium |          | L                 | Flash-prefering                      | Directionally biased                      | Polyaxonal medium-filed                     |               |
| #41 | OFF      | Slow    | Transient |    |                       |          | Oriented |                   | Flash-prefering                      |                                           |                                             |               |
| #42 | OFF      |         |           |    |                       | Small    |          | High-thresh,L     |                                      |                                           |                                             | with G35, G47 |
| #43 | OFF      |         | Transient |    |                       | s-Medium |          | L                 |                                      | Offset                                    | Polyaxonal medium-filed                     |               |
| #44 | OFF      |         | Transient | OS |                       | s-Medium |          | Low-thresh,L      |                                      | Orientationally biased                    |                                             |               |
| #45 | OFF      |         | Transient | DS | horizontal (temporal) | Large    | Oriented | High-thresh,Non-L | DS                                   | Larger PF; Directionally biased; Offset   | Polyaxonal wide-field; Gating               |               |
| #46 | OFF      |         | Transient |    |                       | s-Medium |          | Low-thresh,L      |                                      | Smaller PF                                |                                             |               |
| #47 | OFF      |         | Transient |    |                       | Small    |          | L                 |                                      |                                           |                                             | with G35, G42 |
| #48 | OFF      | Fast    |           | OS |                       | Large    | Oriented | L                 | OS; Speed tuning                     |                                           |                                             |               |
| #49 | OFF      | Fast    | Transient |    |                       | Small    |          | Low-thresh,L      |                                      | Directionally biased                      |                                             |               |

Supplementary Table 1. Summary of characterized GABA response groups.

dON, delayed ON; DS, direction selective; OS, orientation selective; RF, receptive field; s-Medium, small-Medium; l-Medium, large-Medium; Thresh, threshold; L, linear; Non-L, non-linear; TF, temporal frequency; PF, projective field; NCorr, noise correlation.

| Cell type        | Morphological features            |                           |          |             |                    | Clusters in Yan et al. |                       |
|------------------|-----------------------------------|---------------------------|----------|-------------|--------------------|------------------------|-----------------------|
|                  | Dendritic field ( $\mu\text{m}$ ) | IPL depth (%)             | Laminar  | Axon-like   | Physiol.           | ID                     | Key marker            |
| CRH-1            | Intermediate (224 $\pm$ 36)       | 83 $\pm$ 7                | Mono     | no          | ?                  | C31                    | <i>Crh, Maf, Lhx9</i> |
| A1(CRH-2/nNOS-1) | Wide (311 $\pm$ 51)               | 9 $\pm$ 5<br>84 $\pm$ 6   | Bi       | yes         | ON-OFF Trans. / DS | C48                    | <i>Crh, Nos</i>       |
| VIP-1            | Wide (294 $\pm$ 90)               | 14 $\pm$ 8<br>67 $\pm$ 11 | Diffused | no          | ?                  | C22 or C47             | <i>Vip</i>            |
| nNOS-2           | very Wide (2620 $\pm$ 570)        | 47 $\pm$ 3                | Mono     | yes         | ?                  | C52 or C54             | <i>Nos</i>            |
| SST-1            | Wide (337 $\pm$ 64)               | 8 $\pm$ 3<br>88 $\pm$ 10  | Bi       | yes         | ?                  | C63                    | <i>Sst</i>            |
| A17 (CCK-2)      | very Wide (848 $\pm$ 45)          | 90 $\pm$ 2                | Diffused | yes         | ON Sust.           | C6                     | <i>Prkca, Sdk1</i>    |
| TH2-cell         | Wide (RF: 400-500)                | 50%                       | Mono     | not spiking | ON-OFF Sust.       |                        |                       |
| OFF SAC          | Intermediate (200-250)            | 30%                       | Mono     | no          | OFF DS             | C17                    | <i>Chat</i>           |
| ON SAC           | Intermediate (200-250)            | 60%                       | Mono     | no          | ON DS              | C17                    | <i>Chat</i>           |

IPL depth: 30%, OFF SAC; 60%, ON SAC

| Group | Functional properties |                |                 |                 |                    |
|-------|-----------------------|----------------|-----------------|-----------------|--------------------|
|       | Receptive field       | Observed depth | Layer dominance | TTX sensitivity | Physiol.           |
| G14   | Small                 | 80-90          | High            | no              | ON Sust.           |
| G31   | Large                 | 10-20<br>80-90 | Modest          | yes             | ON-OFF Trans. / DS |
| G24   | s-Medium              | 10-20<br>60-80 | Low             | no              | ON-OFF Sust.       |
| G30   | l-Medium              | 40-50          | High            | yes             | ON-OFF Trans. / OS |
| G3    | Large                 | ~10<br>80-90   | Low             | yes             | dON Trans.         |
| G18   | l-Medium              | 80-90          | Modest          | no              | ON Sust.           |
| G22   | l-Medium              | 50-60          | High            | no              | ON-OFF Sust.       |
| G37   | s-Medium              | 30             | High            | no              | OFF DS             |
| G10   | s-Medium              | 60             | High            | no              | ON DS              |

Supplementary Table 2. Predicted cellular identities.

Mono, monostratified; Bi, bistratified; Trans, transient; Sust, sustained.