## SUPPLEMENTARY INFORMATIONS

## FIGURE LEGENDS

**Supplementary Figure 1.** LMD in *w1118* mutant and the current rivals' effect on mating duration. **a.** Mating duration assays of *Drosophila simulans*. **b.** Mating duration assays of *w1118* which were backcrossed to CS for 10 generations. Mating partners' genotype was CS. **c-d.** Distribution of mating duration and initiation time in group- (n=20) and singly reared (n=20) white mutant analogous to CS examples showed in **Fig. 1b-c**. **e.** Mating duration assays of $w^a$ mutant males. **f.** Mating duration assays of *w1118* males. Single- (white bar), group-reared with 3 other males (grey), and group-reared with 11 other males (black). **g.** CS males were group-reared for 5 days then mating duration assay was performed in the presence of 1 male and 1 female (white bar), 2 males and 1 female (grey bar), and 4 males and 1 female (black bar). **h.** CS males were singly reared for 5 days then mating duration assay was performed in the presence of 1 male and 1 female (white bar), or 2 males and 1 female (black bar).

**Supplementary Figure 2.** The general characteristics of LMD. **a.** Mating duration assays of singly reared CS males with small color dots inside the vial. A 1 cm diameter E-tube labeler was used for color stimuli. R represents red dot and W white dot. **b.** Mating duration assays of singly reared CS males with color tapes around the entire vial. R represents red tape, Y yellow, W white. **c.** Mating duration assays of group- (R) or males reared with 3 $w^+$ strains (B and O). The genotypes of $w^+$ strains were *w*;tub-*

*GAL80$^{ts}$* and *npf-GAL4*. Eye color of *w*;tub-GAL80$^{ts}$* strain is bright red and *npf-GAL4* is orange. **d.** Mating duration assays of *Or83b$^{1}$/Or83b$^{2}$* mutant animals that were group- (G) or reared with 4 CS females 1 day before test (F). **e.** Mating duration assays of *GMR-Hid blind* animal reared with 3 other CS males (white bar) or *GMR-Hid* only (black bar) for 7 days. **f.** Mating duration assays of group- (white), or singly reared (black) males, or singly reared CS males with male odor (grey). For odor presentation, vials in which 20 CS males were reared for 2 days were used. **g.** Mating duration assays of *Or83b* mutant alleles in *w1118* background. The genotypes are indicated below the bars. **h.** Average time spent by CS males over the mirror per visit. 5 day-old CS males which were singly reared with a mirror (white bar, n=10) or reversed (upside down) mirror (green bar, n=10) placed at the bottom of the vial were monitored and recorded for 1 h. The visiting frequency to the bottom object (mirror or reversed mirror) and time spent on that object was counted. The bar represents the time spent on the top of the object per visit. Numbers above the bars represent the average of visiting frequency for 1 h.

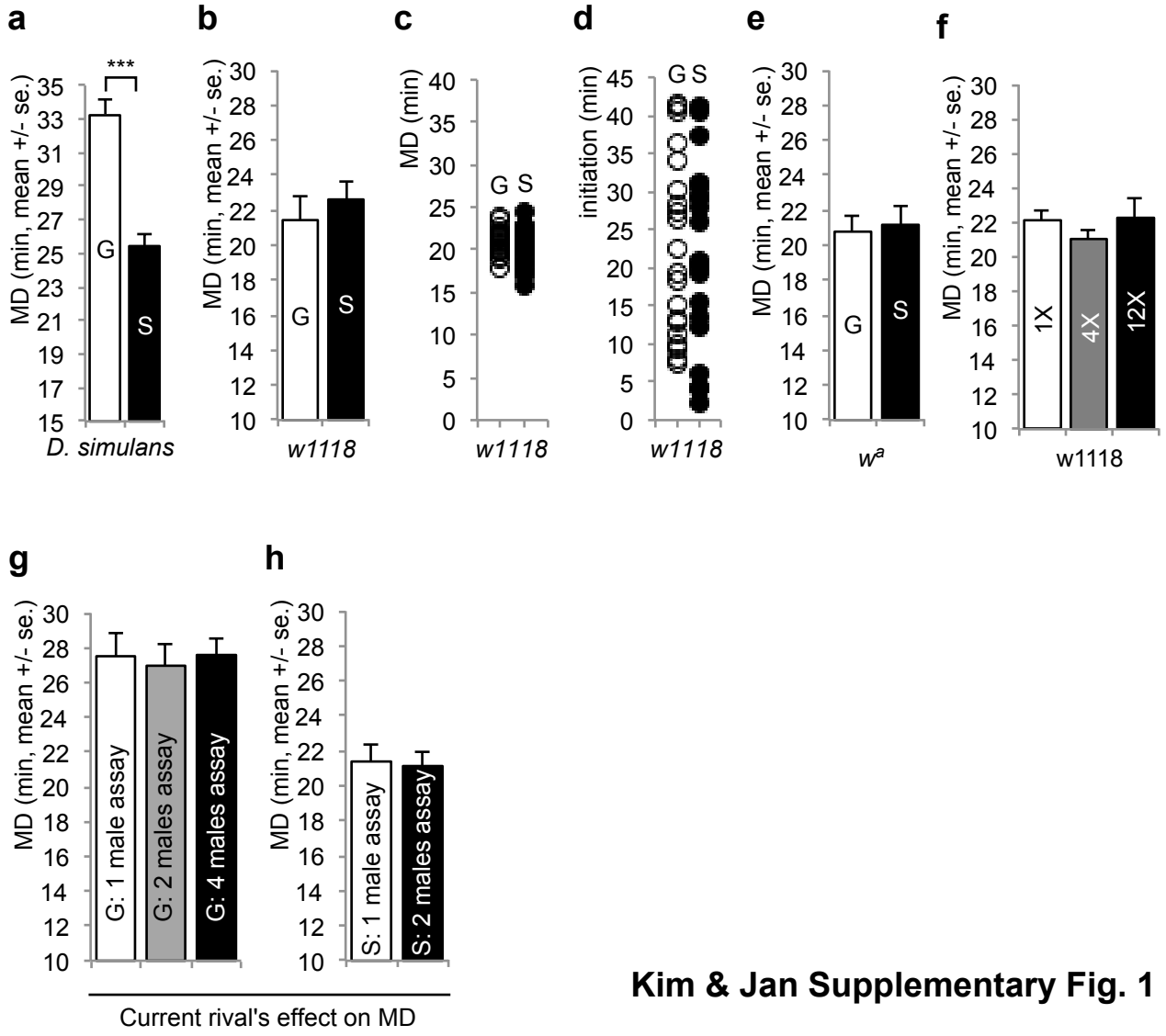
**Supplementary Figure 3. a.** Mating duration assays of eye-expressing *GAL4* driven *tub-GAL80$^{ts}$; UAS-Kir2.1.* Expression patterns of these *GAL4* drivers in visual system were described previously (Hasegawa, E. *et al., 2011)*. **b.** Mating duration assays of *UAS-rut* transgene expression in *rut$^{MB2769}$* mutant background driven by *GAL4* drivers as indicated below the bars. **c.** Mating duration assays of flies from the rescue cross for *amn* mutant. To obtain rescued male flies, virgin females of *amn* mutant was crossed with males of the interchromosomal duplication line *w1118; Dp(1;3)DC368,*

*PBac{DC368}VK00033.* **d.** *GAL4* control experiment of **Fig. 6d**. **e.** Mating duration assays of $pdf^{01}$ mutant. **f.** List of *GAL4* drivers used to drive *UAS-per* expression in clock neurons and their expression patterns in clock neurons. Black check means expression in all the neurons of the indicated clusters, grey check means expression in a subset of neurons in the indicated clusters.

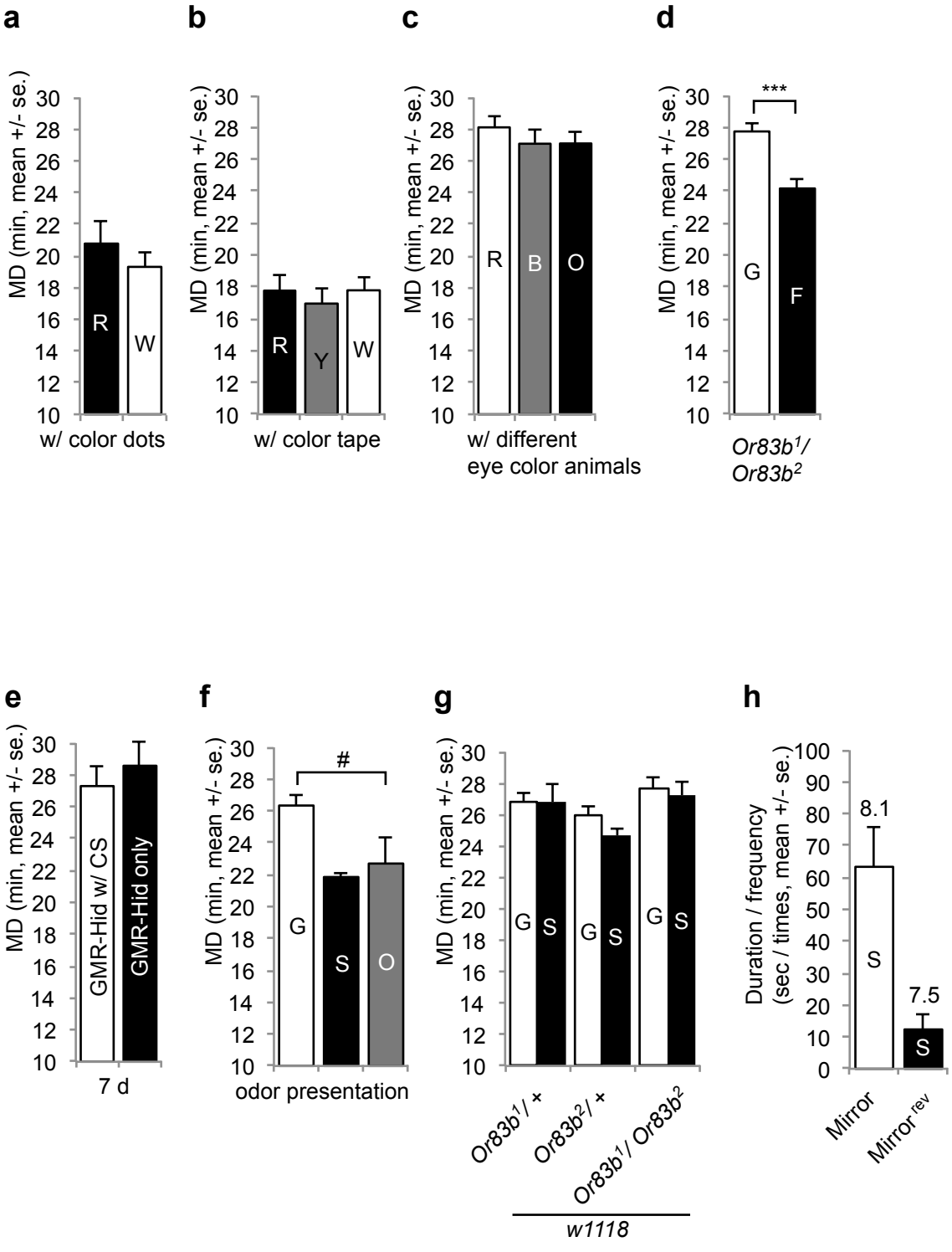
**Supplementary Figure 4.** Control experiments for neural circuitry mapping. **a.** The paradigm for non-permissive condition. group- or singly reared animals expressing *tub-*$GAL80^{ts}$*; UAS-Kir2.1* under the various GAL4 drivers were kept 29℃ for 2 days (strong induction) then moved to 25℃ for 3 days (mild expression). **b.** Paradigm for permissive condition. group- or singly reared animals expressing *tub-*$GAL80^{ts}$*; UAS-Kir2.1* under the various GAL4 drivers were kept at 22℃ for 5 days as a control experiment. **c.** Mating duration assays of group- or singly reared animals expressing *tub-*$GAL80^{ts}$; *UAS-Kir2.1* under *ap-GAL4* driver in non-permissive condition. **d.** Mating duration assays of group- or singly reared animals expressing *tub-*$GAL80^{ts}$*; UAS-Kir2.1* under *ap-GAL4* driver in permissive condition. **e.** *GAL4* control experiment of **Fig. 5b**. **f.** *GAL4* control experiment of **Fig. 5c**. **g.** *GAL4* control experiment of **Fig. 6c**. **h.** Mating duration assays for *UAS* control experiments. The genotypes are indicated with corresponding color boxes above the graph. **i.** Mating duration assays of group- or singly reared animals expressing *UAS-*$shi^{ts}$ under *pdf-GAL4* driver at 29℃ for 5 days. **j.** Mating duration assays of group- or singly reared animals expressing *tub-*$GAL80^{ts}$*; UAS-NachBac* via *pdf-GAL4* driver in non-permissive condition. **k.** Mating duration assays of

group- or singly reared animals expressing *UAS-shi$^{ts}$* under *ok107-GAL4* driver at 29℃ (1) or 22℃ (2) for 5 days.

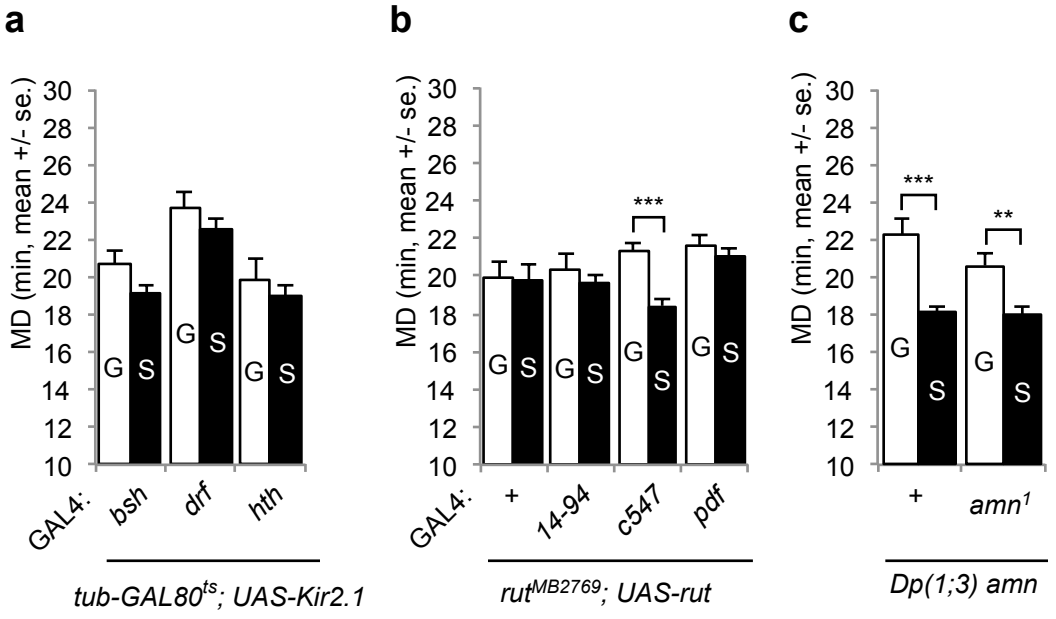
**Supplementary Figure 5.** Control experiments for neural circuitry mapping. **a.** *GAL4* control experiments of **Fig. 4c**. **b.** *GAL4* control experiments of **Fig. 6f**. **c.** List of *GAL4* drivers used to drive *UAS-Kir2.1* expression in central complex neurons and their expression patterns in the brain region. Black check means expression in the indicated clusters, question mark means expression in the indicated clusters are not clearly mapped. Expression profiles of each GAL4 drivers were based on a previous study (Renn, S. C. *et al., 1999)* and the expression data from Bloomington stock center. MB represents mushroom bodies, FB: fan-shape bodies, EB: ellipsoid body, NO: noduli, R1: R1 ring neurons in EB, R2: R2 ring neurons in EB, R3: R3 ring neurons in EB, and R4: R4 ring neurons in EB. **d.** A hypothetical diagram of the neural circuits and genes necessary for LMD. Rivals provide visual cues. Both color and motion cues are required to generate LMD as shown in **Fig. 2**. In the compound eye, several different photoreceptors are required to detect rivals. These visual neural circuits are connected to a subset of the clock neurons. The circadian clock genes *per* and *tim* are required to generate LMD in these neurons. To generate memory for LMD, these clock neurons need to be connected to the ellipsoid body (EB), where the *rut* and *amn* gene products might be important for memory processing for LMD (LNs: lateral clock neurons, EB: ellipsoid body, MB: mushroom bodies, FB: fan-shape bodies).

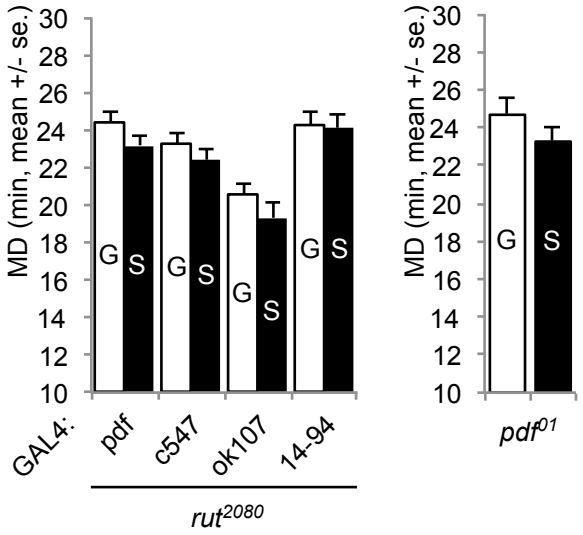



**Kim & Jan Supplementary Fig. 1**




**Kim & Jan Supplementary Fig. 2**

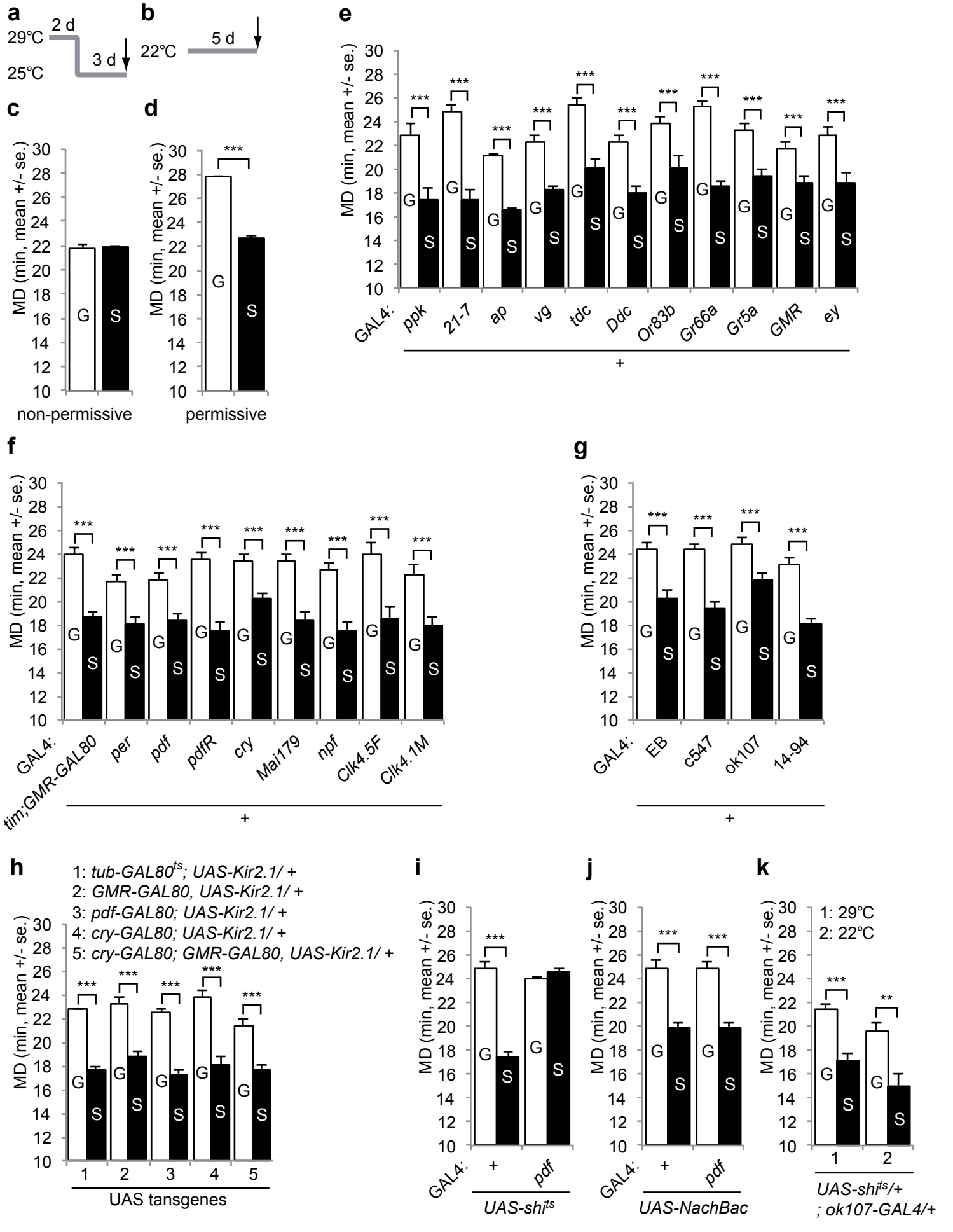



**f**

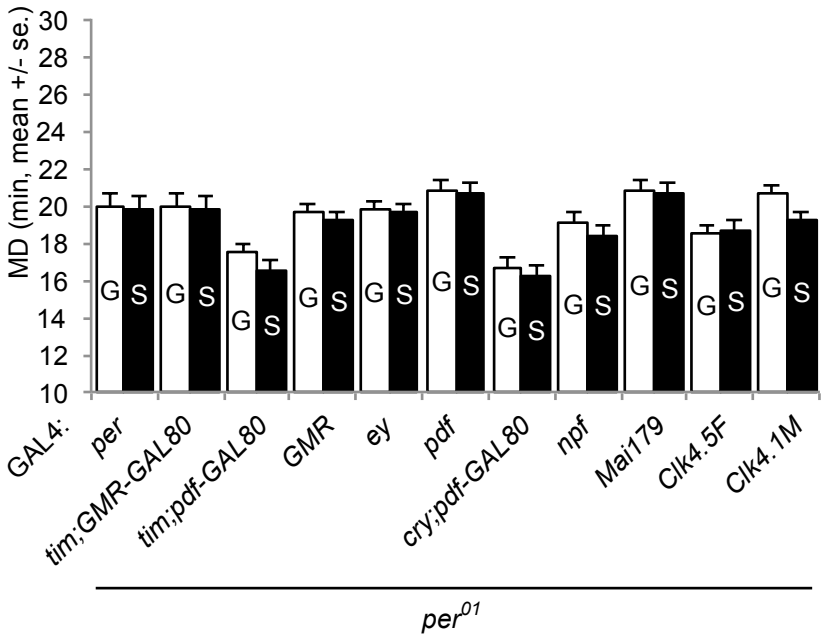
| | sLNv | lLNv | LNd | LPN | DN1 | DN2 | DN3 |
|---|---|---|---|---|---|---|---|
| *per-GAL4* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *tim-GAL4* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *GMR-GAL4* | | | | | | | |
| *ey-GAL4* | | | | | | | |
| *pdf-GAL4* | ✓ | ✓ | | | | | |
| *cry-GAL4* | ✓ | ✓ | ✓ | | ✓ | | |
| *npf-GAL4* | | ✓ | ✓ | | | | |
| *Mai179-GAL4* | ✓ | ✓ | ✓ | | | | |
| *Clk4.5F-GAL4* | | | | | ✓ | | |
| *Clk4.1M-GAL4* | | | | | ✓ | | |

**Kim & Jan Supplementary Fig. 3**

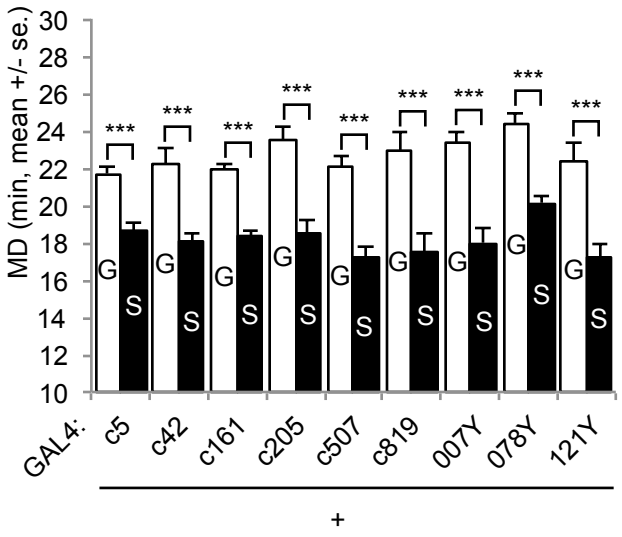



**Kim & Jan Supplementary Fig. 4**

**a**



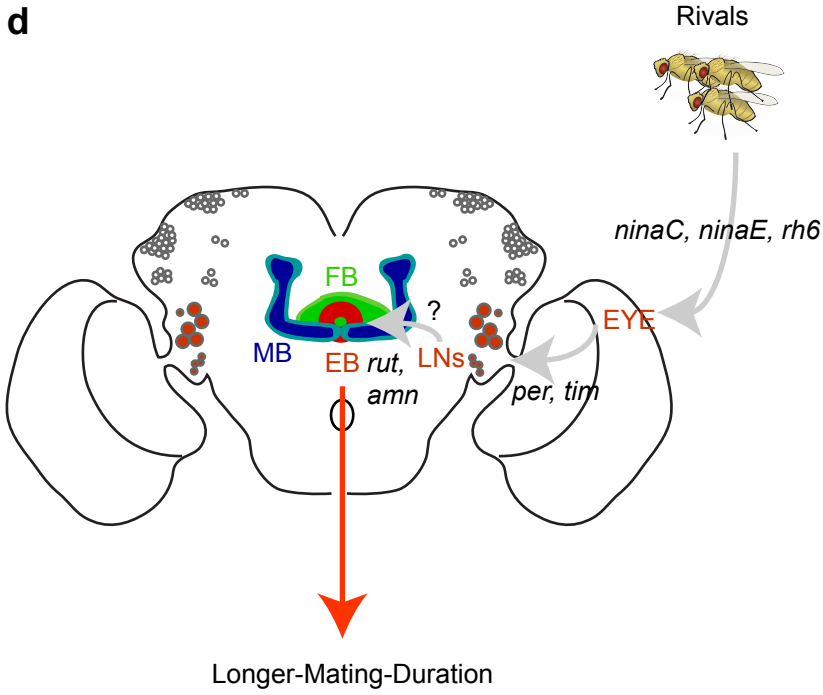

**b**




**c**

| | MB | FB | PB | NO | R1 | R2 | R3 | R4 |
|---|---|---|---|---|---|---|---|---|
| *c5-GAL4* | | ✓ | ✓ | | | | | |
| *c42-GAL4* | | ✓ | | | | ✓ | | ✓ |
| *c161-GAL4* | | | ✓ | ✓ | ? | ? | ? | ? |
| *c205-GAL4* | | ✓ | | | | | | |
| *c507-GAL4* | | | | | | | ✓ | ✓ |
| *c819-GAL4* | | | | | | ✓ | | ✓ |
| *007Y-GAL4* | ✓ | ✓ | ✓ | ✓ | ? | ? | ? | ? |
| *078Y-GAL4* | | ✓ | ✓ | ✓ | ? | ? | ? | ? |
| *121Y-GAL4* | | ✓ | ✓ | | | | | |

**d**




**Kim & Jan Supplementary Fig. 5**