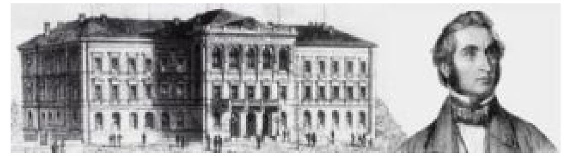

# Saccadic Gain Adaptation follows Perceived Position


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## Introduction

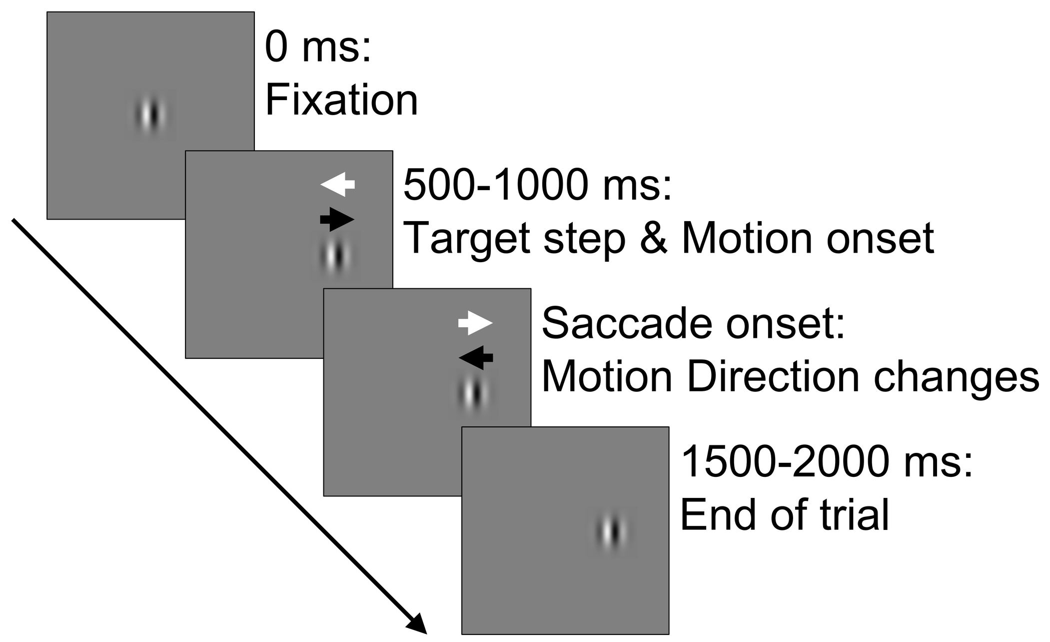
Neuronal motor systems have to adapt to fluctuations of the resulting motor output, in order to maintain precision of movements. A high accuracy is especially important for saccadic eye movements. In the laboratory, the amplitude and the vector of saccades can be adapted by introducing an intra-saccadic displacement of the saccade target [1]. The resulting post-saccadic retinal position error leads to an adaptation of the saccade amplitude or vector over several hundred trials.

It is known that the perceived position of an object may be distorted by several visual illusions. Thus we asked, if saccadic gain adaptation is also affected by position illusions.

## Methods

To disentangle actual and perceived position, we made use of the motion capture effect [2]: the perceived position of a Gabor patch with a stationary Gaussian aperture and a drifting sinusoid is deviated in the direction of motion. This perceptual illusion does also influence action, for instance pointing movements or saccades [3].

We asked subjects to saccade to a 5 deg peripheral Gabor patch. By changing the motion direction of the sinusoid during the saccade, we tried to apply an illusory position step. The Gaussian aperture had a standard deviation of 0.5 deg and the sinusoid a spatial frequency of 1 cpd and a temporal frequency of 4 Hz.




We tested two conditions: first a backward adaptation and second a forward adaptation. In the backward condition, the sinusoid changed its motion direction from outwards to inwards. This should shorten the saccade amplitude. In the forward condition, the sinusoid motion changed from inwards to outwards. This should prolong the saccadic amplitude.

<table>
<tr><th></th><th colspan="2">Motion Direction of Sinusoid<br>(Before Saccade | After Saccade)</th></tr>
<tr><th></th><th>Backward Adaptation</th><th>Forward Adaptation</th></tr>
<tr><td>Pre-Adaptation<br>(40 Trials)</td><td>Outward | Outward</td><td>Inward | Inward</td></tr>
<tr><td>Adaptation<br>(160 Trials)</td><td>Outward | Inward</td><td>Inward | Outward</td></tr>
<tr><td>Post-Adaptation<br>(40 Trials)</td><td>Outward | Outward</td><td>Inward | Inside</td></tr>
</table>


**References:**

[1] Hopp, J. J., & Fuchs, A. F. (2004). The characteristics and neuronal substrate of saccadic eye movement plasticity. Progress in Neurobiology, 72, 27-53.

[2] De Valois, R. L., & De Valois, K. K. (1991). Vernier acuity with stationary moving gabors. Vision Research, 31(9), 1619-1626.

[3] Kerzel, D., & Gegenfurtner K. R. (2005). Motion-induced illusory displacement reexamined: differences between perception and action? Experimental Brain Research, 162, 191-201.



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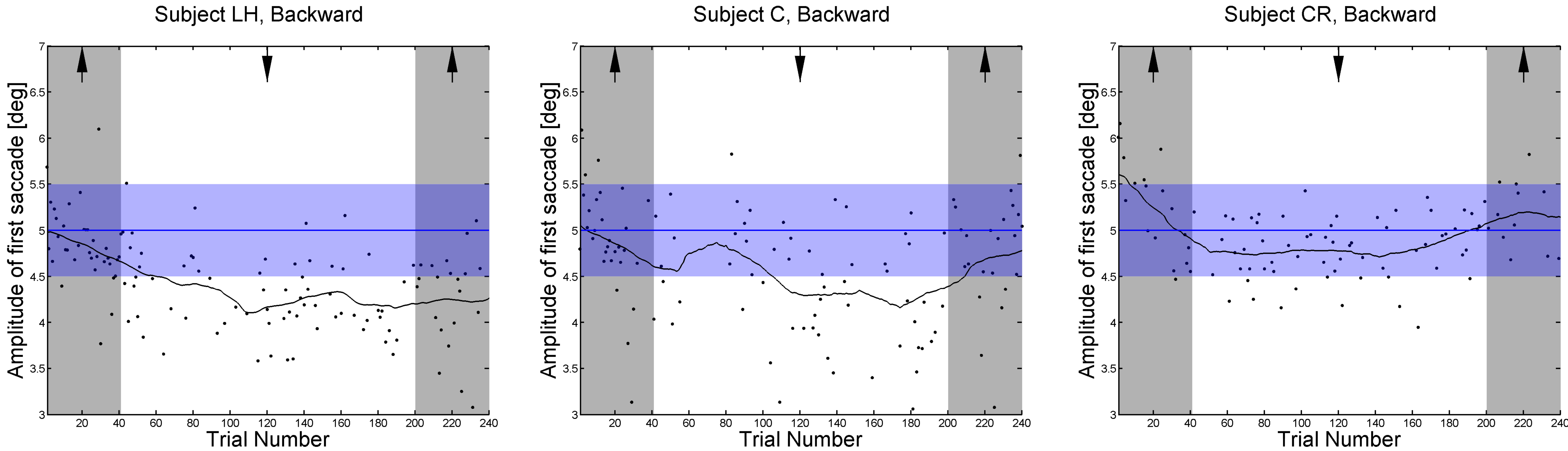
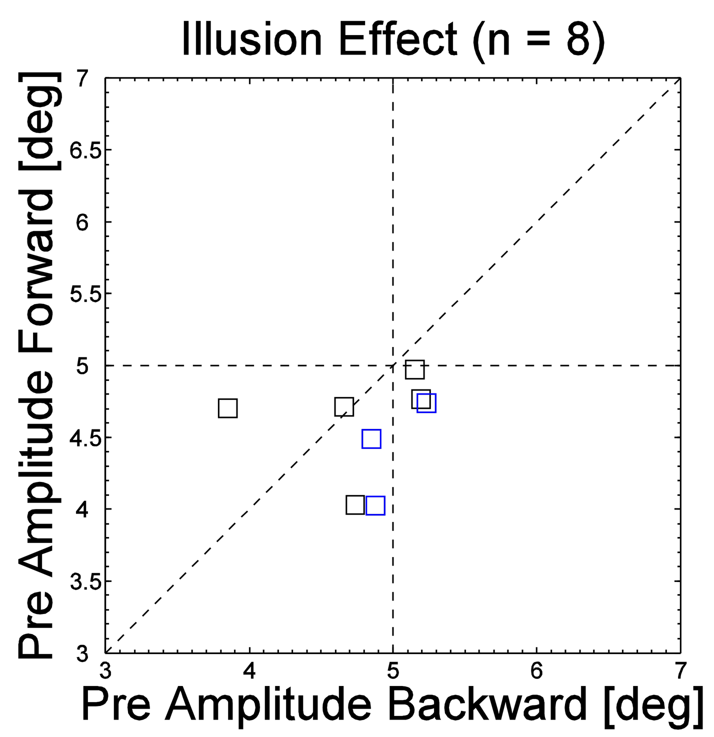
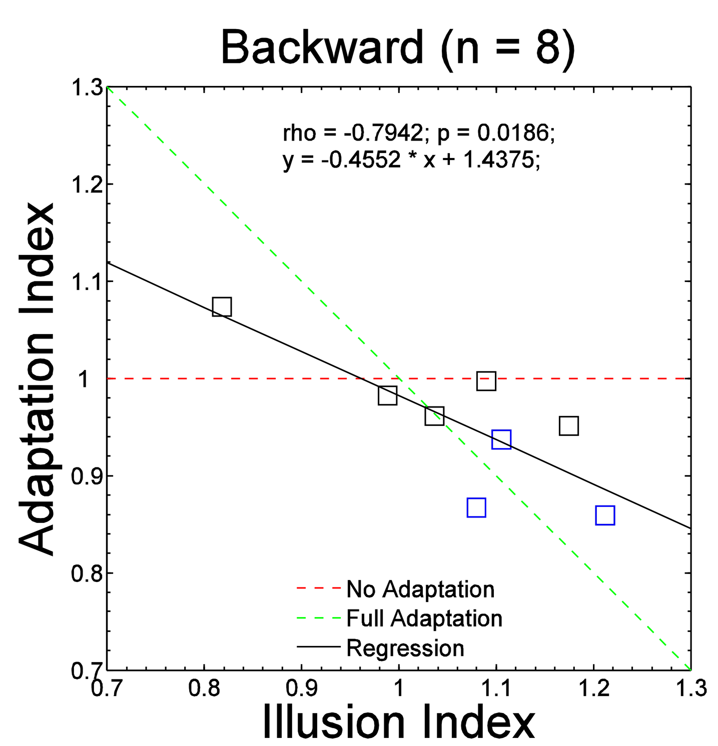
## Results




## Illusion Effect



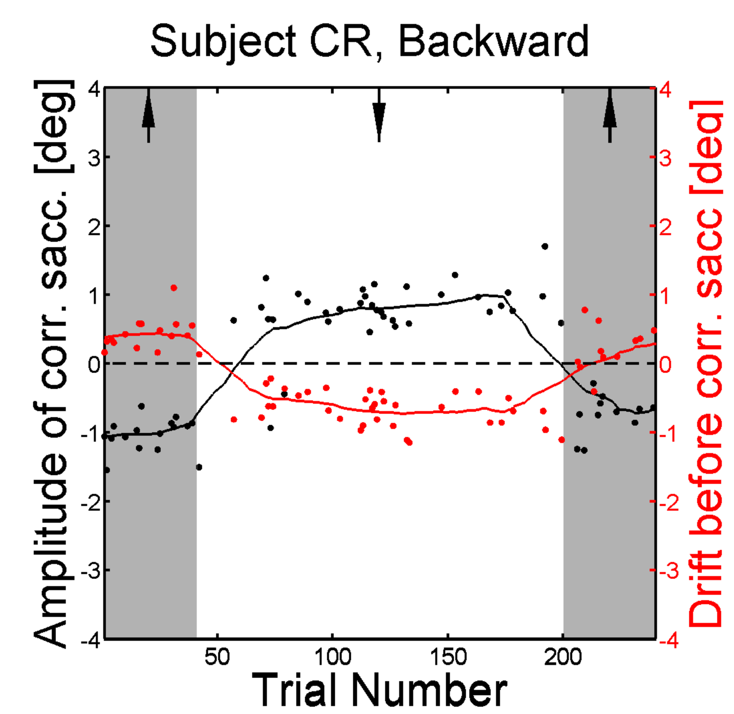

In order to calculate the magnitude and direction of the motion induced position illusion, we compared the saccadic amplitudes in the pre-adaptation phase for the backward and forward conditions. Five out of eight subjects show an illusion effect, which means that their average pre-adaptation saccadic amplitude is larger in the backward condition than in the forward condition.

To calculate an **illusion index**, we divided the average saccadic amplitude in the backward condition by the average saccadic amplitude in the forward condition. An illusion index larger than one means that the saccades are shifted in motion direction, values lower than one mean that the saccades are shifted against motion direction.

To estimate the amount of adaptation for each condition, we calculated the average amplitude in the last 40 trials of the adaptation phase and divided this by the average amplitude in the pre-adaptation phase. An **adaptation index** larger than one means an increase of saccadic amplitudes in the adaptation phase, values lower than one mean a decrease of saccadic amplitudes during the adaptation.

In the backward condition, the adaptation index and the illusion index were negatively correlated, indicating an adaptation according to the illusion effect. There was no correlation in the forward condition.

## Alternative Explanation




Due to the movement of the sinusoid, subjects drifted in motion direction after the first saccade, which foveated the Gabor patch. As this drift inevitably brings the eyes out of the patch, corrective saccades in the opposite direction occurred. Almost every subject showed such a pattern.

It might be possible that this combination of drift and corrective saccades is responsible for the adaptation of the initial saccades.

## Conclusions

In this study, we tried to adapt saccadic amplitudes by manipulating the perceived position of the saccade target. The perceived position of a Gabor patch was changed during saccades, by changing the motion direction of its sinusoid. We tested two conditions: a backward condition, in which saccadic amplitudes should become reduced and a forward condition, in which saccadic amplitudes should become increased. For the backward condition, we found a correlation between the magnitude of the position illusion and the magnitude of saccadic adaptation. This was not true for the forward condition.

Due to the motion of the sinusoid, we found a typical pattern of drift in sinusoid direction and corrective saccades in the opposite direction, as soon as the Gabor was foveated. This pattern might represent an alternative explanation for the obtained backward adaptation.