Adaptation to orientation in natural scenes

Bruno Richard

Patrick Shafto

The encoding mechanisms of the human visual system are associated with the distribution of features in natural environments (Olshausen & Field, 2000). Moreover, exposure to modified environments over an hour or so can generate meaningful changes in the visual sensitivity of observers, suggesting the importance of recent experience (Richard & Shafto, 2022, Schweinhart, Shafto, & Essock, 2017). This work measured sensitivity to the features of natural environments (e.g., orientation contrast and the slope of the amplitude spectrum) before and following the 60-minute adaptation period, which gives little indication of the time course of adaptation in modified environments. Here, we use the horizontal effect; an orientation anisotropy thought to be related to the distribution of orientation contrast in natural environments, to monitor the time course of adaptation in modified reality. We measured sensitivity to orientation with a matching task in nine observers. Observers wore a Head-Mounted Display (HMD) that presented an unaltered or an isotropic version of their environment, recorded from a head-mounted camera. Sensitivity to orientation was measured in the HMD with an orientation and contrast matching task. Before adaptation, observers exhibited the expected anisotropy; sensitivity to horizontally oriented stimuli was worse than vertical and oblique stimuli. During the first half of the adaptation period, sensitivity to horizontal stimuli improved, matching that of other orientations within 30 minutes of immersion in the isotropic environment. Sensitivity to different orientations was unaffected by the isotropic environment. Our findings demonstrate that adaptation to a novel, isotropic environment occurs gradually over a relatively brief time of approximately 30 minutes. Additionally, we bring further evidence that human sensitivity to oriented content is associated with the distribution of orientation contrast in the current environment of observers.

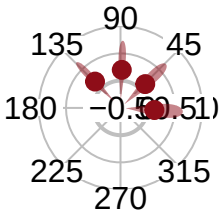
Introduction

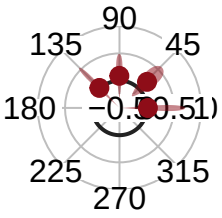
The encoding mechanisms of the human visual system are associated with the distribution of features in natural environments (Olshausen & Field, 2000). Moreover, exposure to modified environments over an hour or so can generate meaningful changes in the visual sensitivity of observers, suggesting the importance of recent experience (Richard & Shafto, 2022, Schweinhart, Shafto, & Essock, 2017). This work measured sensitivity to the features of natural environments (e.g., orientation contrast and the slope of the amplitude spectrum) before and following the 60-minute adaptation period, which gives little indication of the time course of adaptation in modified environments. Here, we use the horizontal effect; an orientation anisotropy thought to be related to the distribution of orientation contrast in natural environments, to monitor the time course of adaptation in modified reality. We measured sensitivity to orientation with a matching task in nine observers. Observers wore a Head-Mounted Display (HMD) that presented an unaltered or an isotropic version of their environment, recorded from a head-mounted camera. Sensitivity to orientation was measured in the HMD with an orientation and contrast matching task. Before adaptation, observers exhibited the expected anisotropy; sensitivity to horizontally oriented stimuli was worse than vertical and oblique stimuli. During the first half of the adaptation period, sensitivity to horizontal stimuli improved, matching that of other orientations within 30 minutes of immersion in the isotropic environment. Sensitivity to different orientations was unaffected by the isotropic environment. Our findings demonstrate that adaptation to a novel, isotropic environment occurs gradually over a relatively brief time of approximately 30 minutes. Additionally, we bring further evidence that human sensitivity to oriented content is associated with the distribution of orientation contrast in the current environment of observers.

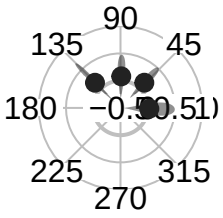
Methods

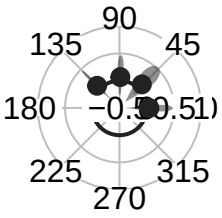
Results

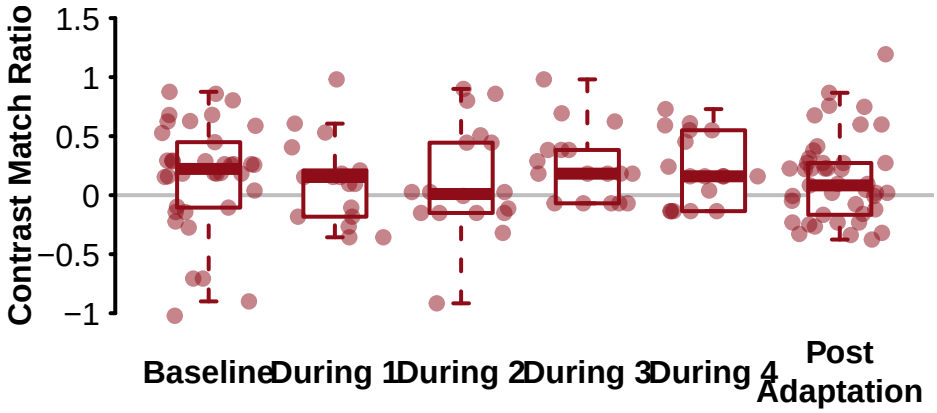
```
[1]  0.00000 15.77778 30.88889 61.11111
```

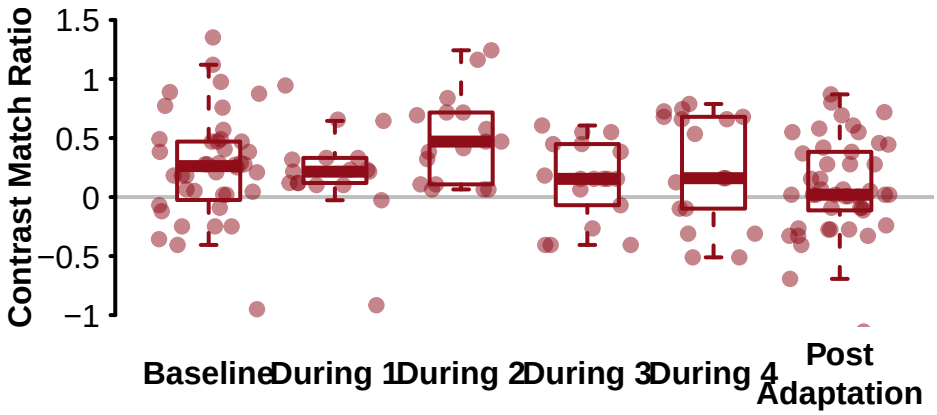

90
135
45
180
225
315
270

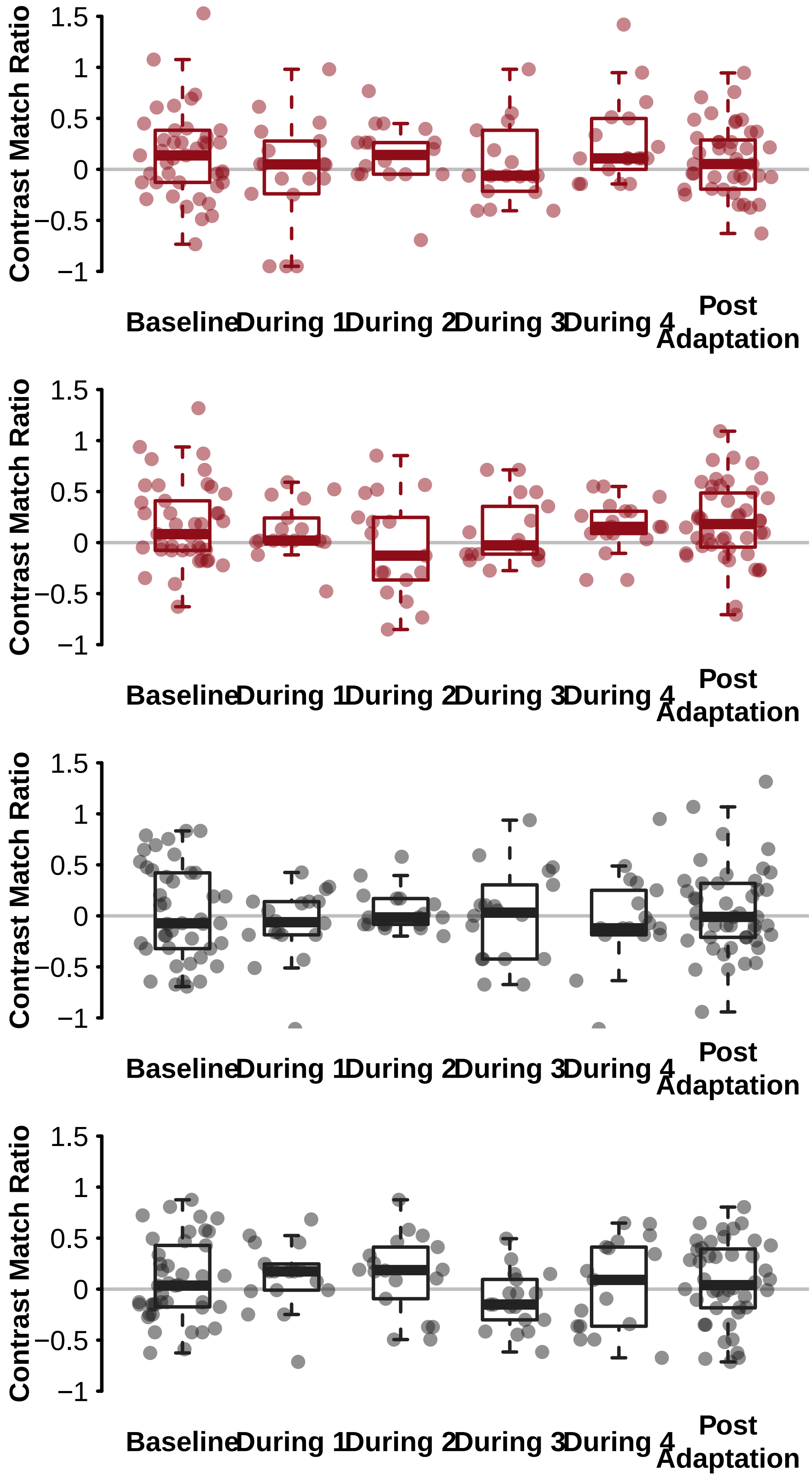

90
135
45
180
225
315
270

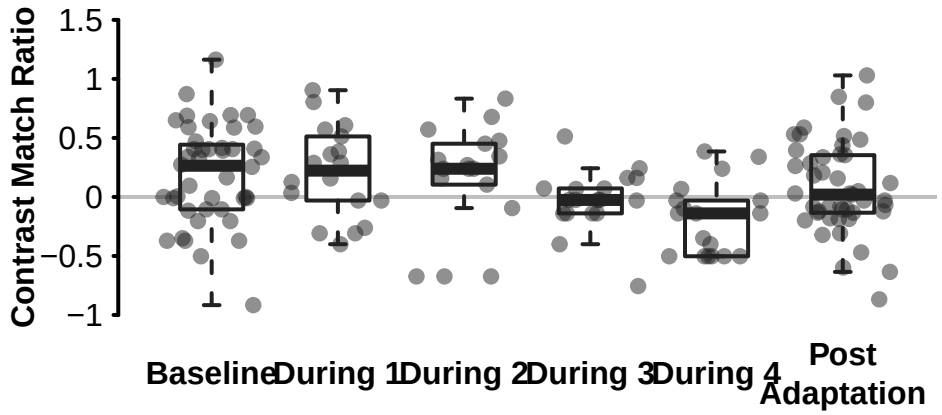

90
135
45
180
225
315
270

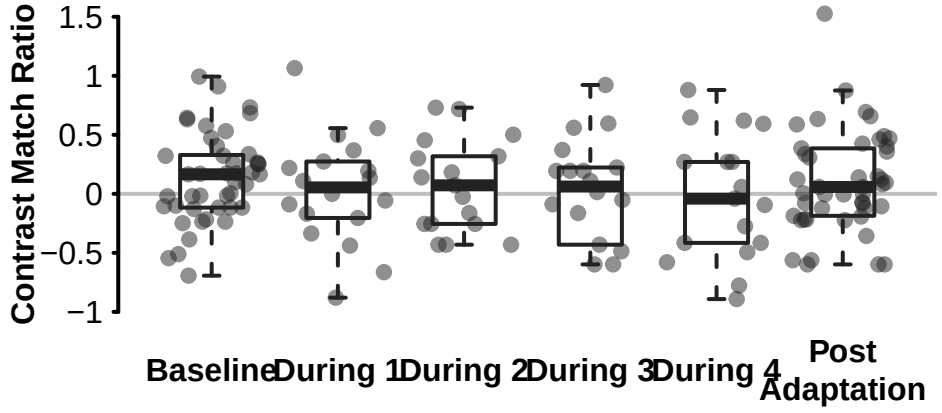

90
135
45
180
225
315
270

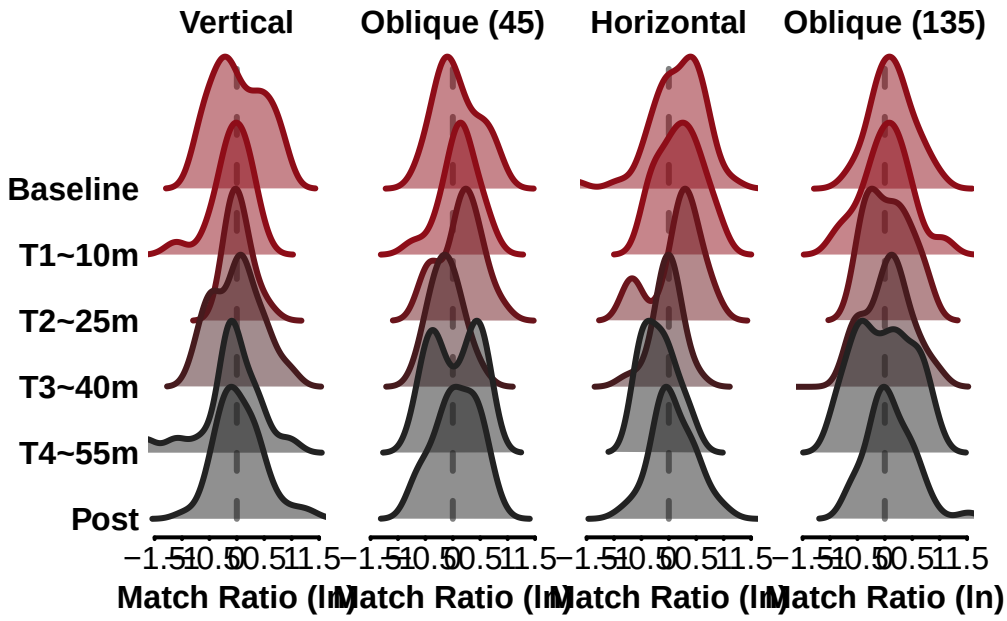

Contrast Match Ratio
1.5
1
0.5
0
−0.5
−1
Baseline
During 1
During 2
During 3
During 4
Post Adaptation


Contrast Match Ratio
1.5
1
0.5
0
−0.5
−1
Baseline
During 1
During 2
During 3
During 4
Post Adaptation


Contrast Match Ratio
1.5
1
0.5
0
−0.5
−1
Baseline
During 1
During 2
During 3
During 4
Post Adaptation


Contrast Match Ratio
1.5
1
0.5
0
−0.5
−1
Baseline
During 1
During 2
During 3
During 4
Post Adaptation


Contrast Match Ratio
1.5
1
0.5
0
−0.5
−1
Baseline
During 1
During 2
During 3
During 4
Post Adaptation


Vertical
Oblique (45)
Horizontal
Oblique (135)
Baseline
T1~10m
T2~25m
T3~40m
T4~55m
Post
−1.5
−1
−0.5
0
0.5
1
1.5
Match Ratio (ln)

Modelling

Discussion

References