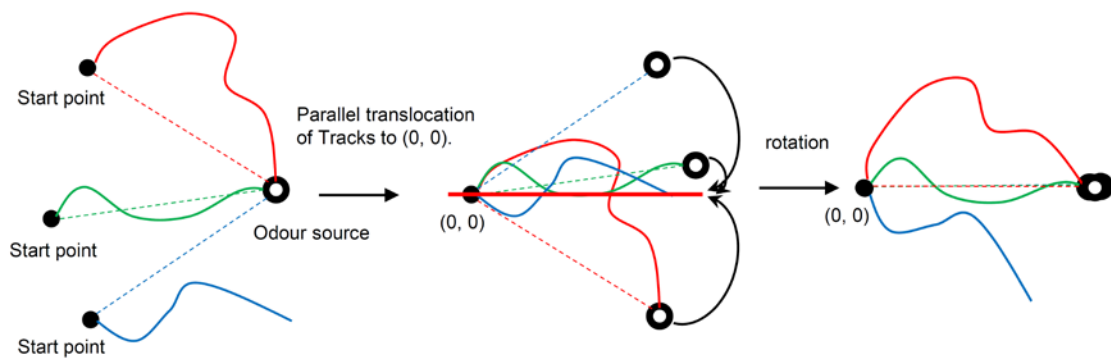## Supplemental Figures

Fig. S1 Scheme of the pre-processing in analysis. To calculate the mean distances between individual worms in the single and paired conditions, the trajectories were translocated and rotated in advance (the detail was described in materials and methods).
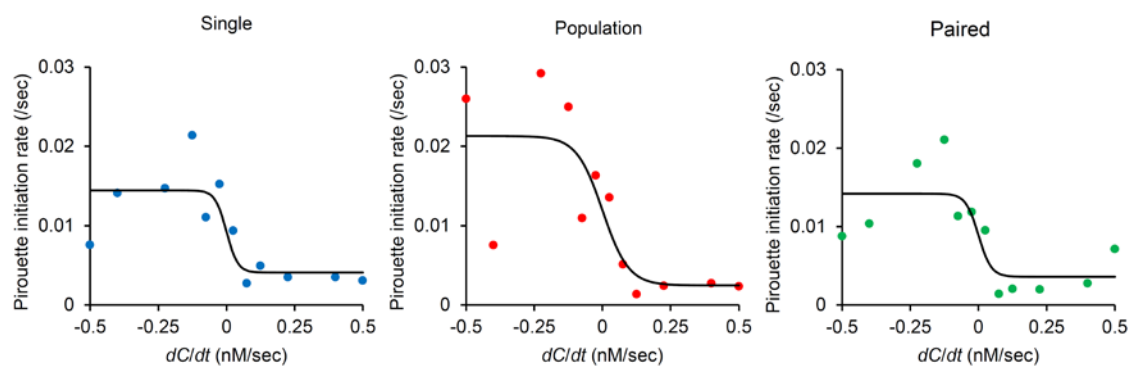
Fig. S2. Pirouette behaviours in each condition. The pirouette initiation rate plotted against dC/dt.

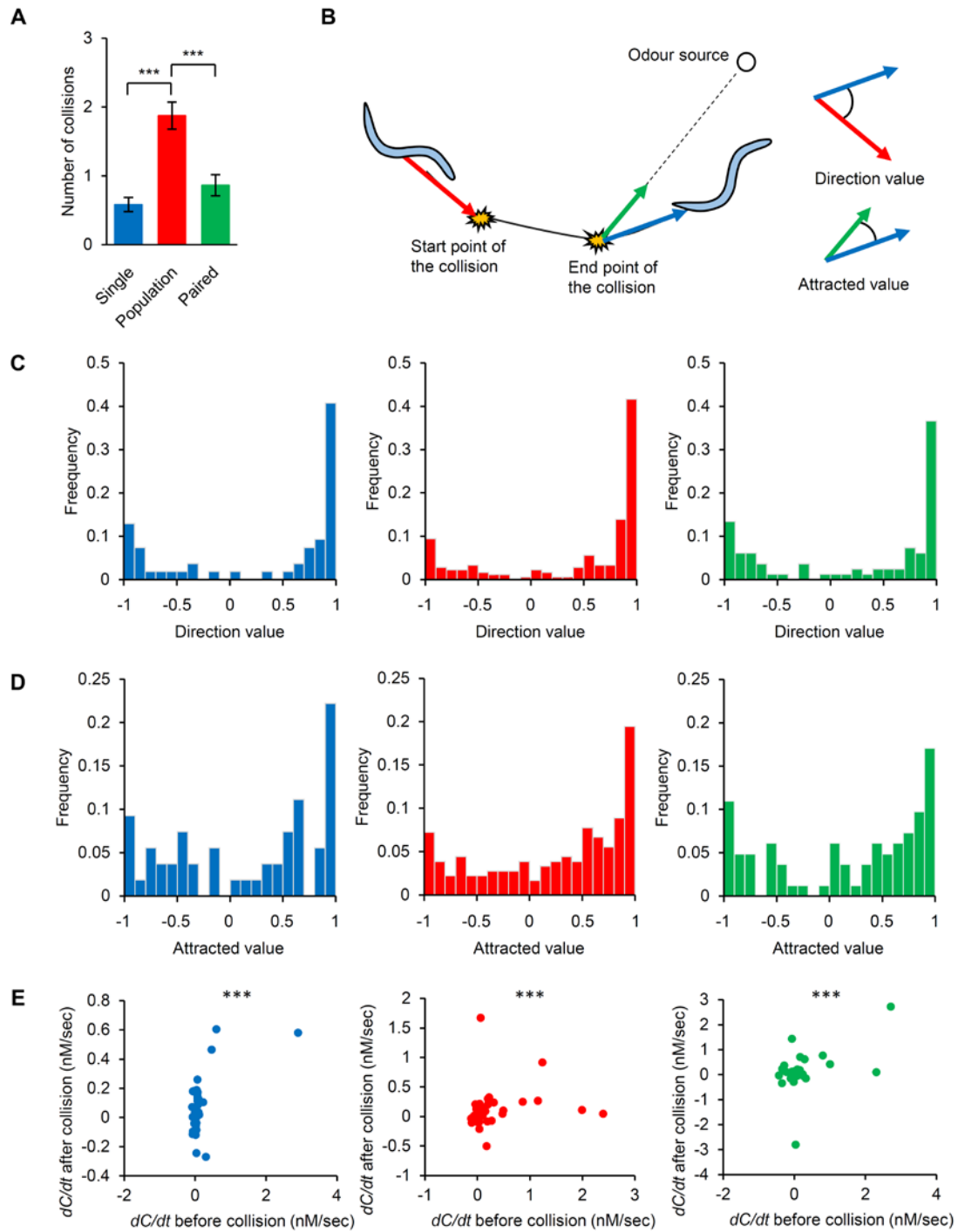Plots were fitted with a sigmoid curve (see materials and methods).

Fig. S3. Direction changes due to collisions of worms. (A) Mean (±s.e.m.) number of collisions.

(B) Scheme of the direction and attracted value when worms collided with others. The direction

value reflects the cosine of the direction vector before and after collision. The attracted value

means the cosine of the direction vector after collision and the direction vector to the odour source. (C) Histograms of the direction values. (D) Histograms of the attracted values. (E) The relationship of dC/dt before and after contacts. The correlation coefficient was described in Table S1 ($N = 12$, $n = 93$, 96 and 95, respectively, for single, population, paired). A: Mann-Whitney U test with Bonferroni correction; E: test for association/correlation between paired samples; ***P<0.001, significant difference.
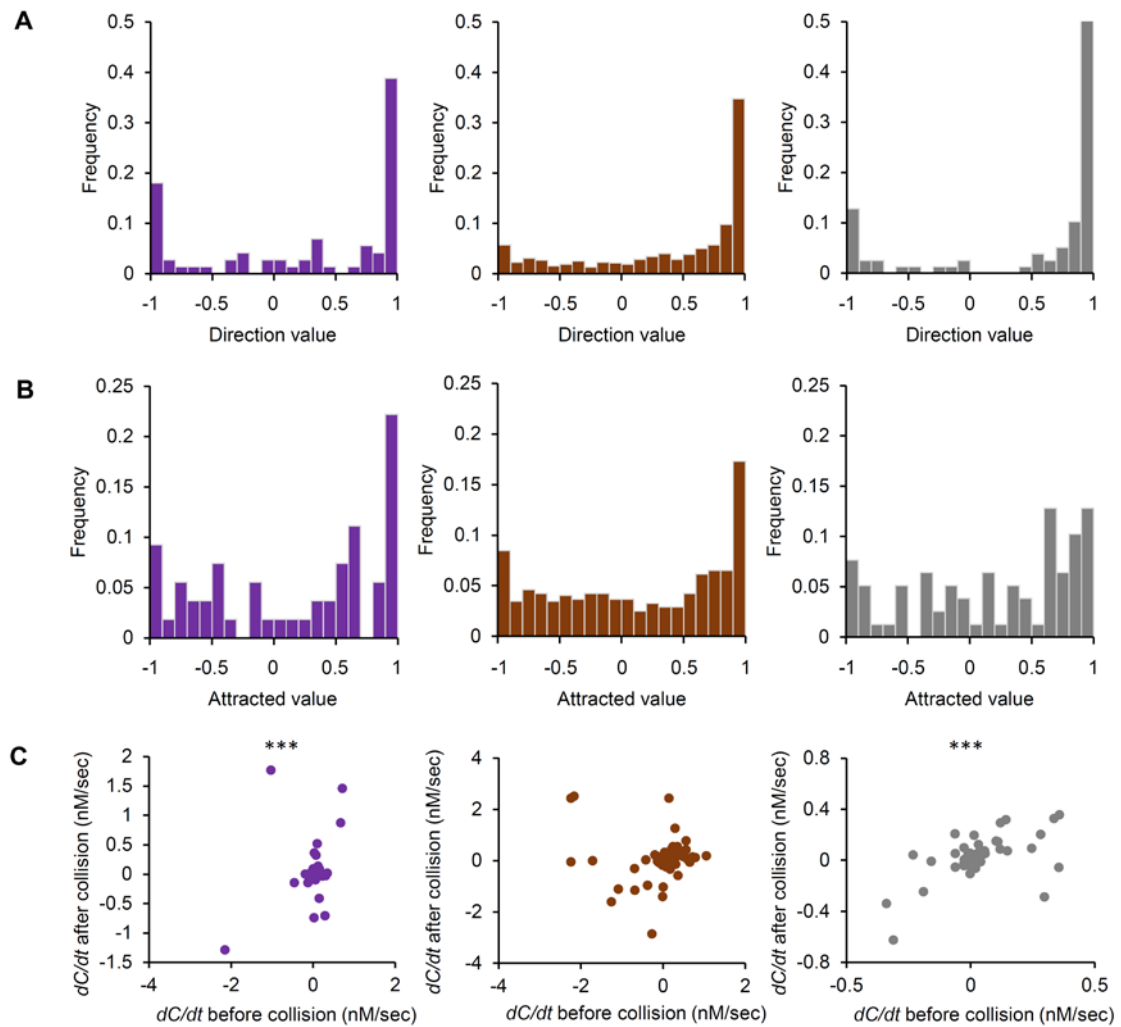
Fig. S4. Direction changes due to collisions of *daf-22* mutant. (A) Histograms of the direction values. (B) Histograms of the attracted values. (C) The relationship of d*C*/d*t* before and after contacts. The correlation coefficient was described in Table S1 [N = 12, n = 90, 95 and 94, respectively, for single (purple), population (brown), paired (grey)]. C: test for association/correlation between paired samples; ***P<0.001 significant difference.
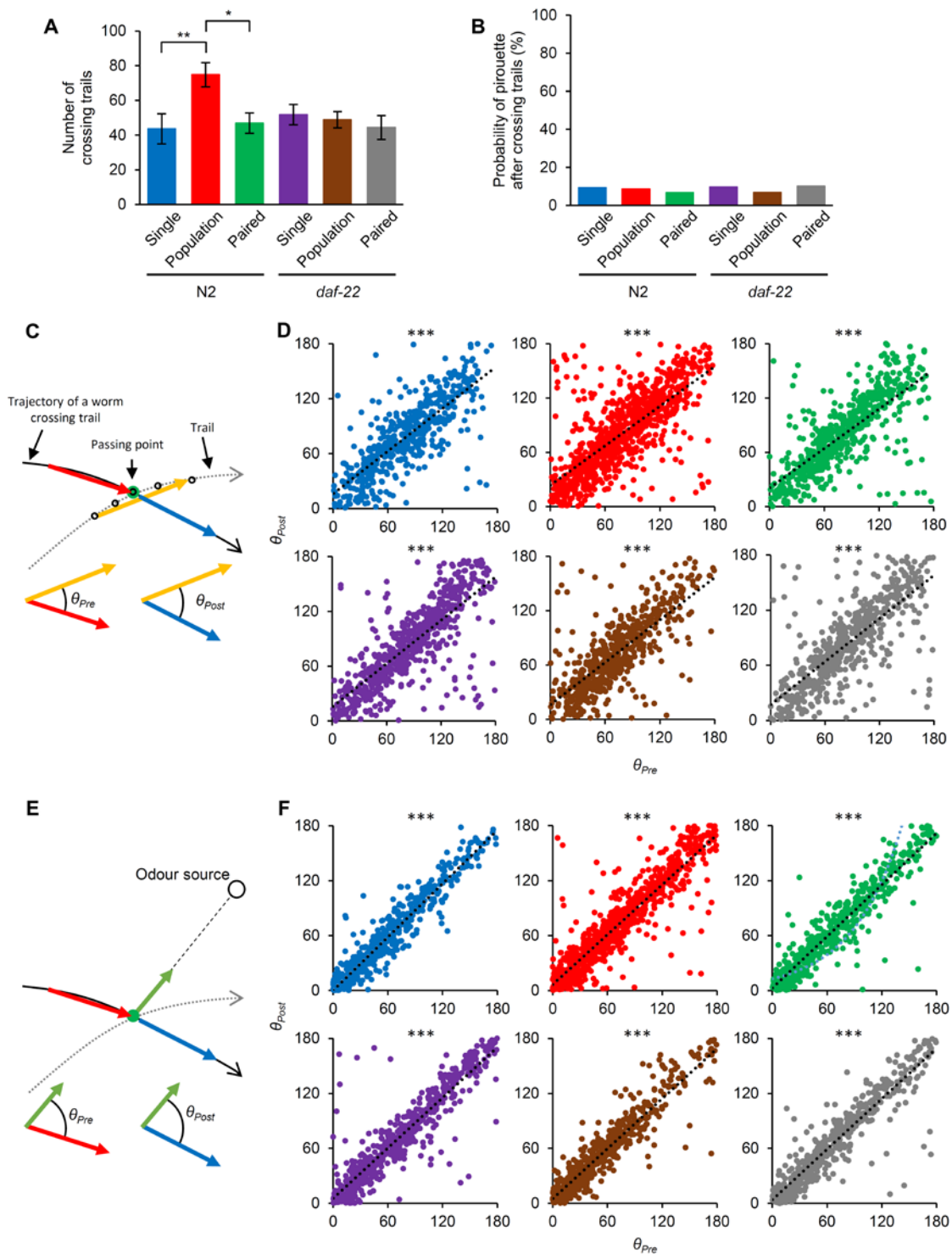
Fig. S5. Direction changes when worms crossed trails. (A) Mean (±s.e.m) of the number of crossing trails per an assay ($N = 12$ in each condition). (B) Probability of pirouettes by 10 s after crossing trails. The probability is calculated as (the total number of pirouette by 10 s after

crossing trails) / (the total number of crossing trails). The values in all conditions were not significantly different from randomly sampled data (Table S2, see materials and methods). (C, D) Direction changes to trails. (C) Scheme of the direction changes to trails. (D) The relationship of angle before and after worms crossing trails. The correlation coefficient was described in Table S1. The slope of linear function was as follows: N2, single (blue), 0.778, population (red), 0.727, paired (green), 0.728; *daf-22*, single (purple), 0.793, population (brown), 0.781, paired (grey), 0.781. (E, F) Direction changes to odour source. (E) Scheme of the direction changes to odour source. (F) The relationship of angle to odour source before and after worms crossing trails. The correlation coefficient was described in Table S1. The slope of linear function was as follows: N2, single, 0.973, population, 0.908, paired, 0.939; *daf-22*, single, 0.916, population, 0.910, paired, 0.921. A: Mann-Whitney *U* test with Bonferroni correction; B: binomial test; E: test for association/correlation between paired samples; *$P<0.05$, **$P<0.01$, ***$P<0.001$ significant difference.
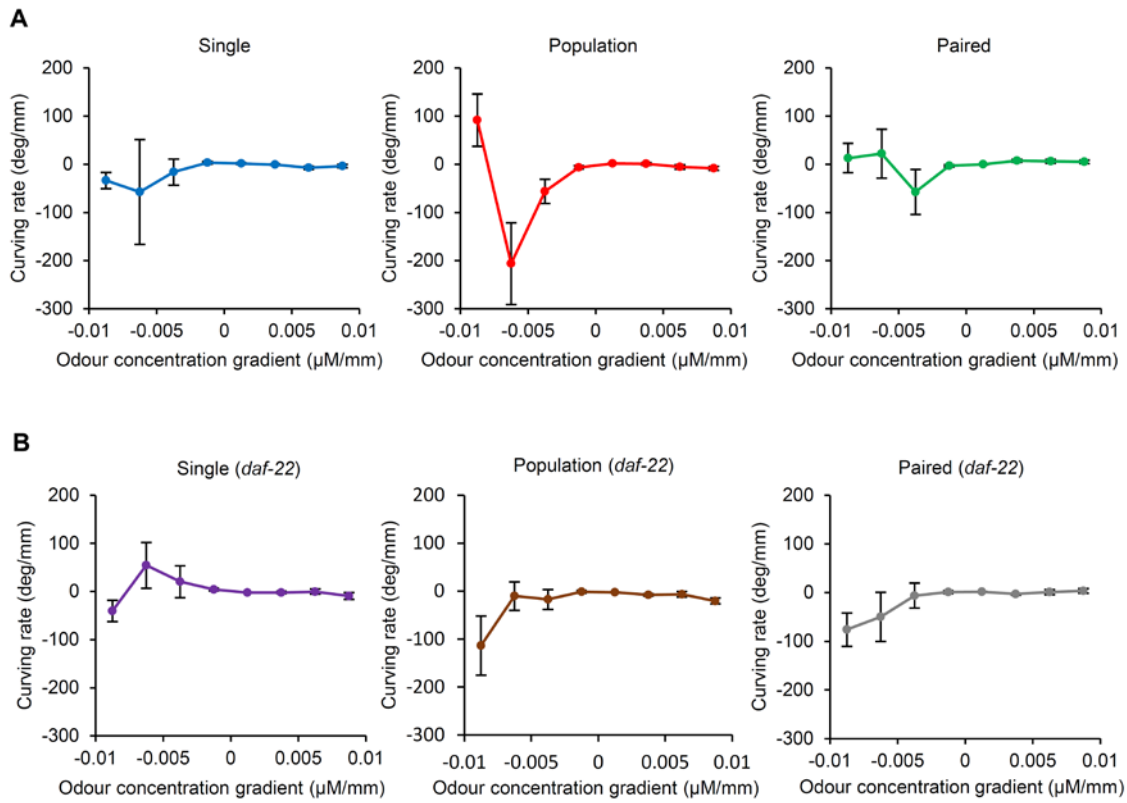
Fig. S6. Direction changes under collective conditions. (A, B) Curving rate (±s.e.m.) against the normal odour gradient of N2 (A) and the *daf-22* mutant ($N = 12$, $n = 93$, 96, 95, 90, 95 and 94, respectively).

Table S1. Correlation coefficient and *p*-value of the results.

		N2			*daf-22*		
		Single	Population	Paired	Single	Population	Paired
Fig. S3E Fig. S4C	correlation coefficient	0.599	0.248	0.49	0.303	-0.0779	0.576
	p-value	1.69×10^{-6}	7.73×10^{-4}	3.04×10^{-6}	9.64×10^{-3}	0.0768	3.44×10^{-8}
Fig. S5D	correlation coefficient	0.789	0.721	0.739	0.773	0.753	0.752
	p-value	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$
Fig. S5F	correlation coefficient	0.953	0.912	0.938	0.915	0.933	0.928
	p-value	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$

Table S2. Parameters for binominal test used in Fig. S6

	N2			*daf-22*		
	Single	Population	Paired	Single	Population	Paired
number of passing points	524	898	563	621	586	533
number of pirouette by 10 s after worms crossed trails	49	78	38	60	40	54
hypothesized probability of pirouette	0.0876	0.104	0.0707	0.0876	0.0853	0.0944
p-value	0.642	0.09	0.869	0.434	0.159	0.554