Fig. S1. Temporal dynamics of body rotations throughout the saccadic maneuver.

Rotational dynamics of the fly body are described as angular positions (A-C), normalized angular velocities (D-F) and normalized angular accelerations (G-I) about the principal body axes (roll axis, pitch axis and yaw axis as defined in Fig. 1C). The temporal dynamics of the angular positions were estimated by integrating angular velocities in the body reference frame (integration constant was set to zero at the start of each track); angular velocities were normalized by the wingbeat frequency at steady flight, f_{steady}, estimated by Muijres et al. (2014); angular accelerations were estimated by differentiating angular velocities, and were normalized by the steady wingbeat frequency f^2_{steady}. Grey lines show data from all measured saccades, and black lines with grey bars are means and 95% confidence intervals for all trails.

Fig. S2. Torque dynamics within the stroke plane throughout the saccadic maneuver.

Torque dynamics is described by the temporal dynamics of torque about the primary torque axis μ_1 (A) and its orthogonal axis $\mu_{1\perp}$ (B), and by the temporal dynamics of torque about the counter-torque axis μ_2 (C) and its orthogonal axis $\mu_{2\perp}$ (D). All torques are normalized by $|\boldsymbol{a}+\boldsymbol{g}|ml$; grey lines show data from the separate saccades, and black lines with grey bars are means and 95% confidence intervals for all trails. The vertical dotted line defines the point in time where torque in the stroke plane is approximately zero, and that therefore separates the primary rotation phase and the counter-rotation phase (t=12.5 ms).

Fig. S3. Correlation between the wingbeat kinematics angles of the left and right wing, for the kinematics that results in peak yaw torque (left column), peak torque about the primary μ_1 axis (middle column), and peak torque about the counter-torque axis μ_2 (right column). (A-C) kinematics angles of the right wing (red), the original kinematics of the left wing (grey), and the translated left wing kinematics for which correlation between the wingbeat kinematics angles of the left and right wing were maximal (blue dotted traces). (D-L) root mean squared error (RMSE) based on the difference between the left and right wing kinematics angle throughout the measured phase shift range $-10° < \Delta\tau < 10°$ and mean kinematics angle shift range $-10° < \Delta\kappa < 10°$ (maximum correlation at minimum RMSE is depicted by a white dot): (D-F) for stroke angle; (G-I) for deviation angle; (J-L) for wing rotation angle. Logarithmic values of RMSE are scaled according to the scale bar in (L).

Movie 1. Top view of a fruit fly performing a saccadic maneuver. The movie is slowed down 100 times, and every third recorded frame is shown. The turn angle of this saccade is approximately 90 degrees, which is close to the average saccadic turn angle for all trails.

Movie 2. Body and wings model of a fruit fly performing a saccadic maneuver. The movie is slowed down 300 times. The turn angle of this saccade is approximately 90 degrees, which is close to the average saccadic turn angle for all trails.

Movie 3. A movie of all 44 flight tracks overlaid on top of each other, viewed from below. The movie is slowed down 100 times, and traces are color-coded with time according to the scale bar in Fig. 1E. Note that all left-handed turns have been mirrored into right-handed turns, and all sequences were aligned according to position and heading at the start of the saccadic maneuver (t_{start} = 0 ms).

Movie 4. A movie of all 44 flight tracks overlaid on top of each other, viewed from the side. The movie is slowed down 100 times, and traces are color-coded with time according to the scale bar in Fig. 1E. Note that all left-handed turns have been mirrored into right-handed turns, and all sequences were aligned according to position and heading at the start of the saccadic maneuver (t_{start} = 0 ms).

Movie 5. A movie of all 44 flight tracks overlaid on top of each other, viewed from behind. The movie is slowed down 100 times, and traces are color-coded with time according to the scale bar in Fig. 1E. Note that all left-handed turns have been mirrored into right-handed turns, and all sequences were aligned according to position and heading at the start of the saccadic maneuver (t_{start} = 0 ms).

Movie 6. A movie of all 44 flight tracks overlaid on top of each other, in perspective view. The movie is slowed down 100 times, and traces are color-coded with time according to the scale bar in Fig. 1E. Note that all left-handed turns have been mirrored into right-handed turns, and all sequences were aligned according to position and heading at the start of the saccadic maneuver (t_{start} = 0 ms).

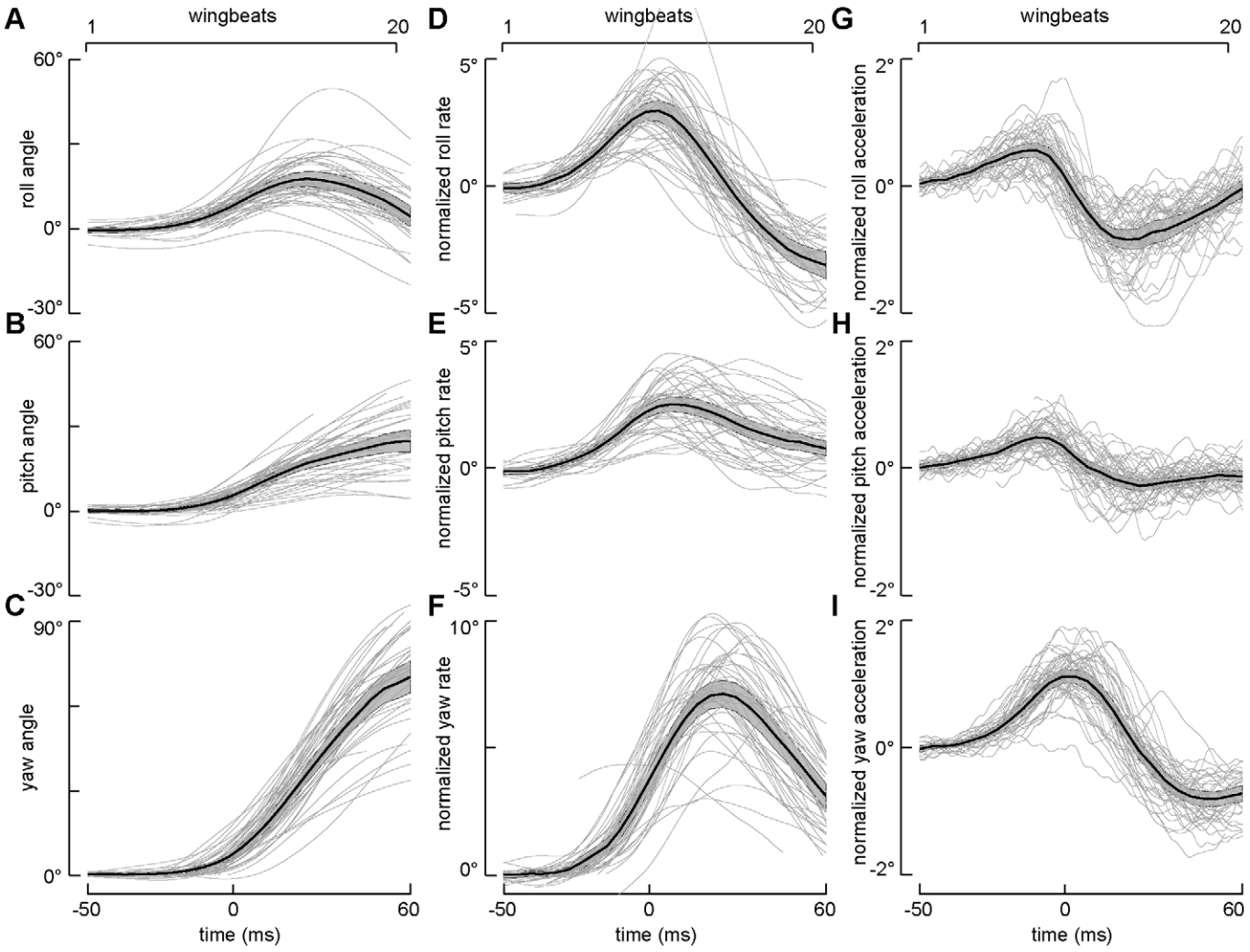


Figure S1

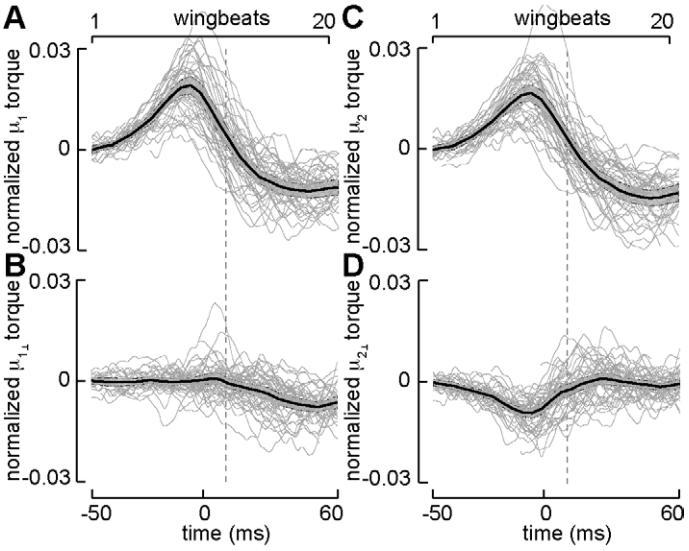


Figure S2

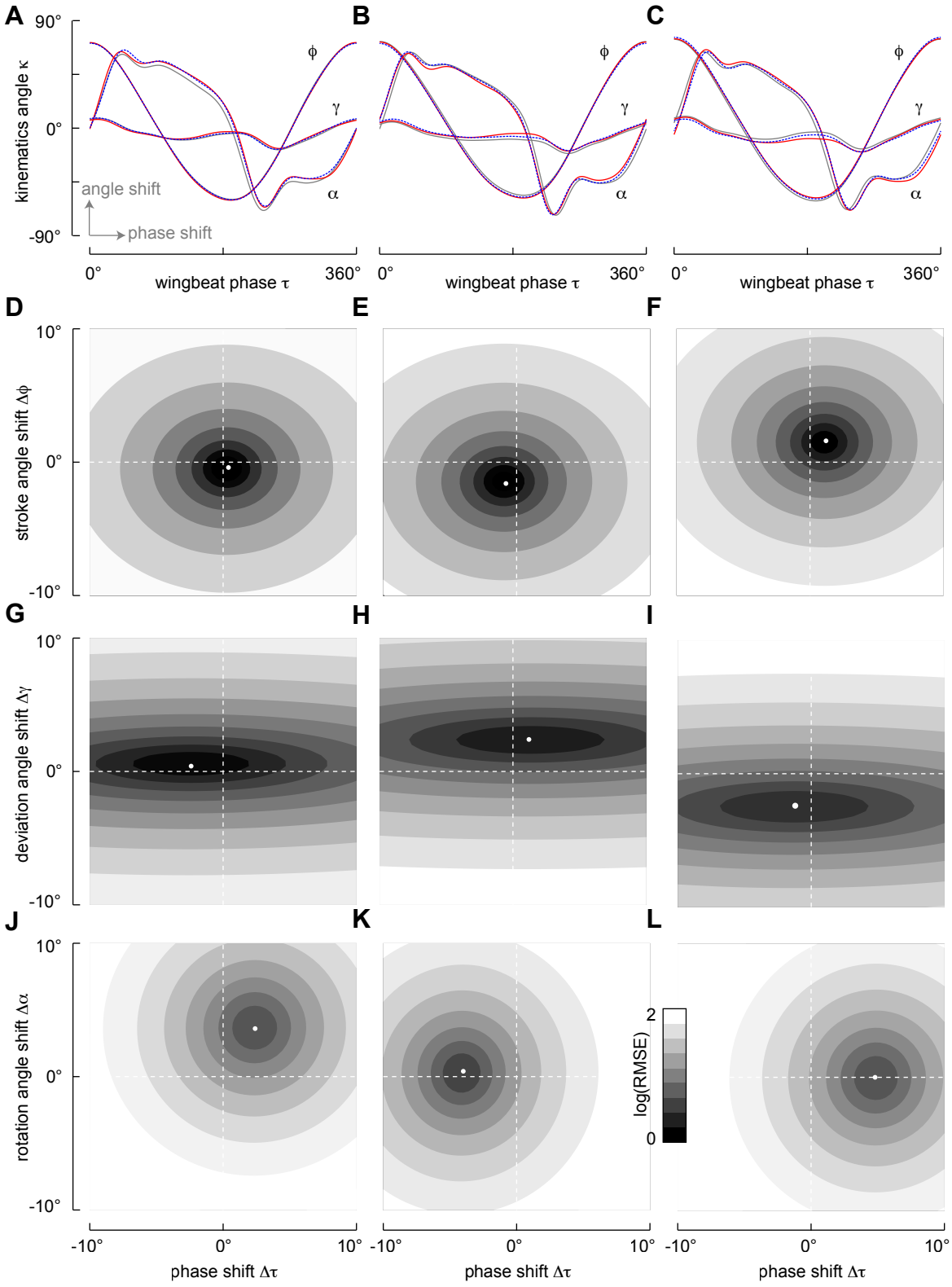
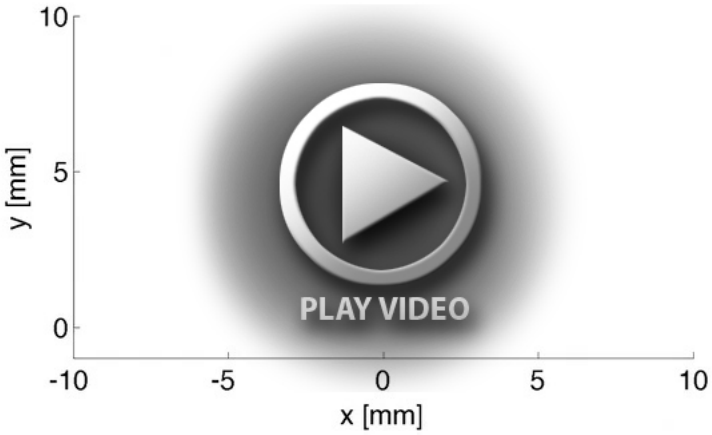

A
B
C
90°
0°
-90°
kinematics angle κ
ϕ
γ
α
angle shift
phase shift
0°
wingbeat phase τ
360°
D
E
F
10°
0°
-10°
stroke angle shift Δϕ
G
H
I
deviation angle shift Δγ
J
K
L
rotation angle shift Δα
log(RMSE)
2
0
-10°
phase shift Δτ

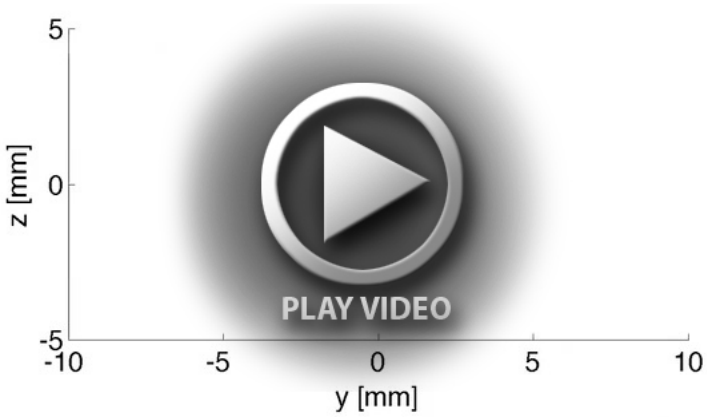
Figure S3

Movie 1.

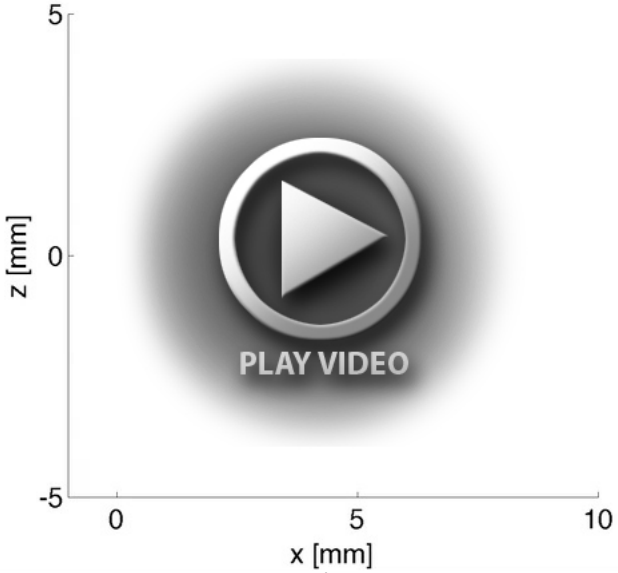
Movie 2.



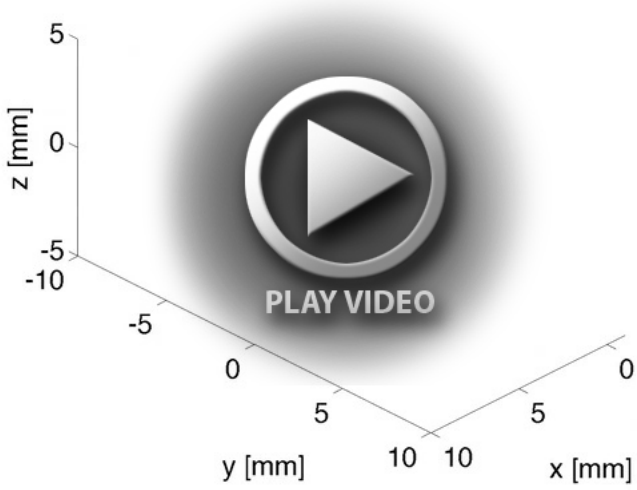
Movie 3.



Movie 4.



Movie 5.



Movie 6.