Scan 043 of MyConnectome database

Scan 053 of MyConnectome database

Head motion (mm)

2

0

Undenoised signals (mean and trend removed)

Undenoised signals (mean and trend removed)

Signal (%)

2

-2

Gray matter

White matter

Undenoised signals (mean and trend removed; 6 mm blur within-compartment)

Undenoised signals (mean and trend removed; 6 mm blur within-compartment)

10 minutes

10 minutes

Note emergence of structured signals after blurring

FreeSurfer masks, see color bars at sides of heat maps

Cortical ribbon
Subcortical nuclei
Cerebellum
Superficial WM
Deeper WM
Deepest WM
Superficial CSF
Deeper CSF

Figure 1: **Thermal noise can obscure structured signals.** Two scans of the MyConnectome database are shown with motion traces at top, undenoised signals at middle, and blurred but otherwise undenoised signals at the bottom. These data are 2.4 x 2.4 x 2.4 mm voxels acquired every 1.16 seconds. The blurring occurs within brain compartment masks defined by FreeSurfer so that signals are not combined across brain compartments. Blurring averages away thermal noise, revealing structured signals. Note that periodic head motion is present and that similarly periodic signals become visible in the gray matter upon reduction of thermal noise (yellow arrows). See Online Movie 1 for such plots of all MyConnectome scans.

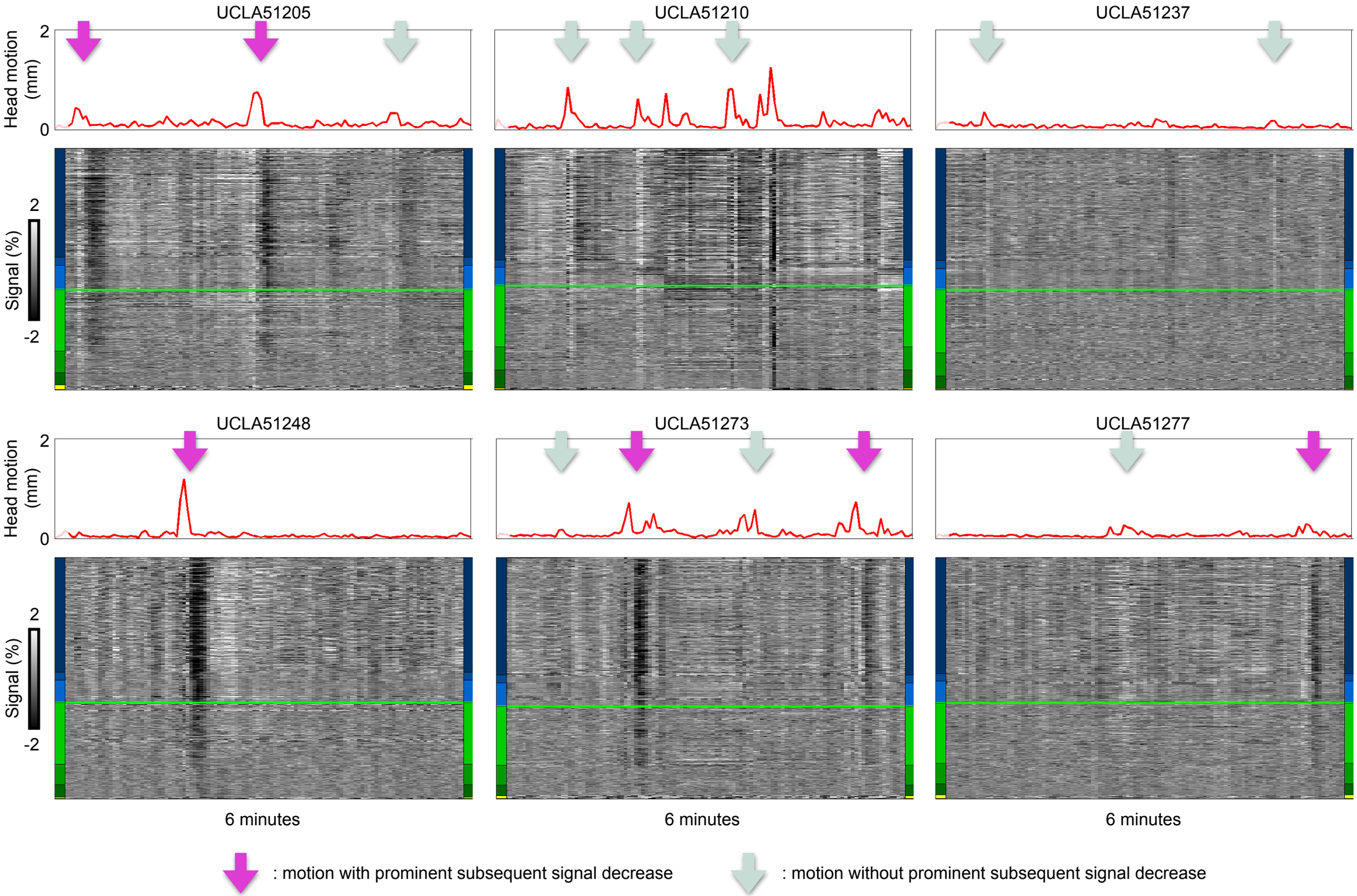

Figure 2: **Motion is sometimes paired with prolonged signal decreases.** Scans from six subjects of the University of California at Los Angeles (UCLA) site of the ABIDE database are shown following the conventions of Figure 1. These data are 3 x 3 x 4 mm voxels acquired every 3 seconds. See Figure S1 and S2 for similar examples in the Utah School of Medicine (USM) and New York University (NYU) ABIDE scans, or Online Movie 2 for plots of all subjects from these ABIDE sites. Purple arrows denote motion with prominent signal decreases afterwards, light blue arrows denote motion without such prominent signal decreases.

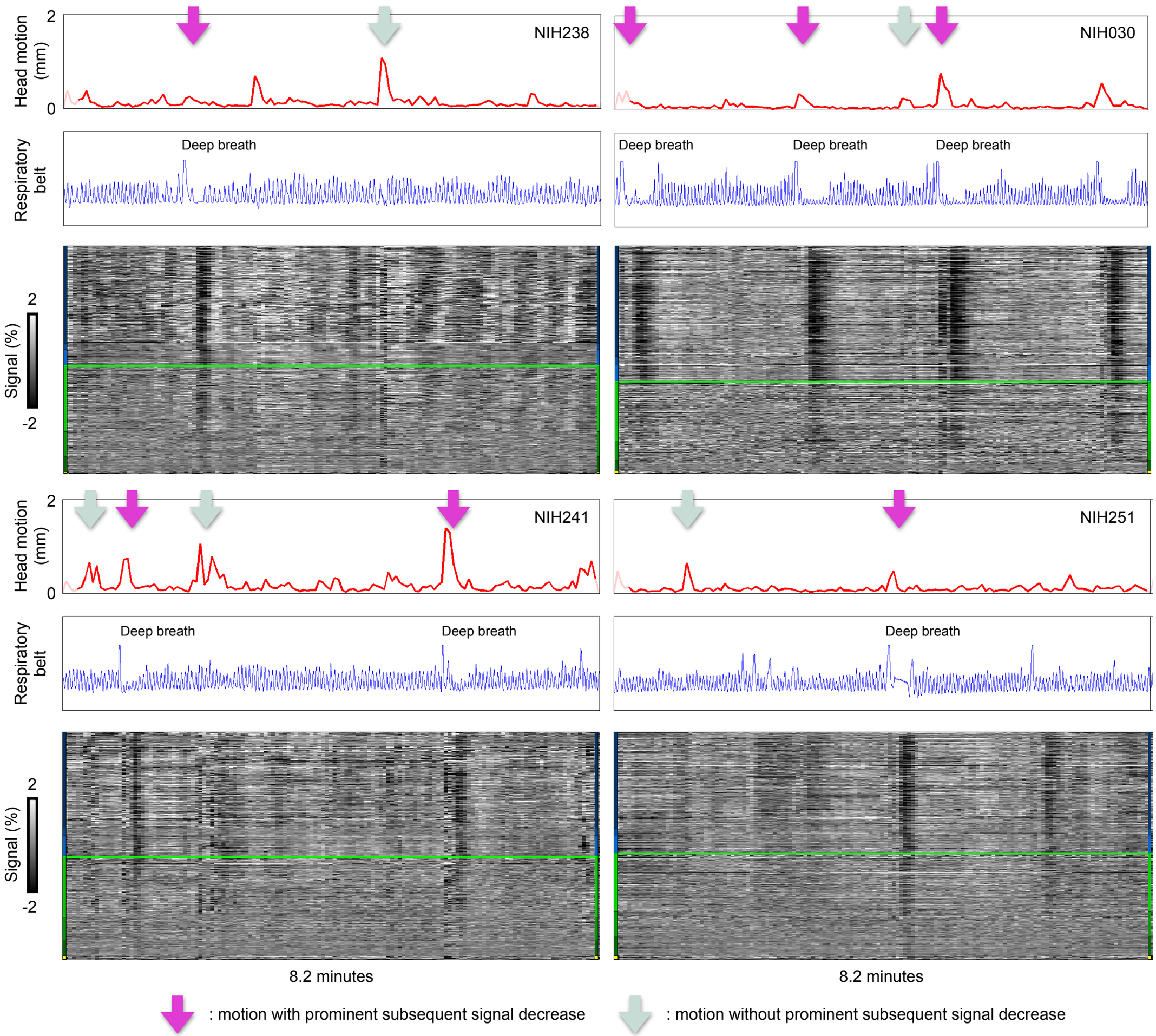

Figure 3: **Deep breaths discriminate motions with subsequent signal decreases from motions without subsequent signal decreases.** Scans from 4 subjects of the NIH cohort are shown following the conventions of Figure 2. Respiratory belt traces are in arbitrary units. These data are 1.7 x 1.7 x 3 mm voxels acquired every 3.5 seconds. As in Figure 2, purple arrows denote motion with prominent signal decreases afterwards, light blue arrows denote motion without such prominent signal decreases.

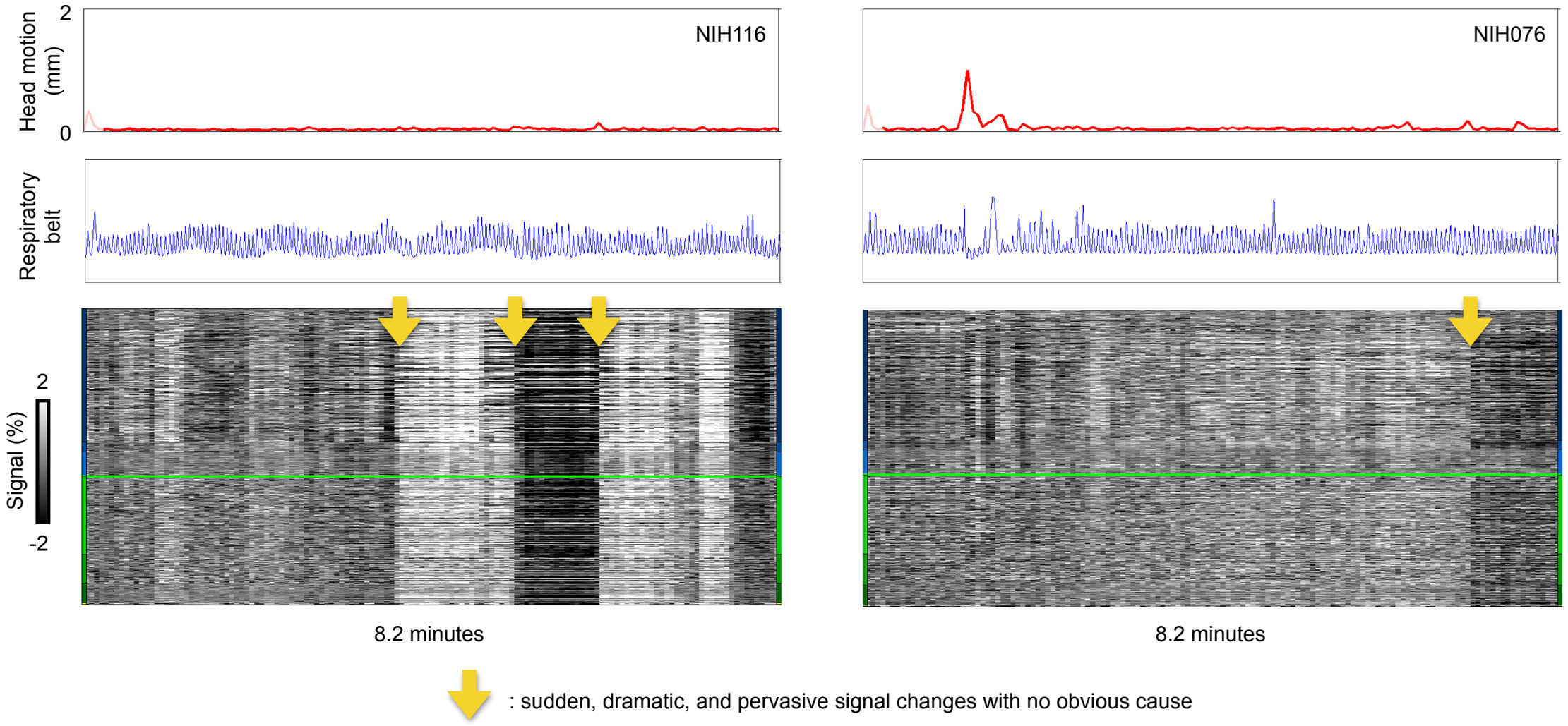

Figure 4: **Abnormalities without obvious causes may be hardware-related artifacts.** Scans from 2 subjects of the NIH cohort are shown following the conventions of Figure 3, illustrating sudden, dramatic, and pervasive signal changes with no obvious cause (yellow arrows).

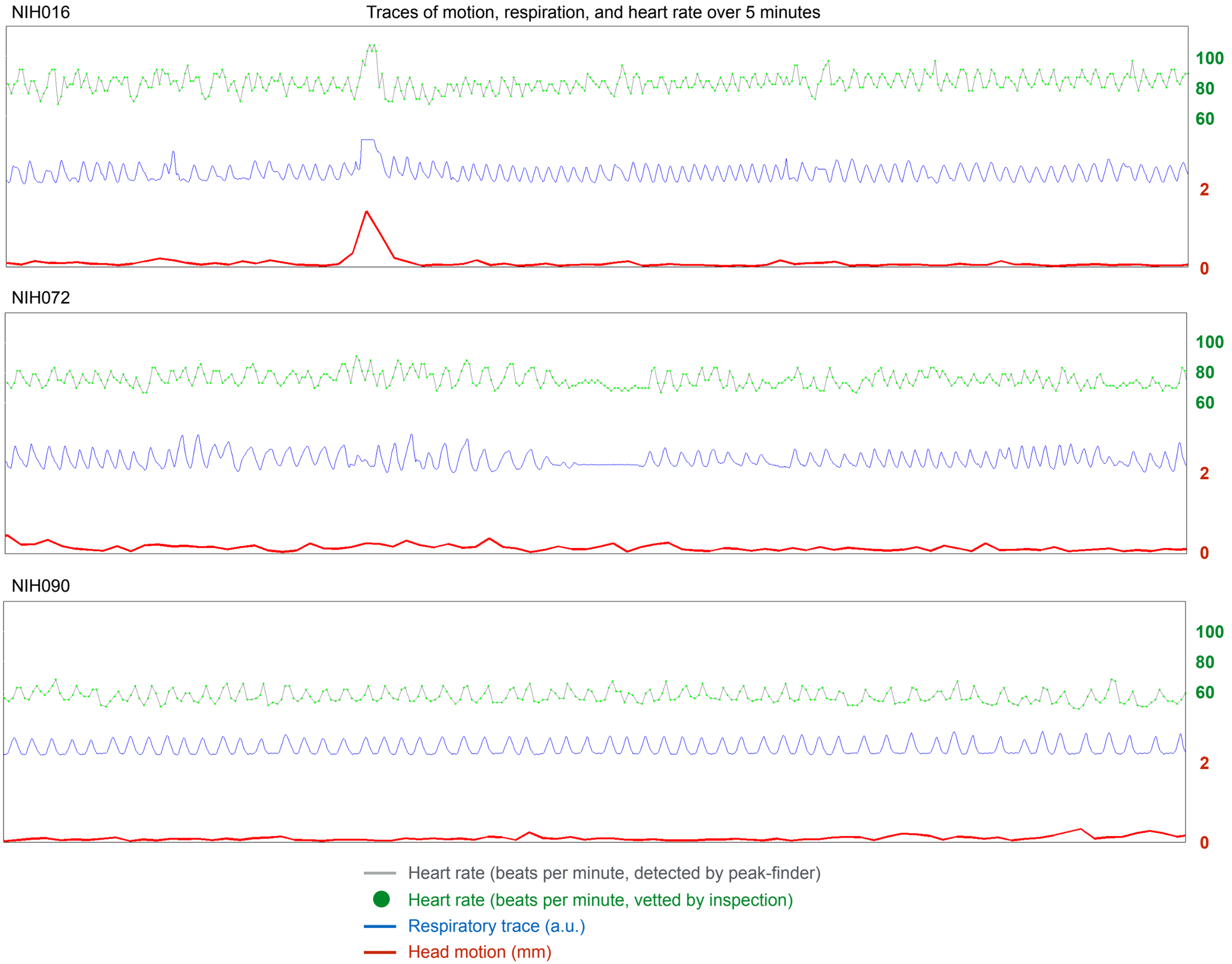

Figure 5: **Interrelationships among motion, respiration, and heart rate.** For 3 NIH subjects, 5 minutes of heart rate, respiratory, and head motion traces are shown. Note the slightly lagged modulation of heart rate by respiratory cycle; this finding is called “sinus arrhythmia”, a normal finding in most children and adults. Also note that transient elevations in heart rate accompany deep inspiration, which in turn is often marked by head motion. See additional examples of these plots in Figure S4 and Online Movie 3 for plots of all NIH subjects.

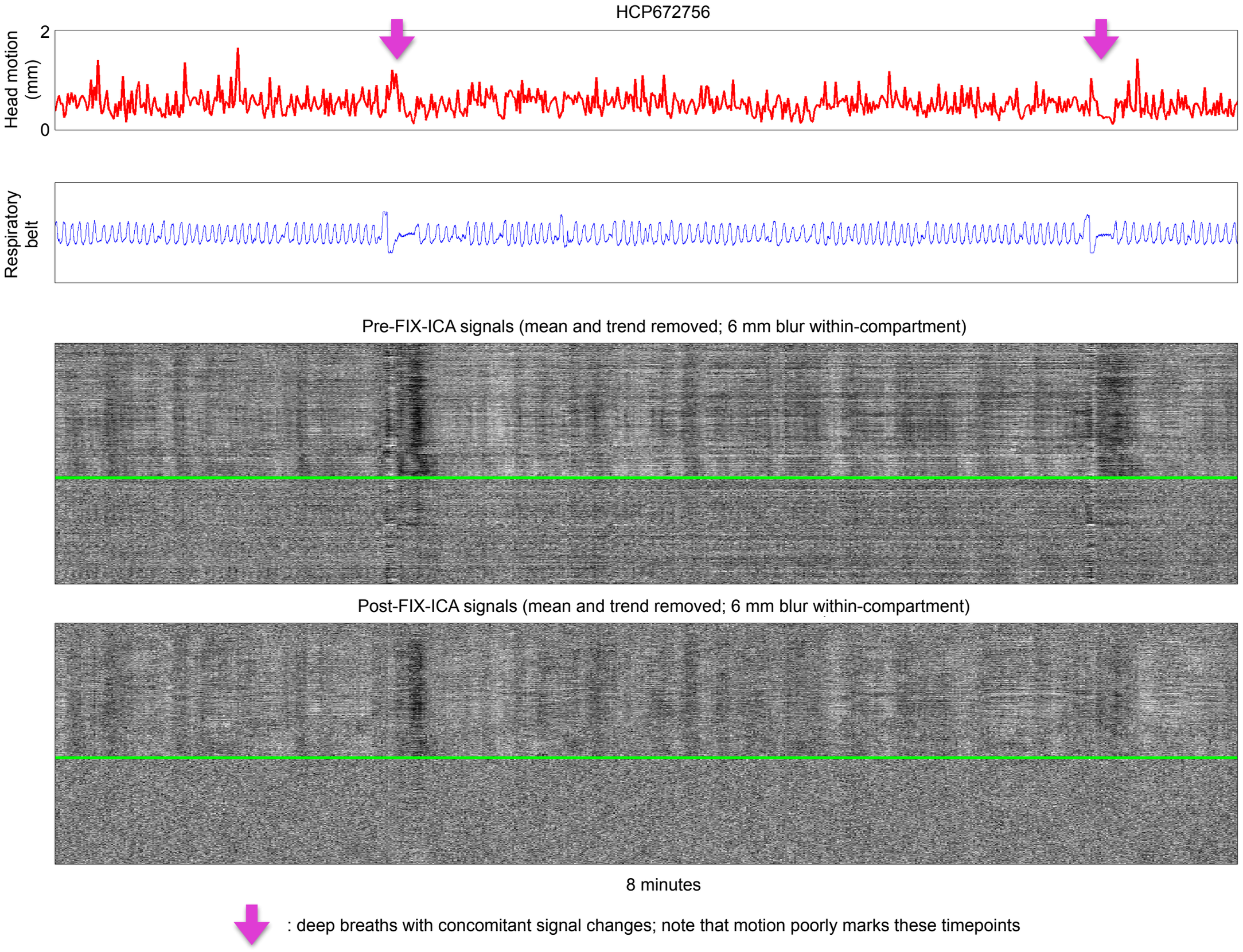

Figure 6: **Examining single scans before and after a denoising step.** A scan from the HCP dataset is shown before and after FIX-ICA. Purple arrows denote breaths (see blue respiratory traces). These data are 2 x 2 x 2 mm voxels acquired every 0.72 seconds. Only 8 minutes of the 15-minute scan are shown because the data are highly sampled in time and the image becomes “cramped” if more time is included. See Figure S5 and S6 for additional examples, or Online Movie 4 for plots of all HCP subjects.

Supplemental figures

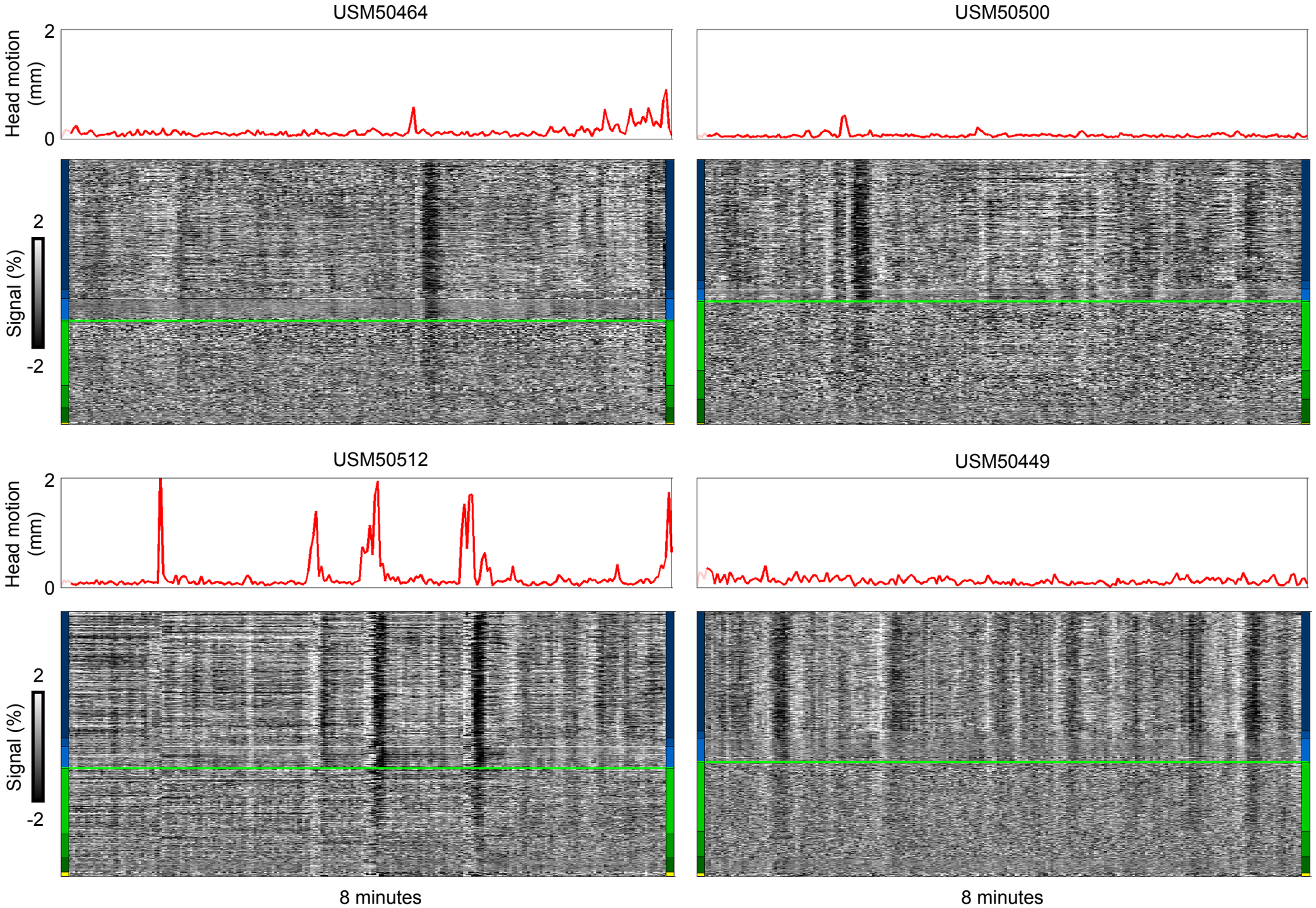

Figure S1: **Motion is sometimes paired with prolonged signal decreases.** Scans from four subjects of the Utah School of Medicine (USM) site of the ABIDE database are shown following the conventions of Figure 2. These data are 3.4 x 3.4 x 4 mm voxels acquired every 2 seconds.

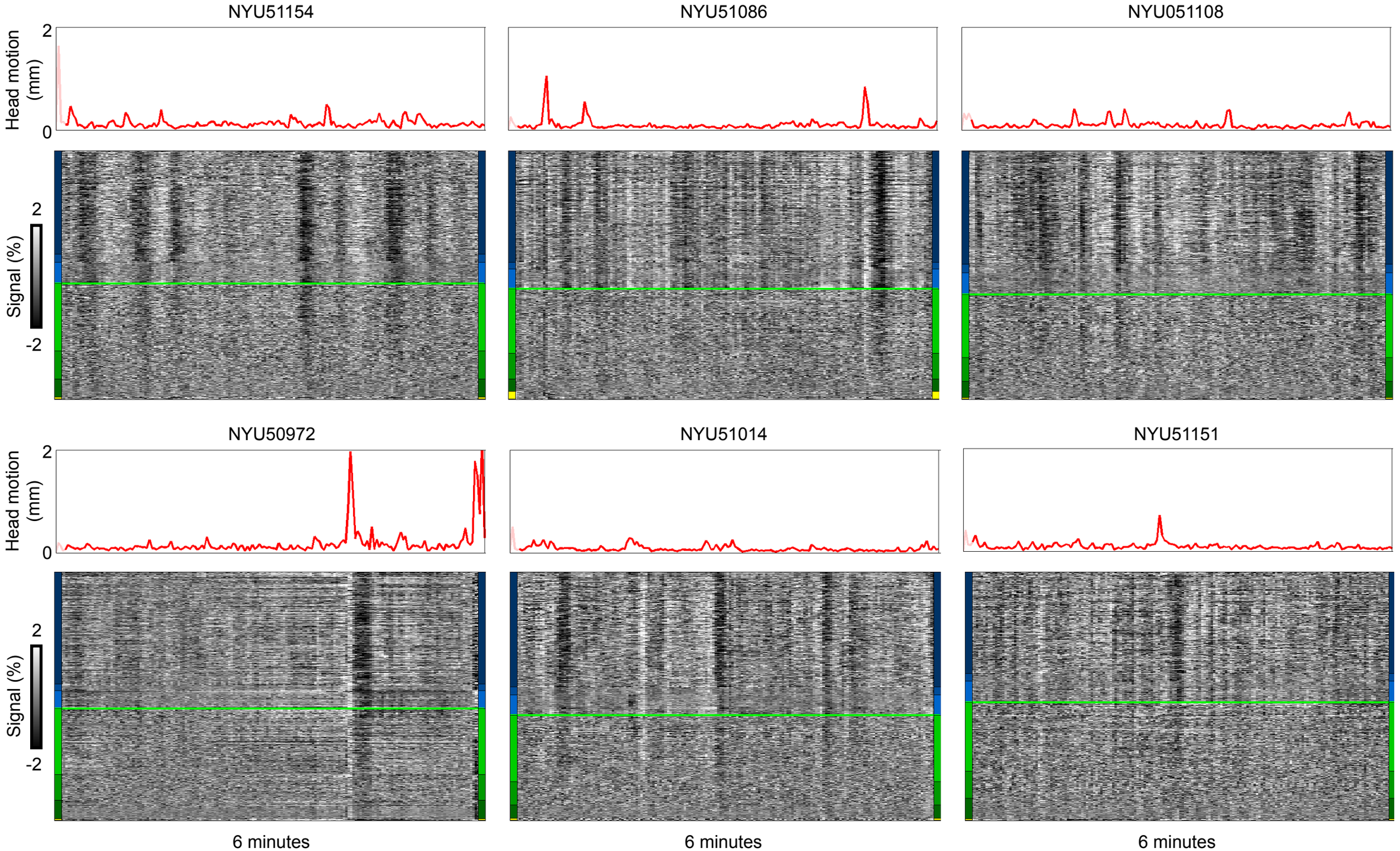

Figure S2: **Motion is sometimes paired with prolonged signal decreases.** Scans from six subjects of the New York University (NYU) site of the ABIDE database are shown following the conventions of Figure 2. These data are 3 x 3 x 3 mm voxels acquired every 2 seconds.

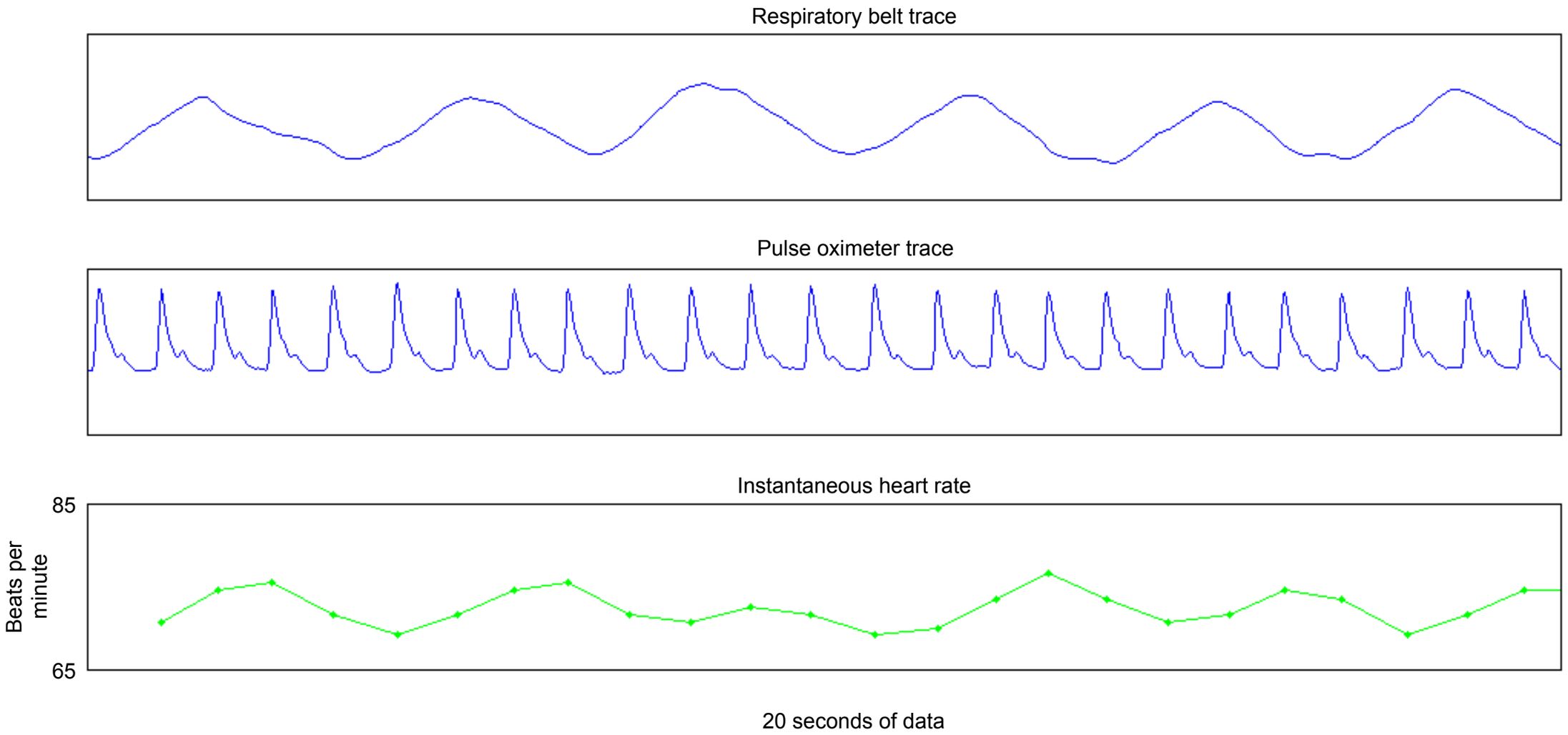

Figure S3: **What physiological traces "should" look like.** Top, an unprocessed respiratory trace. Middle, an unprocessed pulse oximeter trace. Bottom, instantaneous heart rate calculated from the time between peaks in the pulse oximeter trace. The modulation of heart rate by respiratory phase is called "sinus arrhythmia"; it is a normal finding seen in most children and young adults.

Figure S4: More examples of interrelationships among motion, respiration, and heart rate. Plots in 3 additional subjects following conventions of Figure 5.

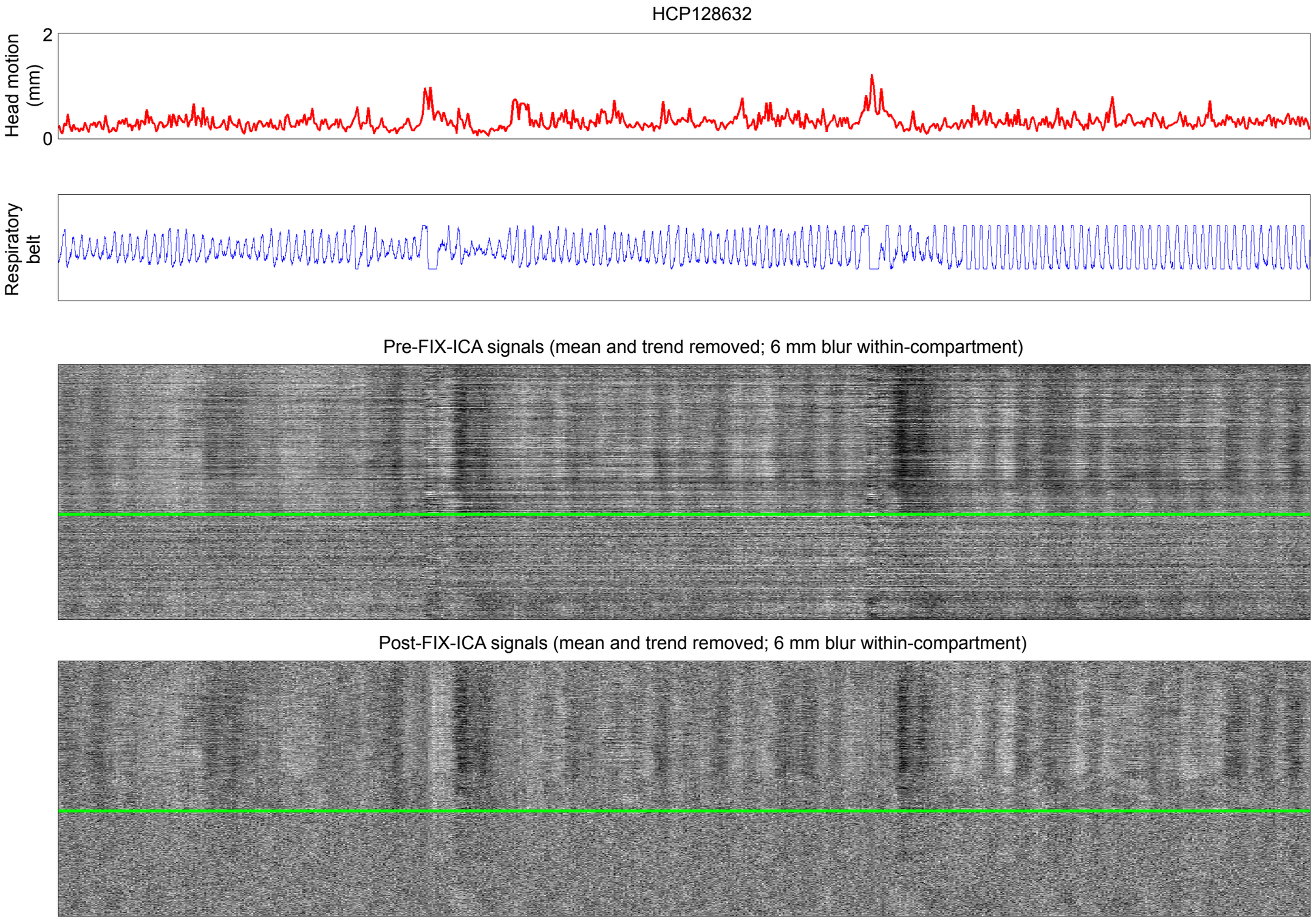

Figure S5: **Examining single scans before and after a denoising step.** Plot follows the conventions of Figure 6, using a different subject.

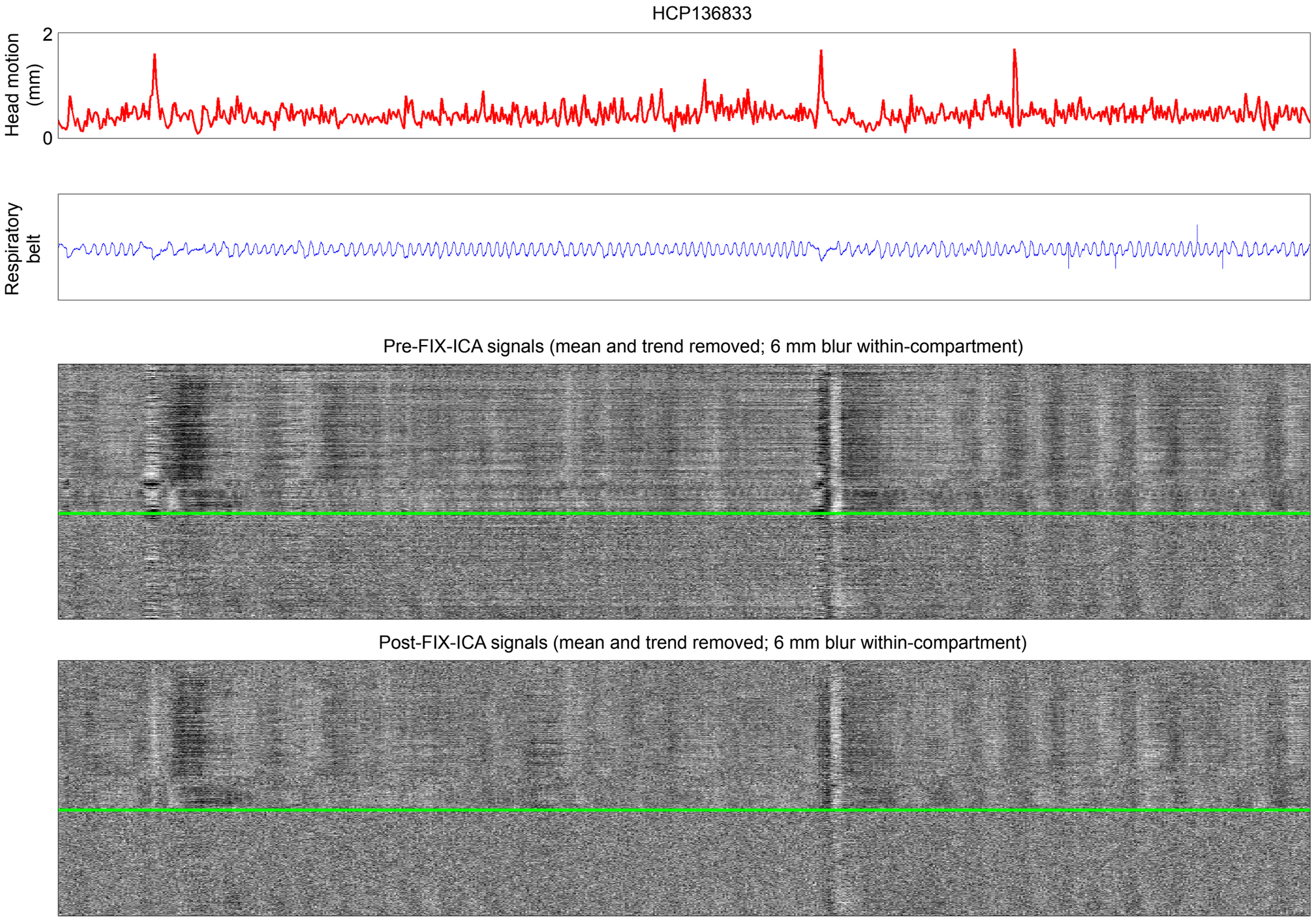

Figure S6: **Examining single scans before and after a denoising step.** Plot follows the conventions of Figure 6, using a different subject.