

## Supporting Information for “Self-motion and the shaping of sensory signals”

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### High speed videography

Included in this supporting section is an example of the high speed videography of the rat traversing the grating-lined region of the track. Figure 2A in the main text shows three frames of this particular trial, separated by 25 ms each. The diffuse illumination from below allows for good visualization of the individual vibrissae within a row. In this particular trial (rat ID#: F13; grating 3: 9.8 mm spacing), the running speed was  $0.88 \pm 0.03$  m/s and the distance from the center of the track was  $2.35 \pm 0.92$  mm. Vibrissae on both sides of the face were in contact with the respective gratings on the side, as the animal veers toward the left side of the track (relative to the direction of running). See the corresponding movie file (RatMovie.mov) for the complete video of this trial.

### Vibrissa tracking

Tracking of head and vibrissa movements was implemented by modifying a software package provided by Knutsen, Derdikman, and Ahissar (Knutsen et al., 2005). The software uses code written in MatLab (v6.5, MathWorks, Natick, MA) and the C programming language. To track vibrissa motion, it was necessary to track the position of the head. Head movements were tracked by following reflections of a halogen spotlight in the two aluminum ball bearings rigidly attached to the head, giving a measure of head angle in a 2D plane. Once the head position and orientation were calculated in the laboratory frame of reference, two regions of interest defined close to either side of the head are translated and rotated into the head frame of reference.

Shown in Figure 1B in the main text is a typical frame from a different movie in which the head, reference vibrissa, and an untrimmed vibrissa in contact with the grating are being

tracked. Vibrissae are tracked in this frame of reference using a 3-point spline fitting algorithm (see (Knutzen et al., 2005) for details). The inset shows a magnification of the spline-tracking of the vibrissae for this particular frame (reference vibrissa in green, vibrissa in contact with grating in blue). See the corresponding movie file (WhiskerTrackingMovie.mov) for the video of this trial.

For a fixed mystacial pad and hair follicles, such as that in an anesthetized preparation, the angle (and its time derivatives) of the vibrissa close to its base is a good measure of the input signal to the vibrissa system. However, since movement of the mystacial pad and rotation of the hair follicles causes rotation of the vibrissae, the angle of the base of the vibrissa alone is not sufficient to characterize the input signal for an awake behaving animal. To decouple mystacial pad and vibrissa follicle movement from externally-induced movement of the vibrissae, we measured the angle both of the target vibrissa, which was in contact with the grating, and of a trimmed “reference” vibrissa in the same row which was not in contact with any surface (see Figure 1A of the main text). Previous studies have shown (Carvell and Simons, 1990), and we observed, that vibrissae in the same row tend to move in phase with each other over 95% of the time. Therefore, in most cases the reference vibrissa accounts for movement of the mystacial pad or follicle. We subtracted the angle of the reference vibrissa from the measured vibrissa angle. The angular deflection of a vibrissa close to its base was estimated by calculating the angle of a straight line segment between the extreme points of a short (3mm long) spline fitted to a segment of the vibrissa close to its base (within 2 mm of the mystacial pad).

We should also note that recent studies have implicated higher order measures (i.e. curvature) as potentially important aspects of the mechanical signals transduced by the pathway (Birdwell et al., 2007). Although we were able to measure curvature from the high-speed video in controlled situations in which an isolated vibrissa was rigidly clamped and deflected, repeating previous studies, the relatively unconstrained nature of our behavioral paradigm resulted in exceedingly noisy measurements of curvature under these conditions due to the motion of the boundary, and thus these measures were excluded from this analysis. However, Birdwell et al. show that for small angular deflections in non-whisking conditions that the moment at the base of the vibrissa is linearly related to the angular position, and the static relationship we find between distance

and differential angle during behavior is at least qualitatively similar to the reported relationship between the rate of change of angular momentum and distance (Birdwell et al., 2007). As we show for continuous contact of the vibrissae with a surface under these behavioral conditions, the angular deflection captures a significant element of the motion of the animal relative to the wall, providing perhaps a lower bound of the available information, which may only be enhanced with the consideration of higher-order representations.

## References

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