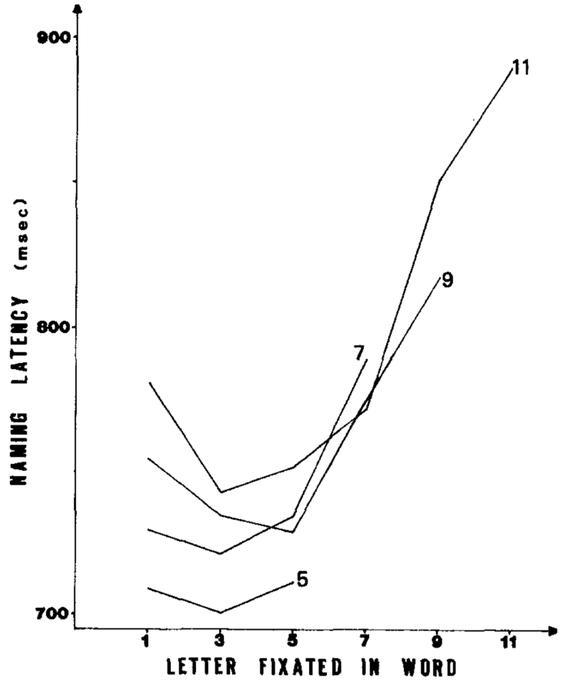
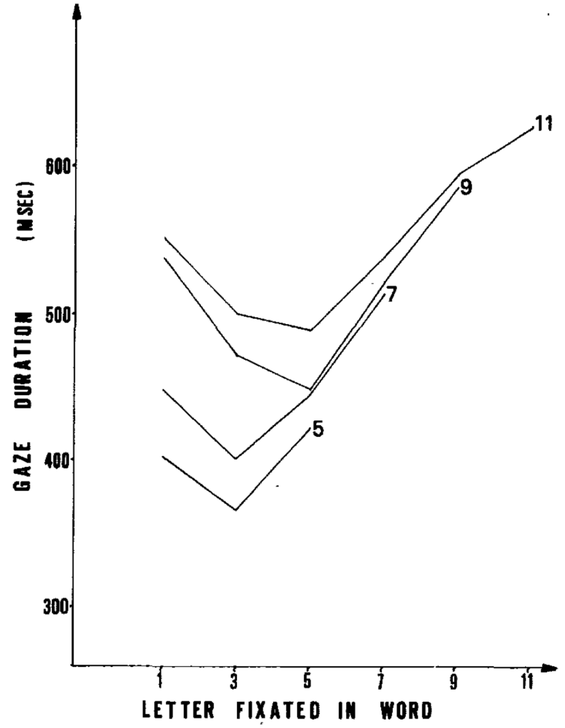
Reader targeting of words is guided by the distribution of information in the lexicon

Jon W. Carr and Davide Crepaldi
International School for Advanced Studies, Trieste, Italy

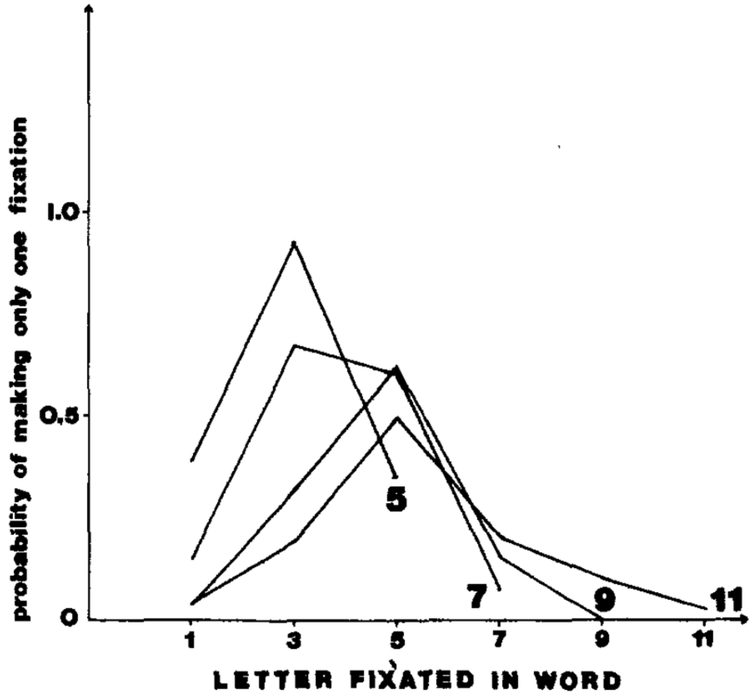
Naming latency



Gaze duration

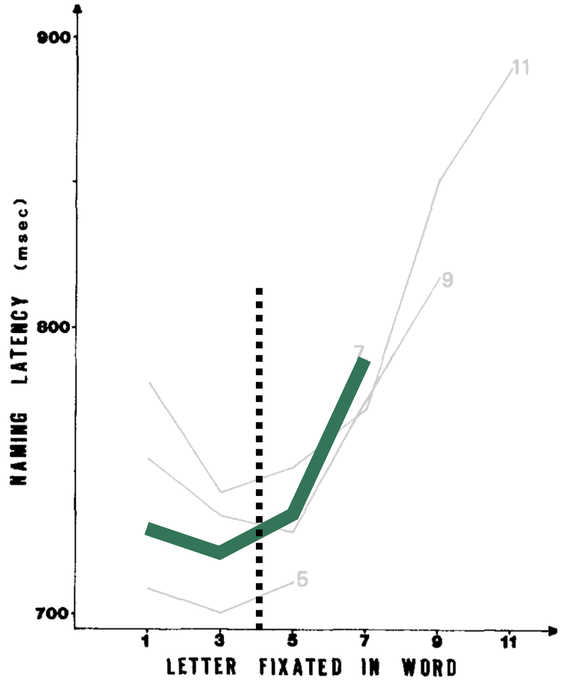


Probability of one fixation

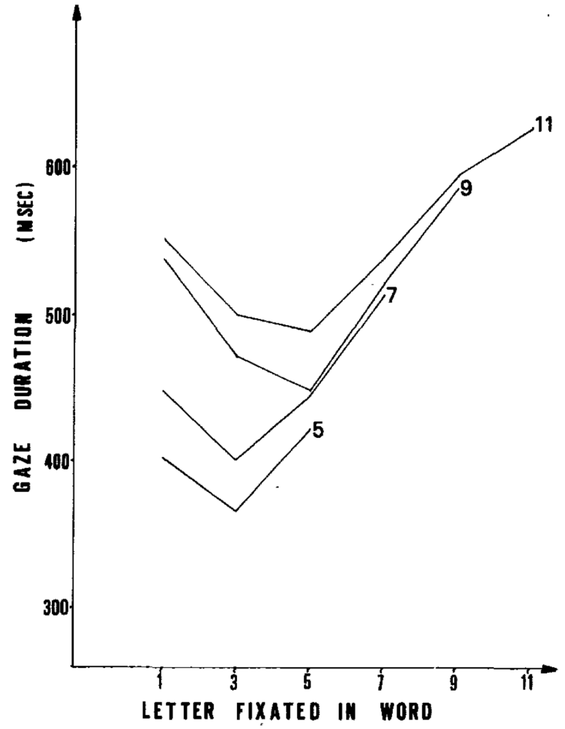


O'Regan et al. (1984)

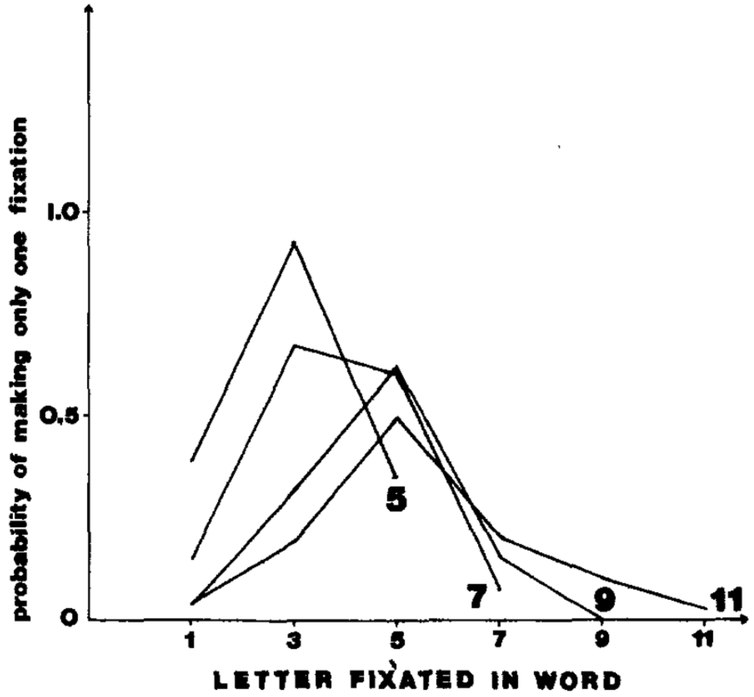
Naming latency



Gaze duration

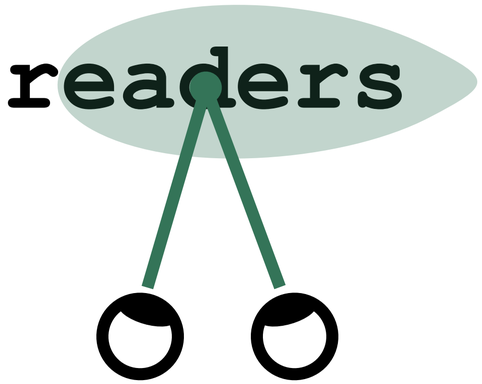


Probability of one fixation



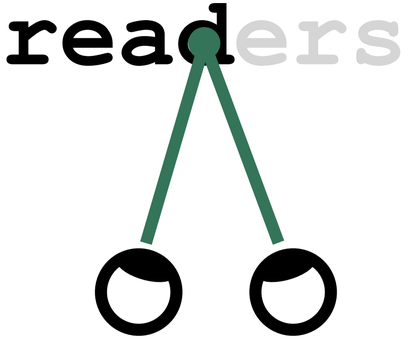
O'Regan et al. (1984)

Perceptual bias



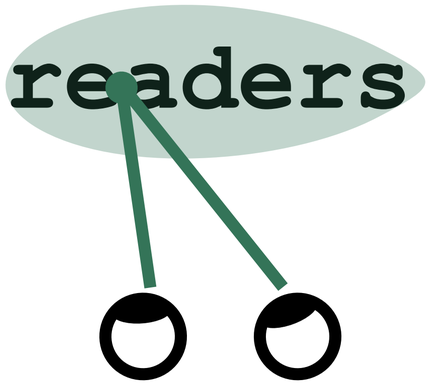
Visual span is asymmetric (right-visual-field advantage), so fixating left-of-center maximizes how much of the word is in view

Informational bias



Words are typically more informative at the beginning, so fixating left-of-center places greater constraint on the possible words

Perceptual bias



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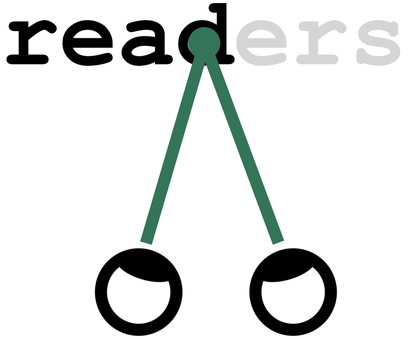
Informational bias



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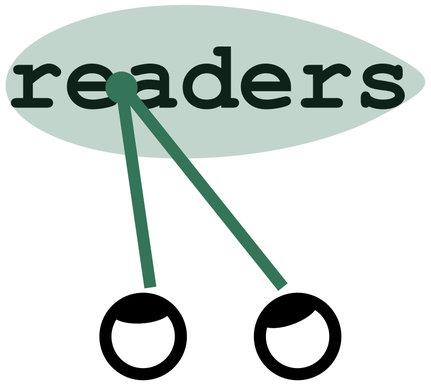

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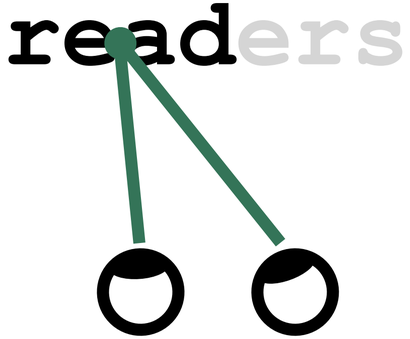
Informational bias



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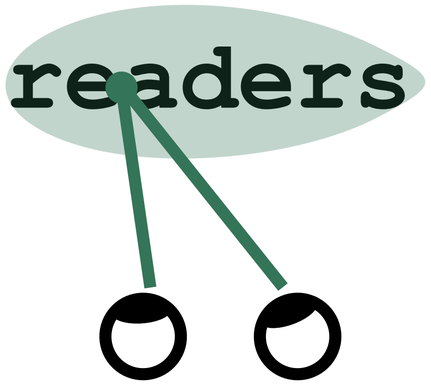
Perceptual bias

The human factor



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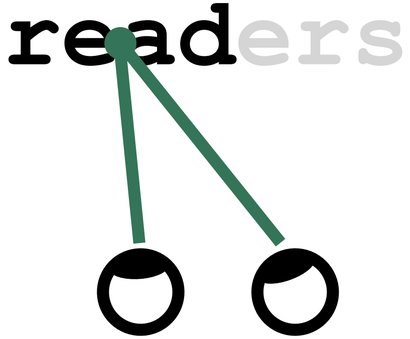
Informational bias



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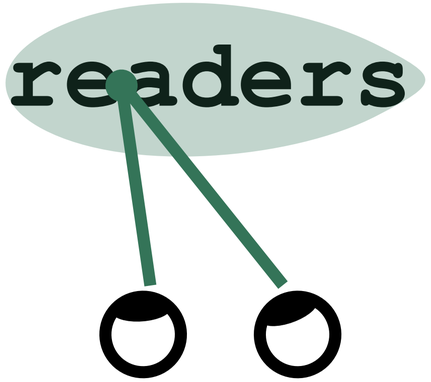
Perceptual bias

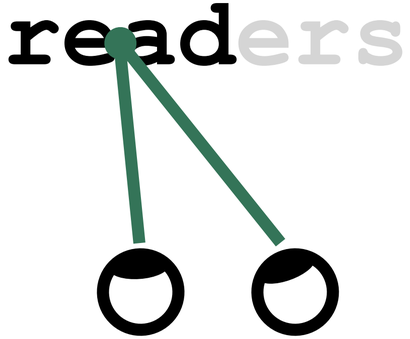
The human factor



Visual span is asymmetric (right-visual-field advantage), so fixating left-of-center maximizes how much of the word is in view

Informational bias

The language factor



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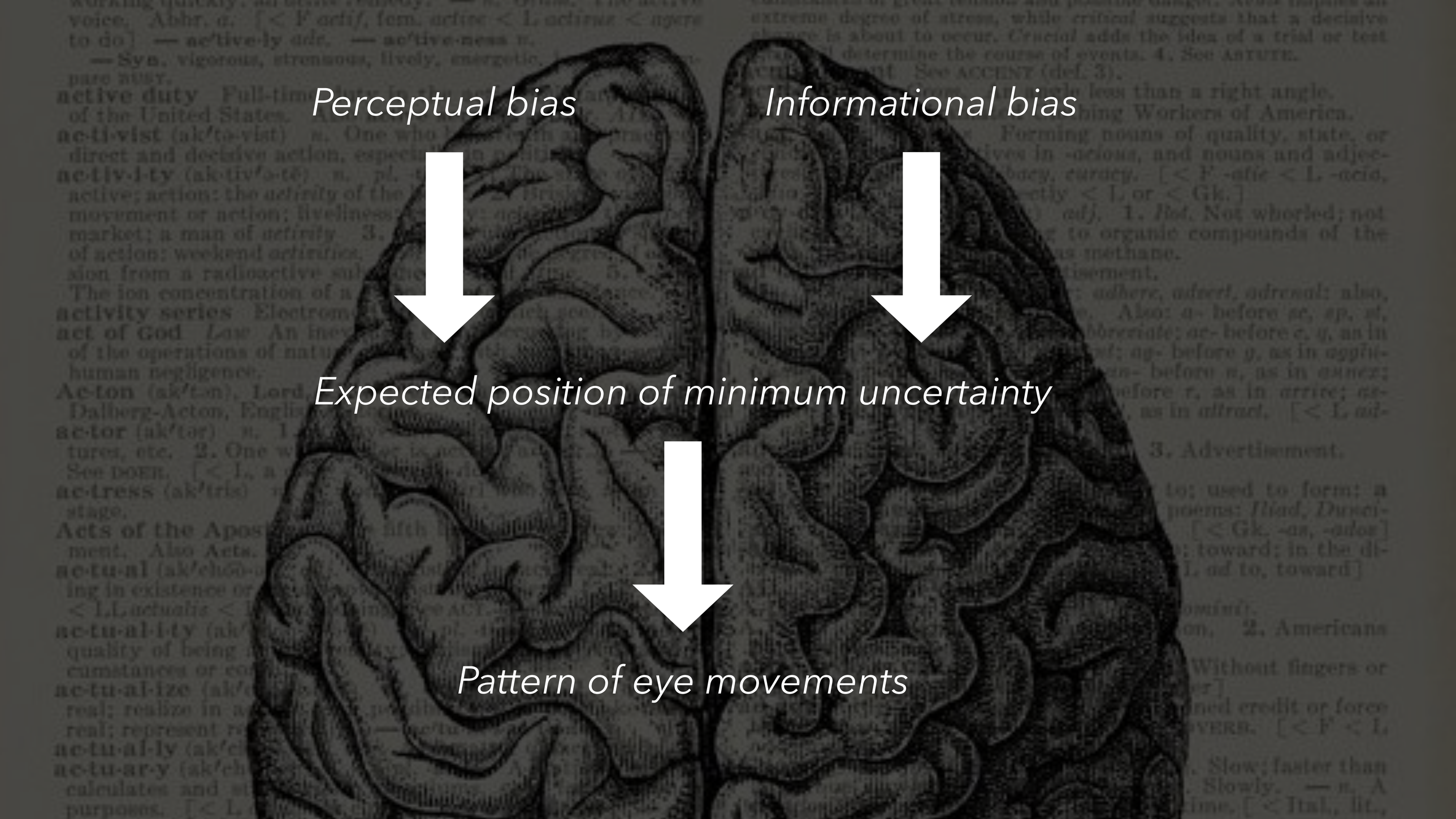
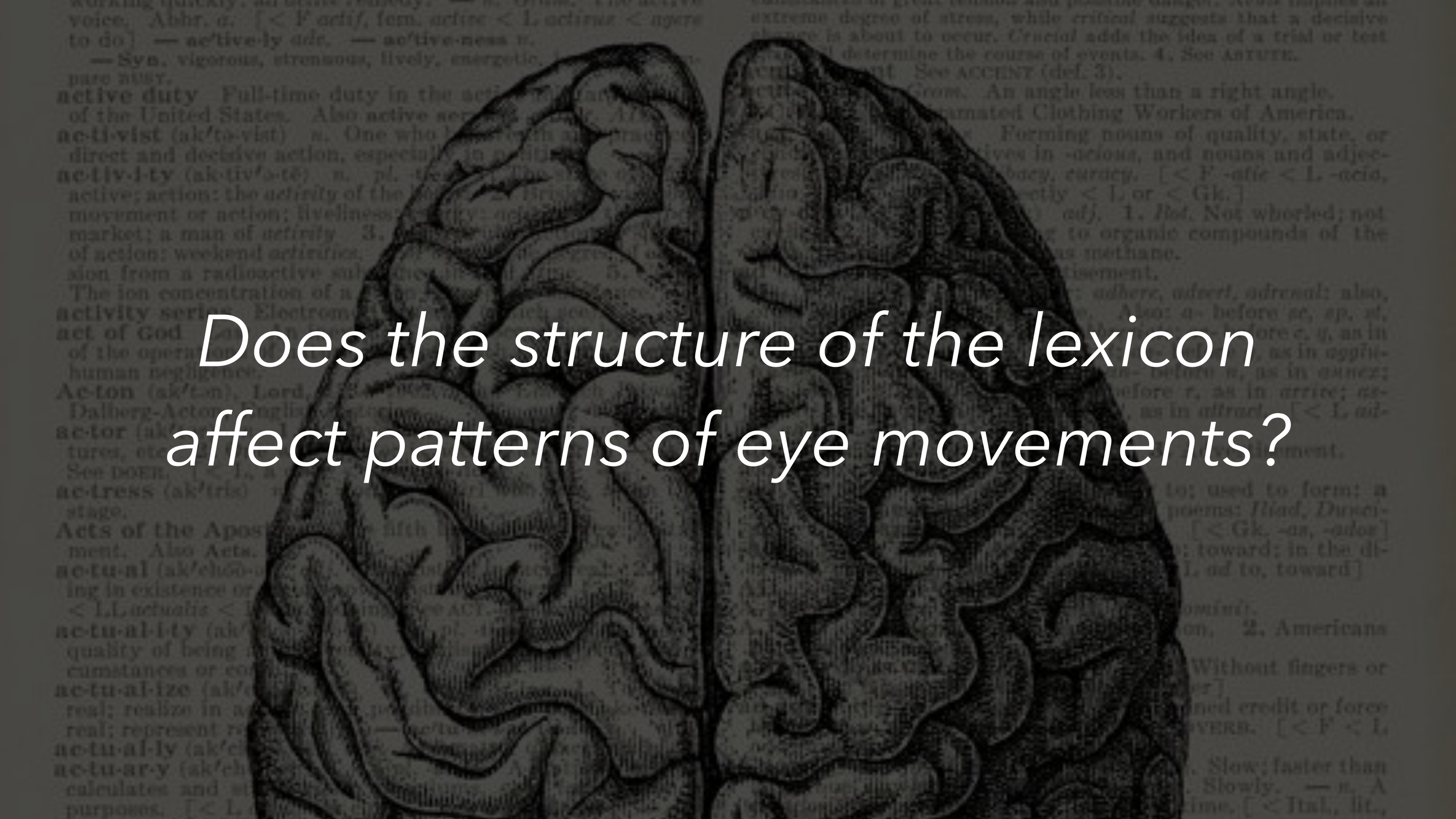
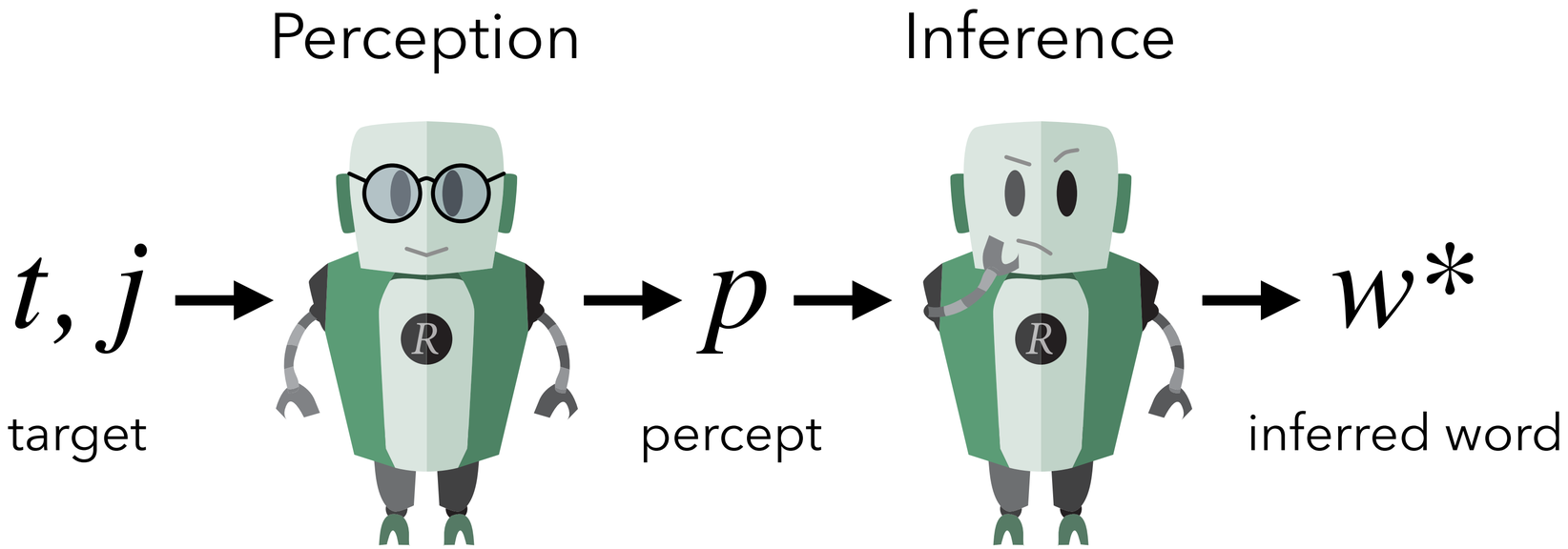
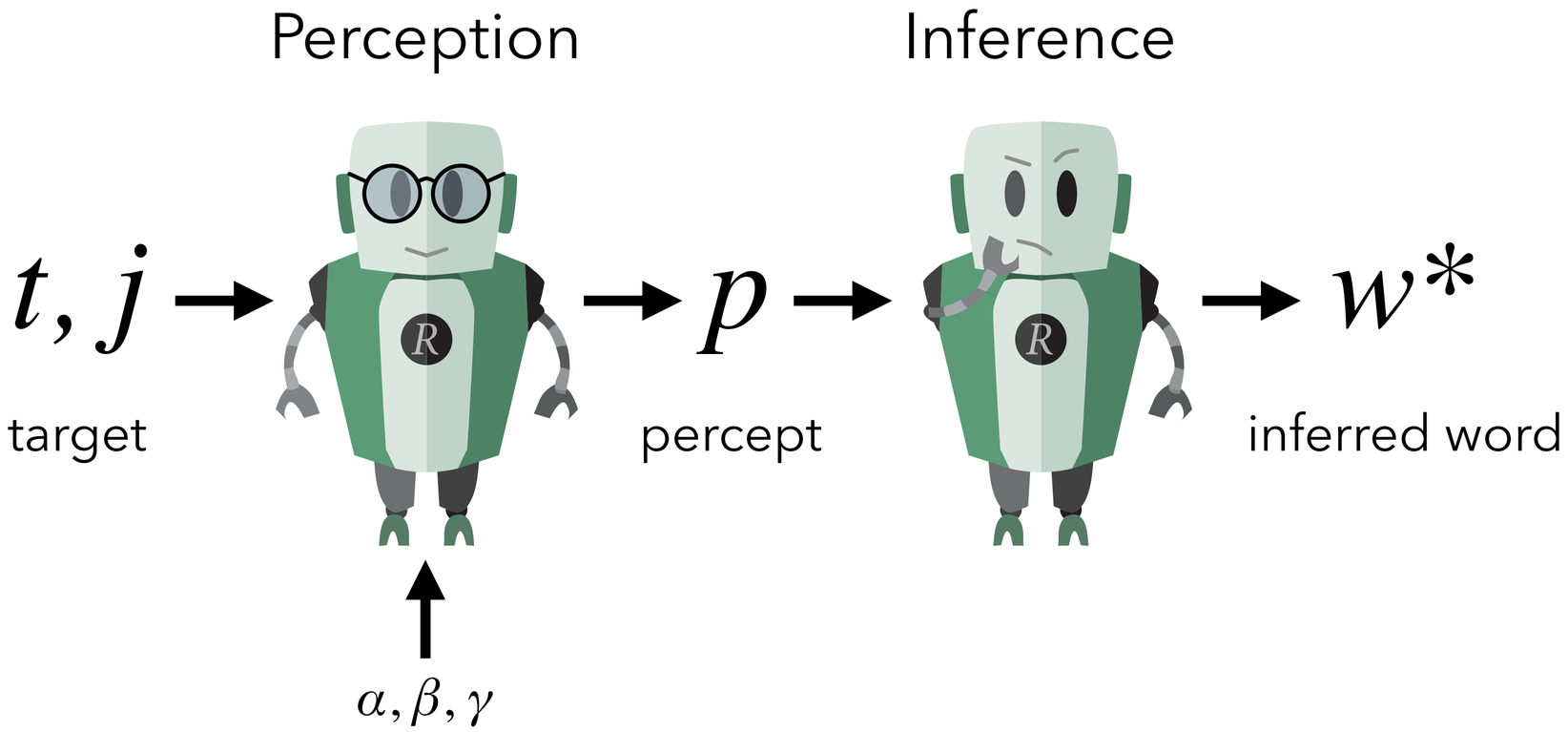

Perceptual bias
Informational bias
Expected position of minimum uncertainty
Pattern of eye movements

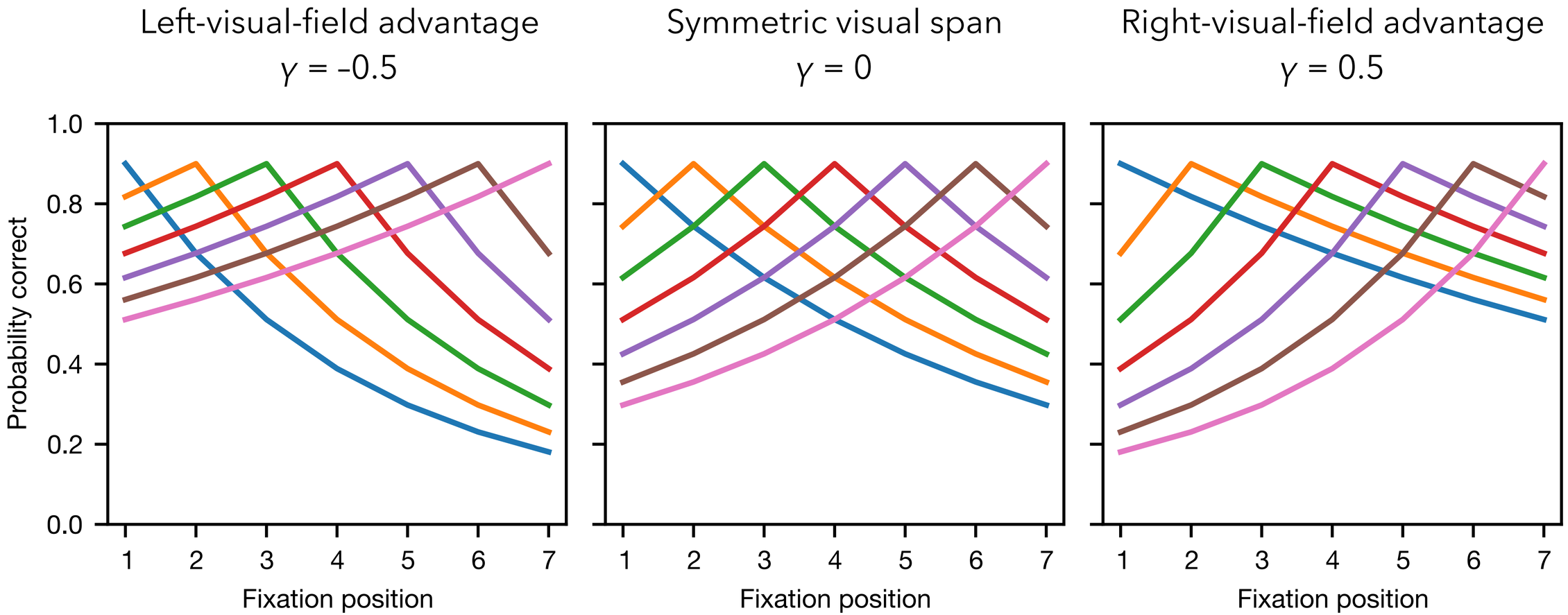


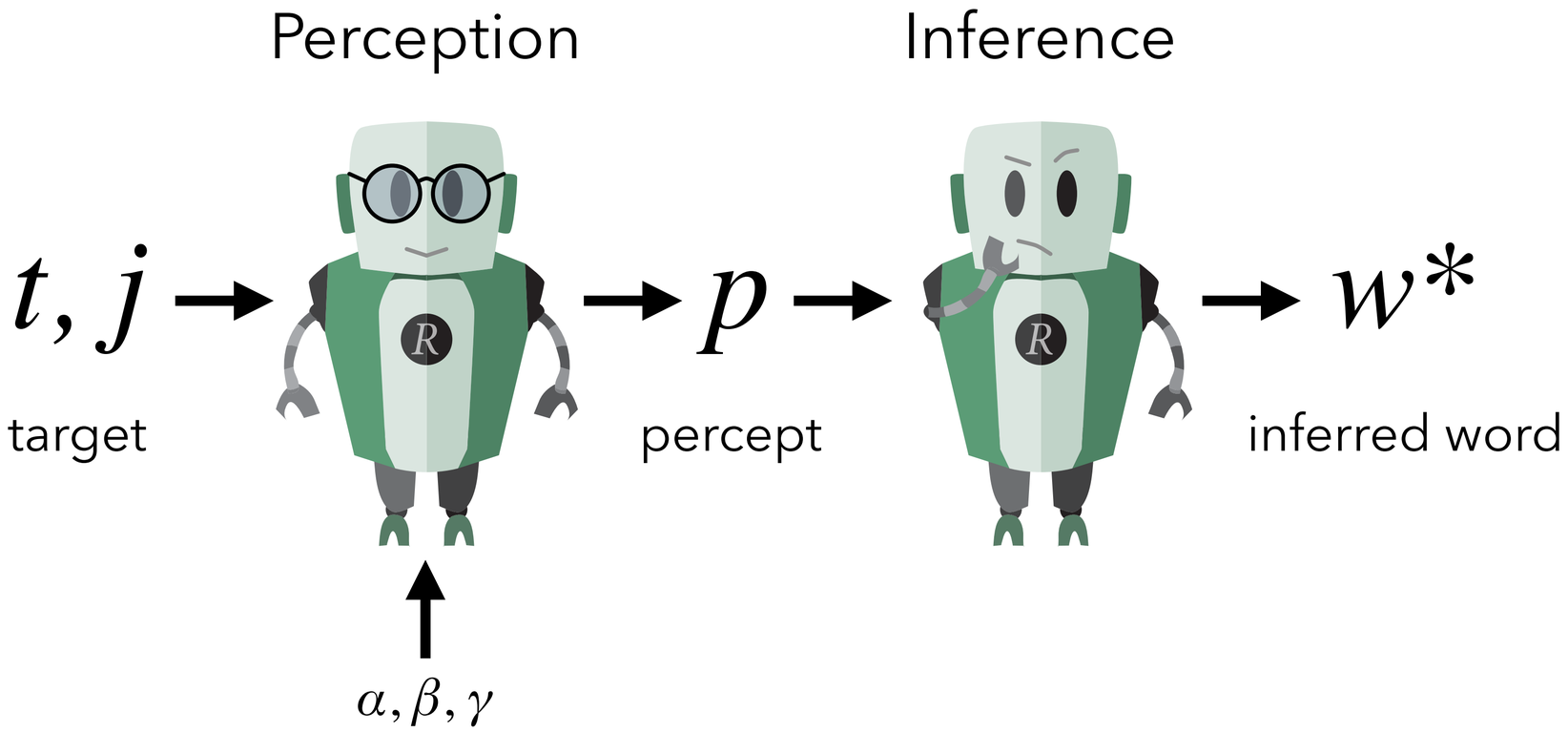
Does the structure of the lexicon affect patterns of eye movements?

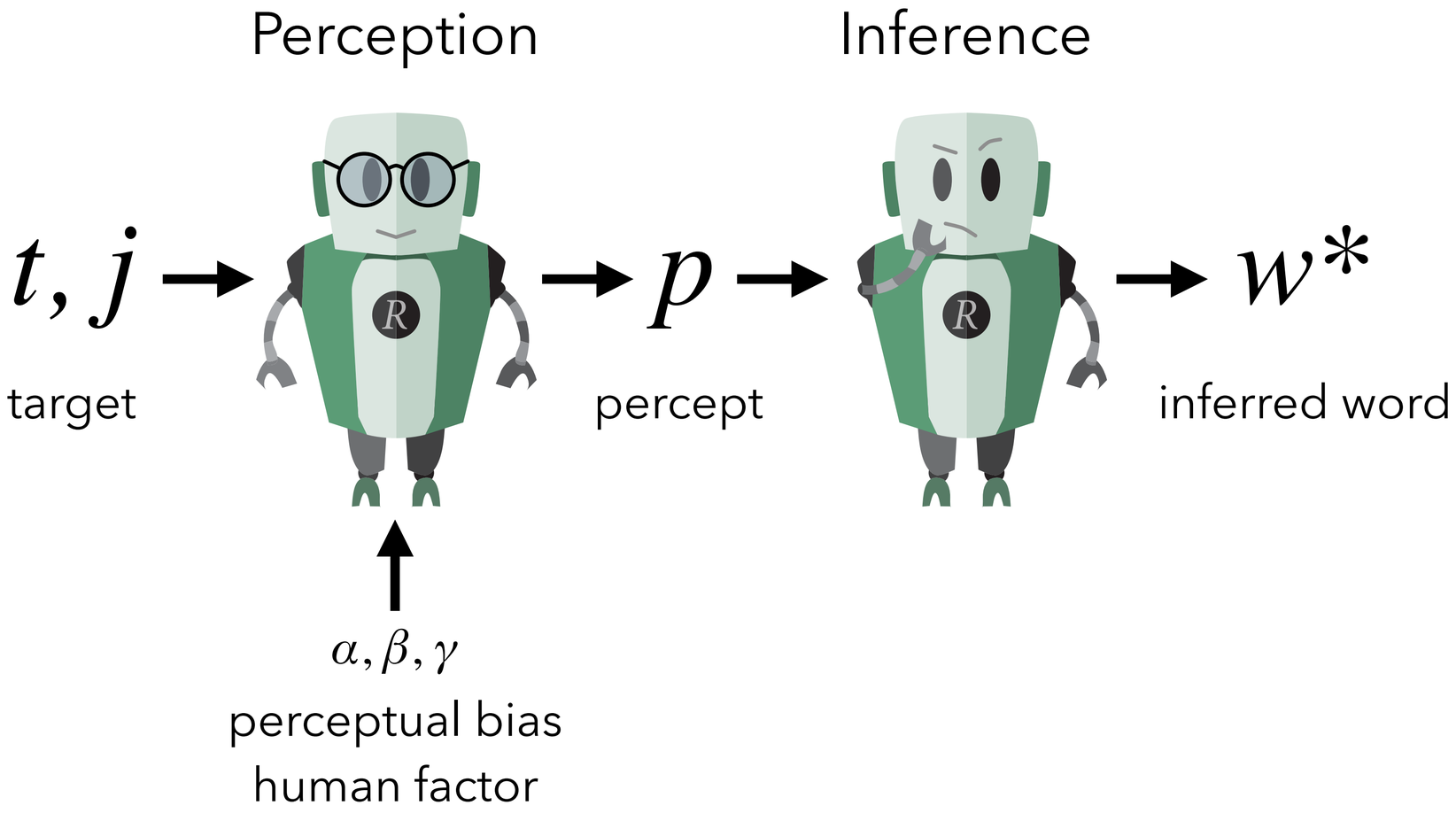
Cognitive model

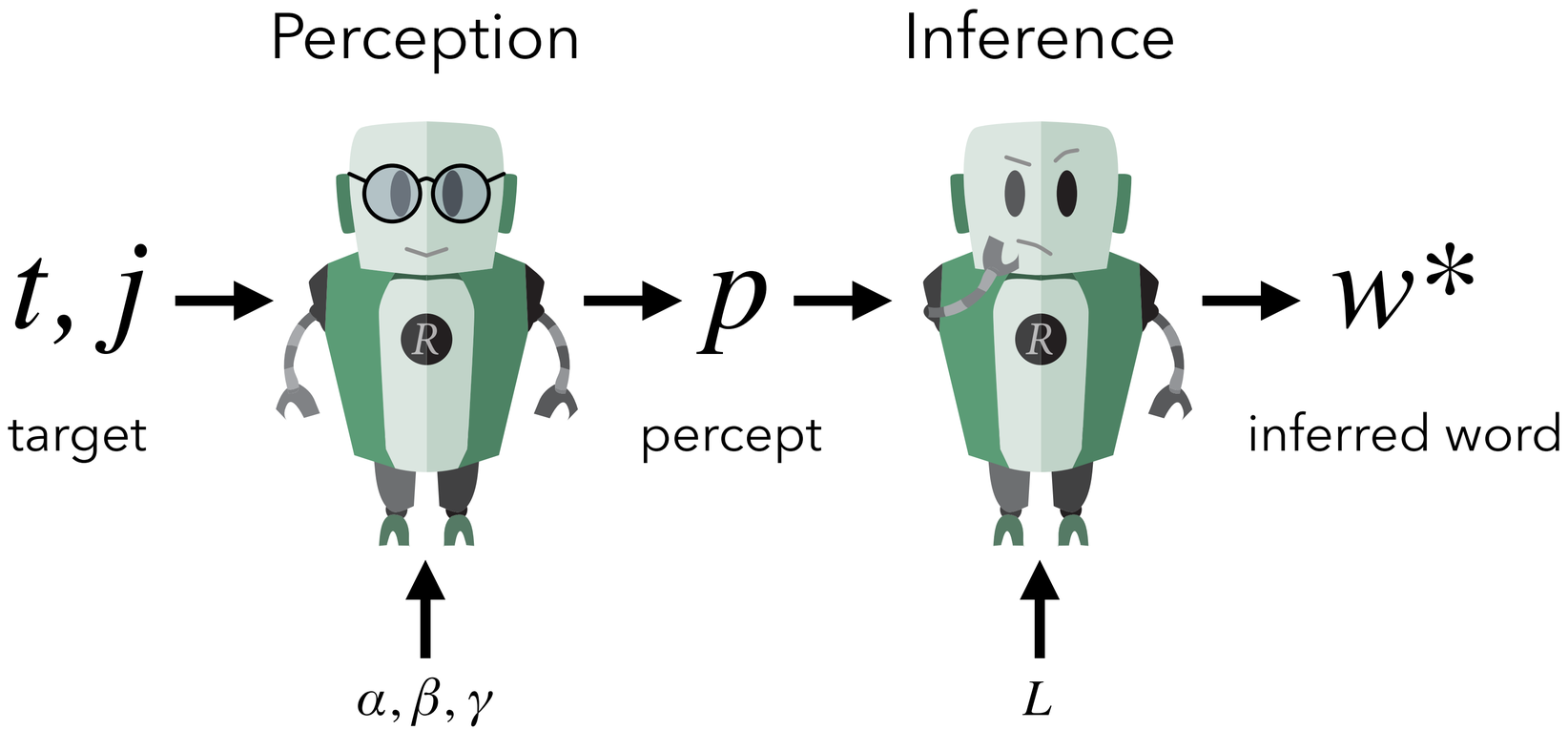

Perception
Inference
t, j
target
p
percept
w^*
inferred word

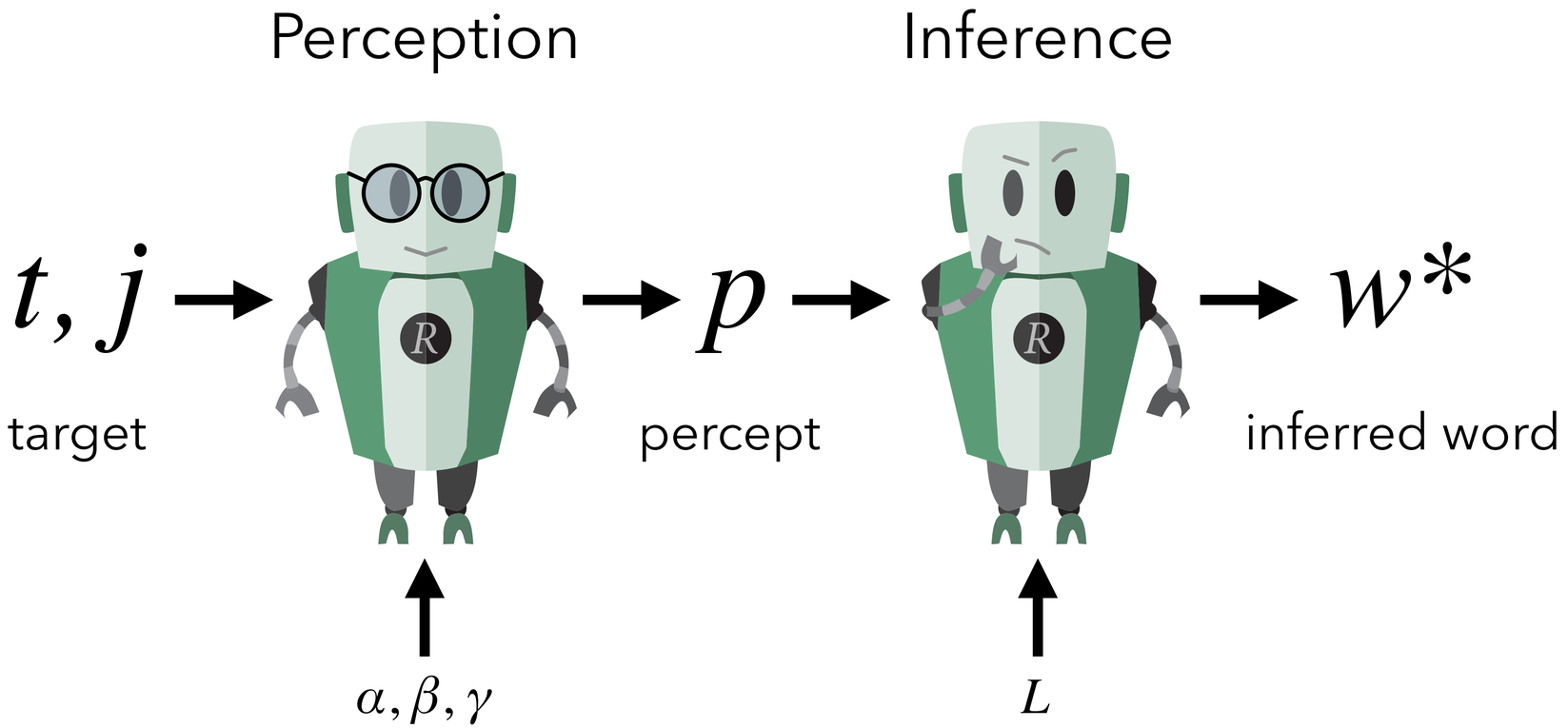

Perception
Inference
t, j
target
p
percept
w^*
inferred word
α, β, γ

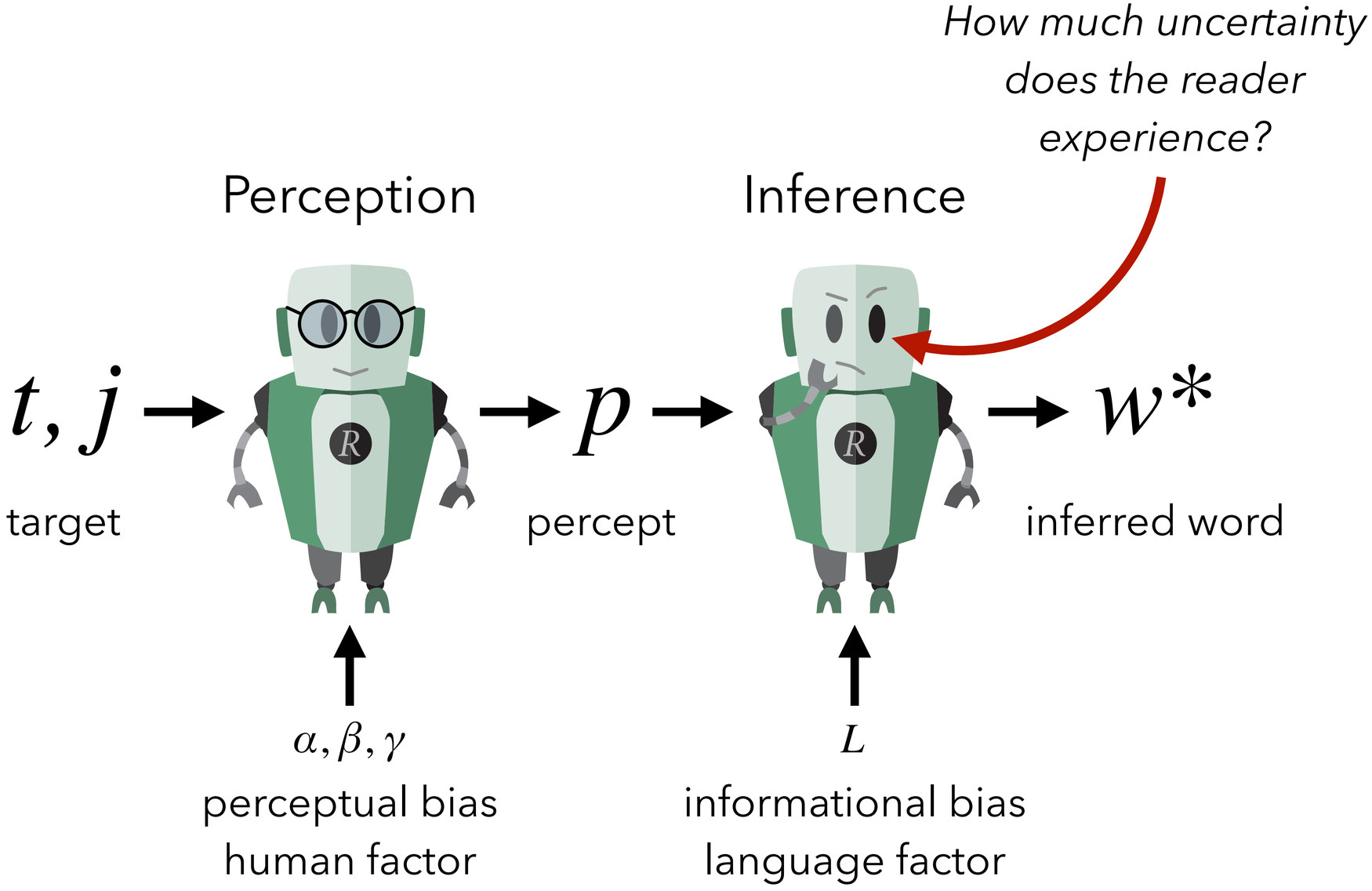

Left-visual-field advantage
γ = -0.5
Symmetric visual span
γ = 0
Right-visual-field advantage
γ = 0.5
Probability correct
1.0
0.8
0.6
0.4
0.2
0.0
1
2
3
4
5
6
7
Fixation position

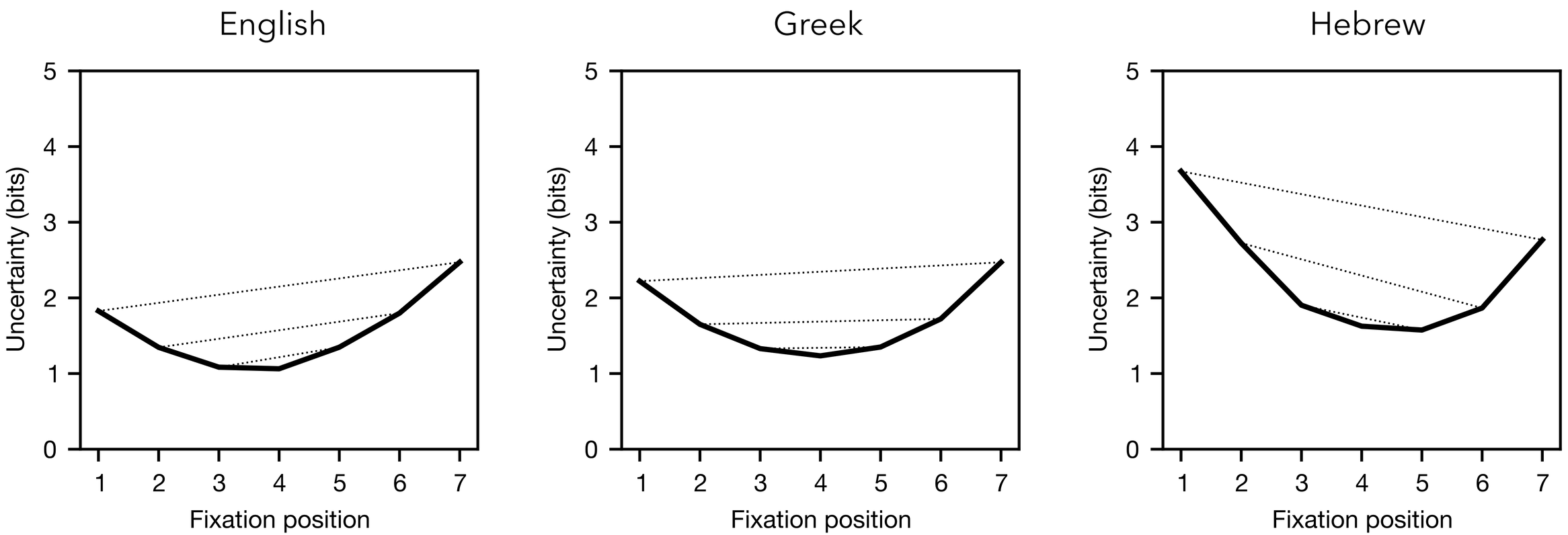

Perception
Inference
t, j
target
p
percept
w^*
inferred word
α, β, γ


Perception
Inference
t, j
target
p
percept
w^*
inferred word
α, β, γ
perceptual bias
human factor

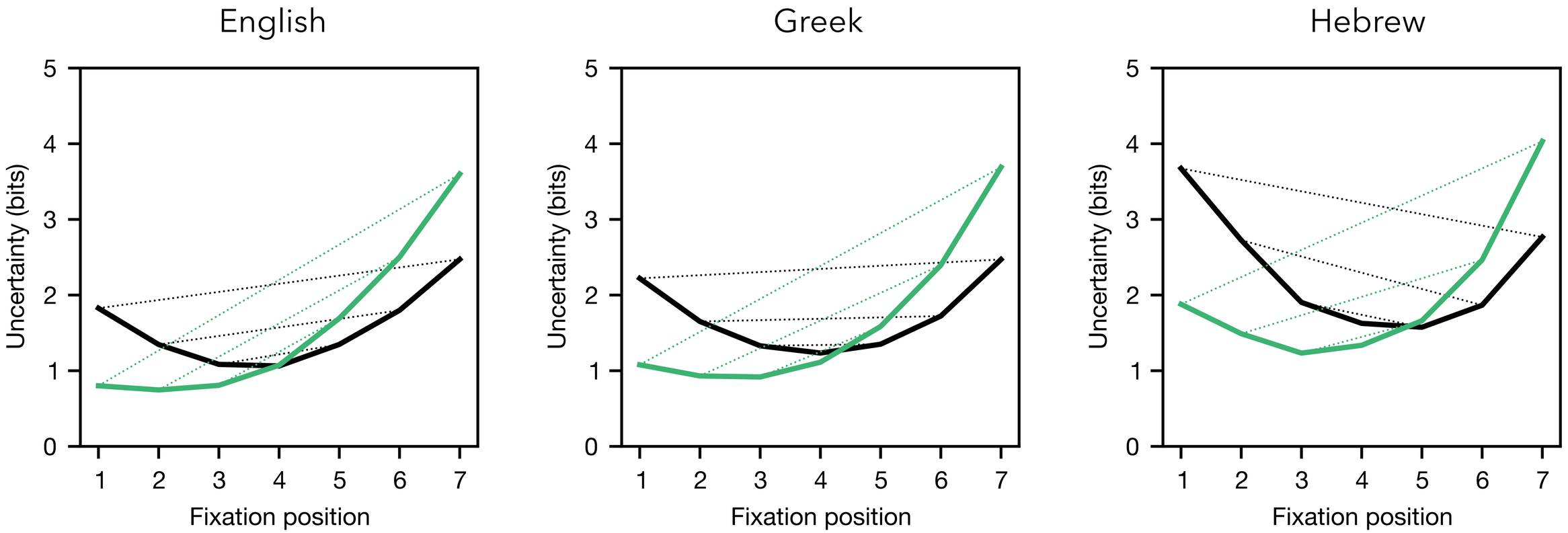

Perception
Inference
t, j
target
p
percept
w^*
inferred word
α, β, γ
perceptual bias
human factor
L


Perception
Inference
t, j
target
p
percept
w^*
inferred word
α, β, γ
perceptual bias
human factor
L
informational bias
language factor


How much uncertainty does the reader experience?
Perception
Inference
t, j
target
p
percept
w^*
inferred word
α, β, γ
perceptual bias
human factor
L
informational bias
language factor



informational bias alone (symmetric visual span; $\gamma = 0$)



informational bias alone ($\gamma = 0$)

informational bias + perceptual bias ($\gamma = 0.5$)

Experiment 1

Left-heavy lexicon

SNYBEVS

STOBEVS

SGUPEVS

SKAPEVS

SGYDIVS

SNODIVS

SKUMIVS

STAMIVS

High information content

Low information content

Right-heavy lexicon

SVEBYNS

SVEBOTS

SVEPUGS

SVEPAKS

SVIDYGS

SVIDONS

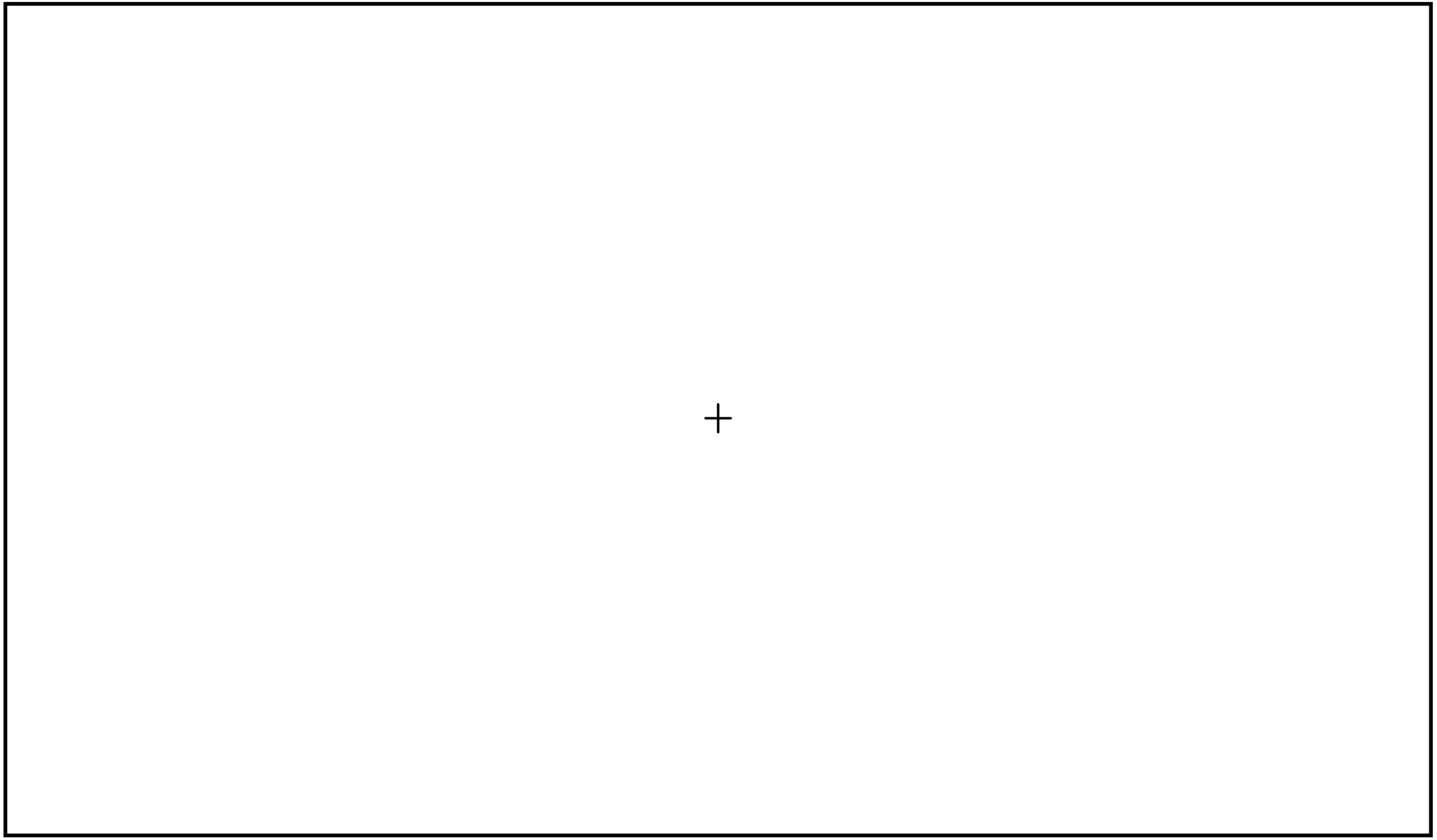
SVIMUKS

SVIMATS

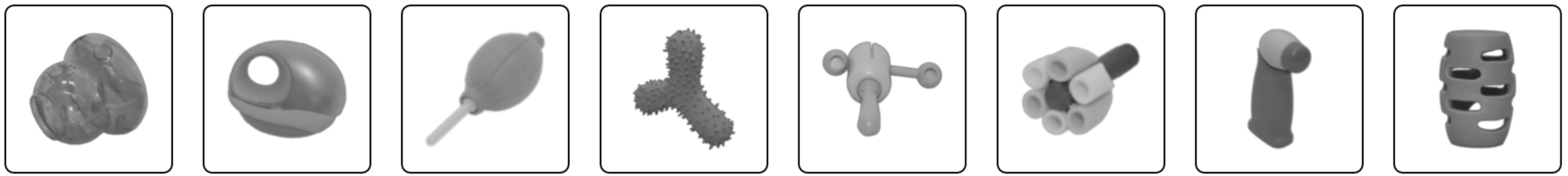
Low information content

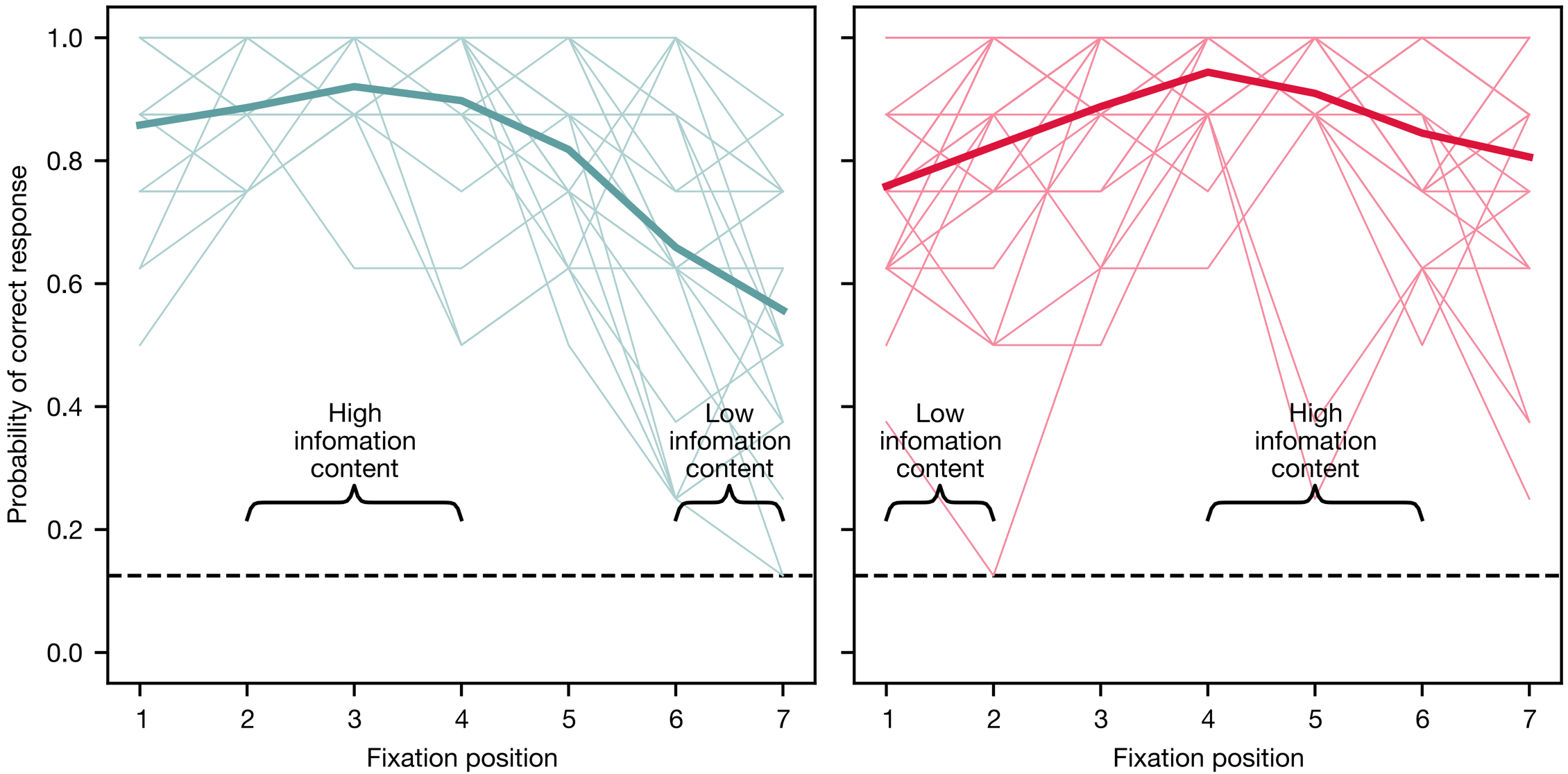
High information content

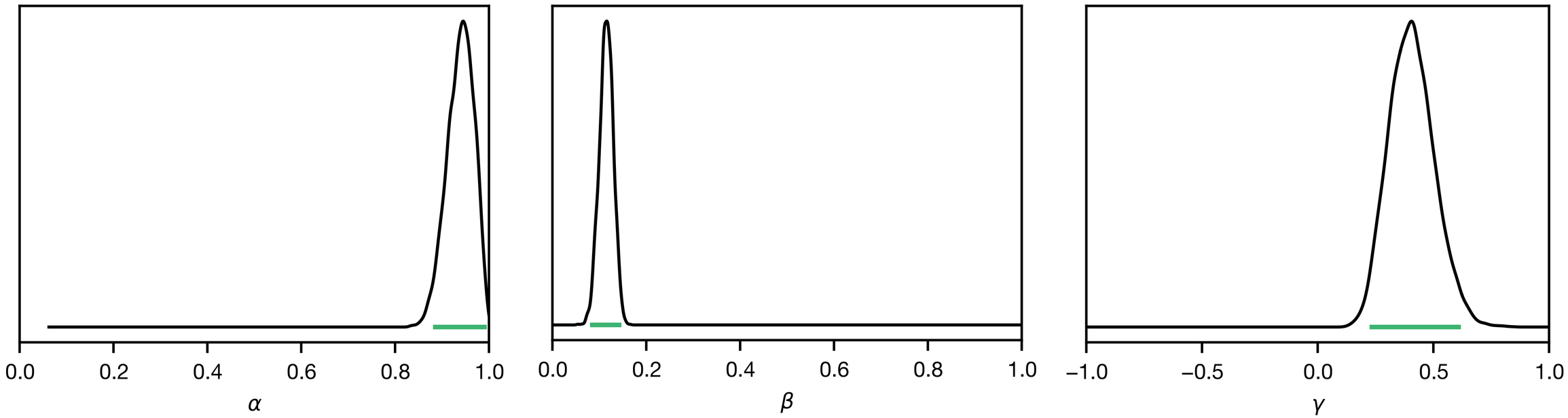
Left-heavy lexicon		Right-heavy lexicon
SNYBEVS		SVEBYNS
STOBEVS		SVEBOTS
SGUPEVS		SVEPUGS
SKAPEVS		SVEPAKS
SGYDIVS		SVIDYGS
SNODIVS		SVIDONS
SKUMIVS		SVIMUKS
STAMIVS		SVIMATS
High information content Low information content		Low information content High information content

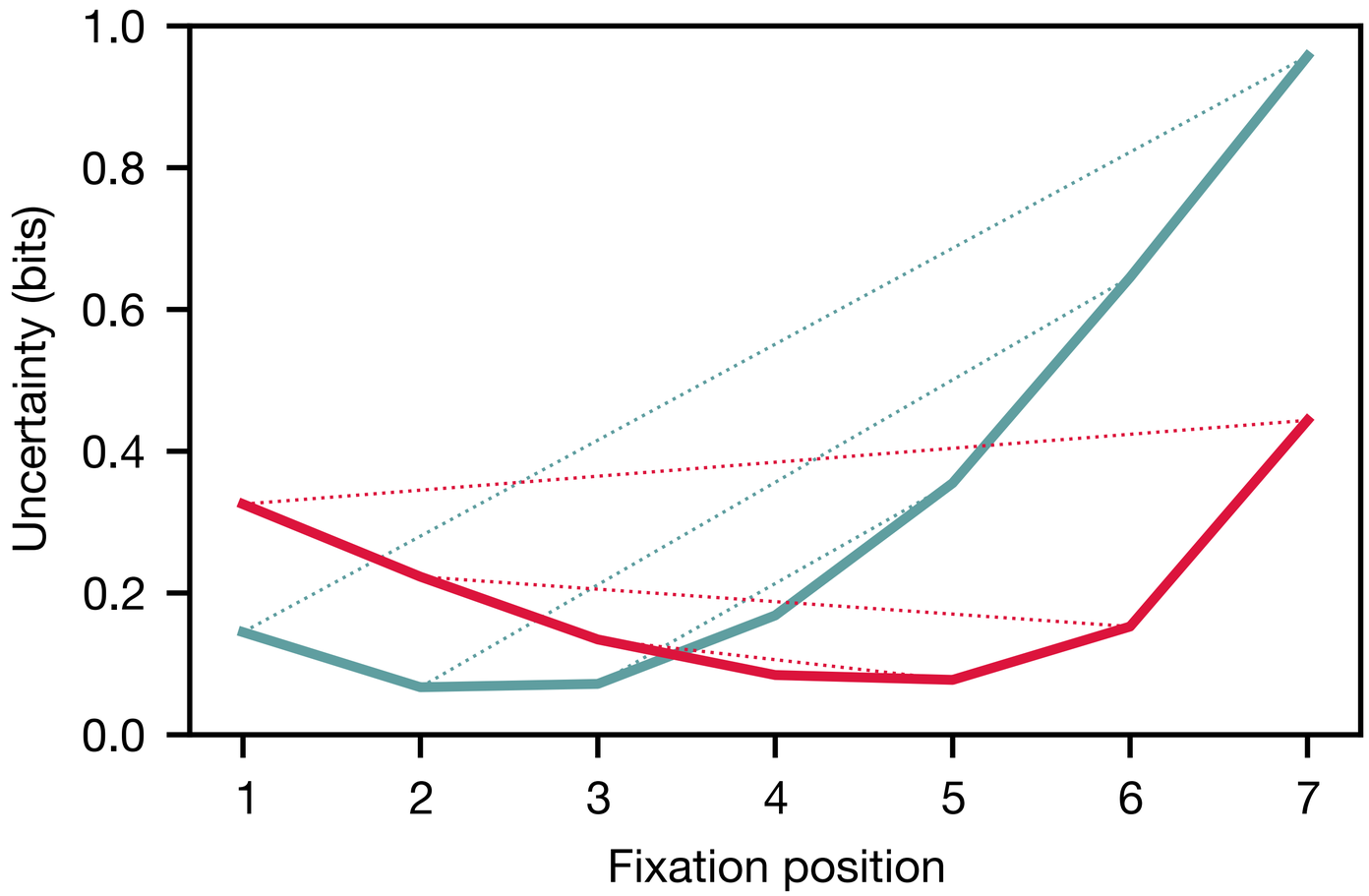


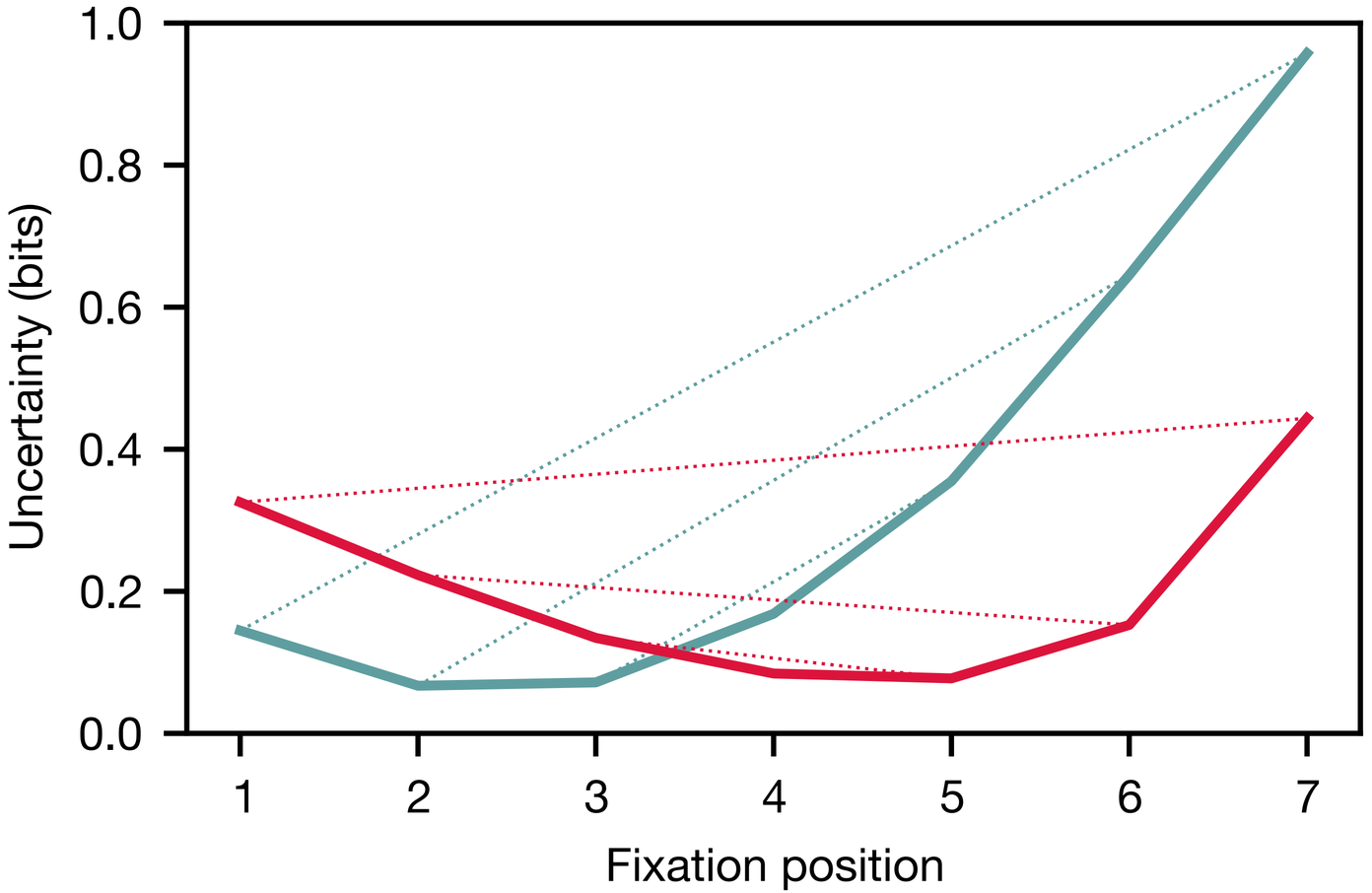
SNYBEVS



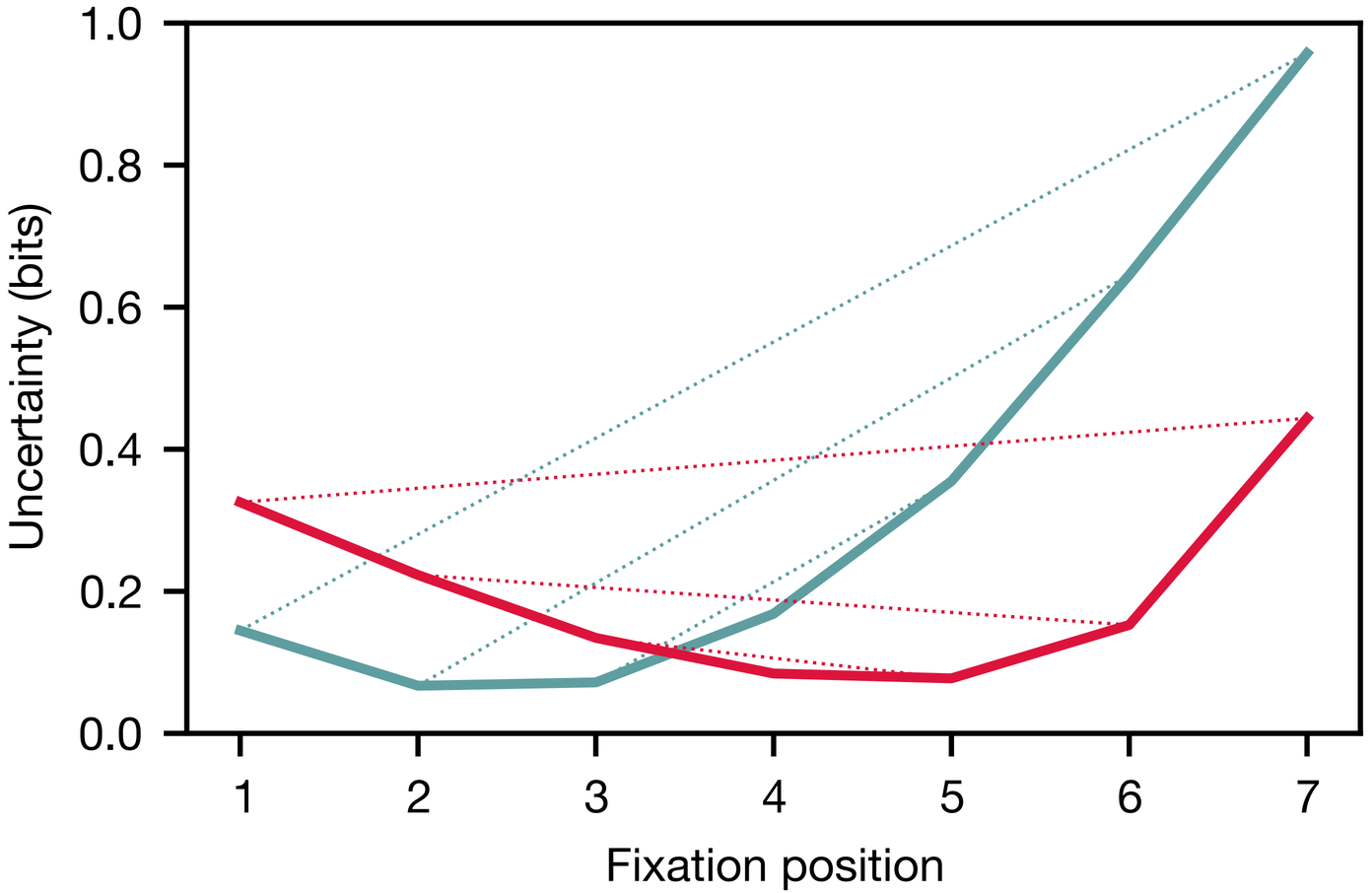

Probability of correct response
1.0
0.8
0.6
0.4
0.2
0.0
High infomation content
Low infomation content
1
2
3
4
5
6
7
Fixation position
Low infomation content
High infomation content
1
2
3
4
5
6
7
Fixation position


0.0
0.2
0.4
0.6
0.8
1.0
α
0.0
0.2
0.4
0.6
0.8
1.0
β
−1.0
−0.5
0.0
0.5
1.0
γ

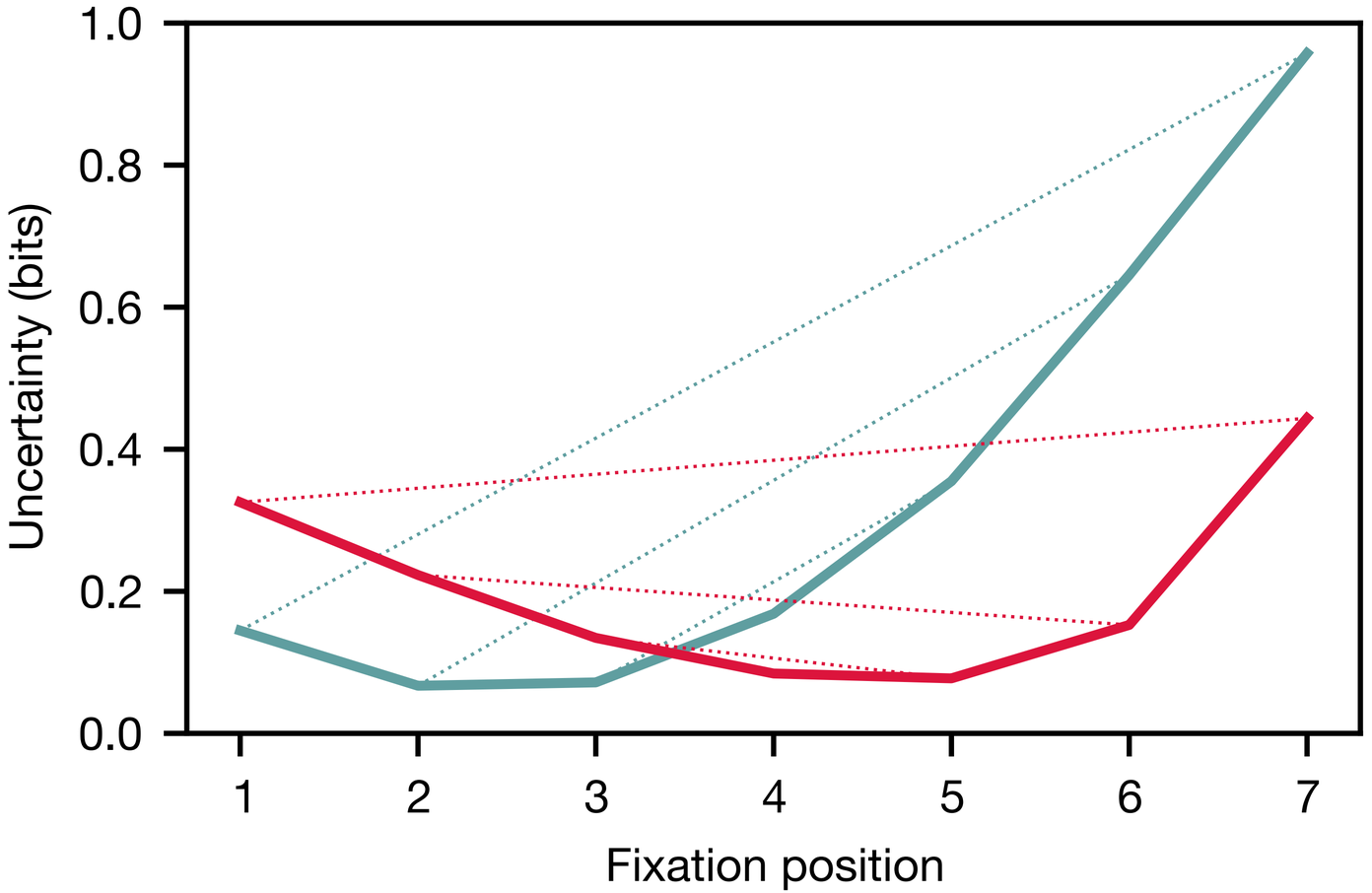

1.0
0.8
0.6
0.4
0.2
0.0
Uncertainty (bits)
1
2
3
4
5
6
7
Fixation position

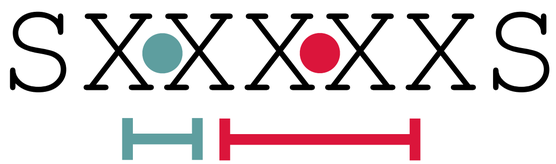

1.0
0.8
0.6
0.4
0.2
0.0
Uncertainty (bits)
1
2
3
4
5
6
7
Fixation position

SXXXXXXS


1.0
0.8
0.6
0.4
0.2
0.0
Uncertainty (bits)
1
2
3
4
5
6
7
Fixation position

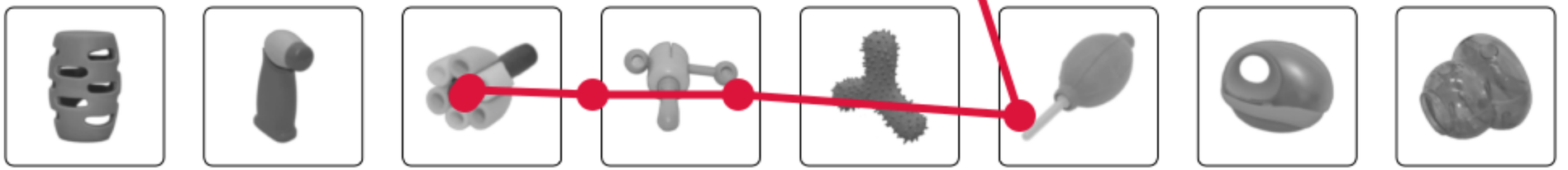
SXXXXXXS

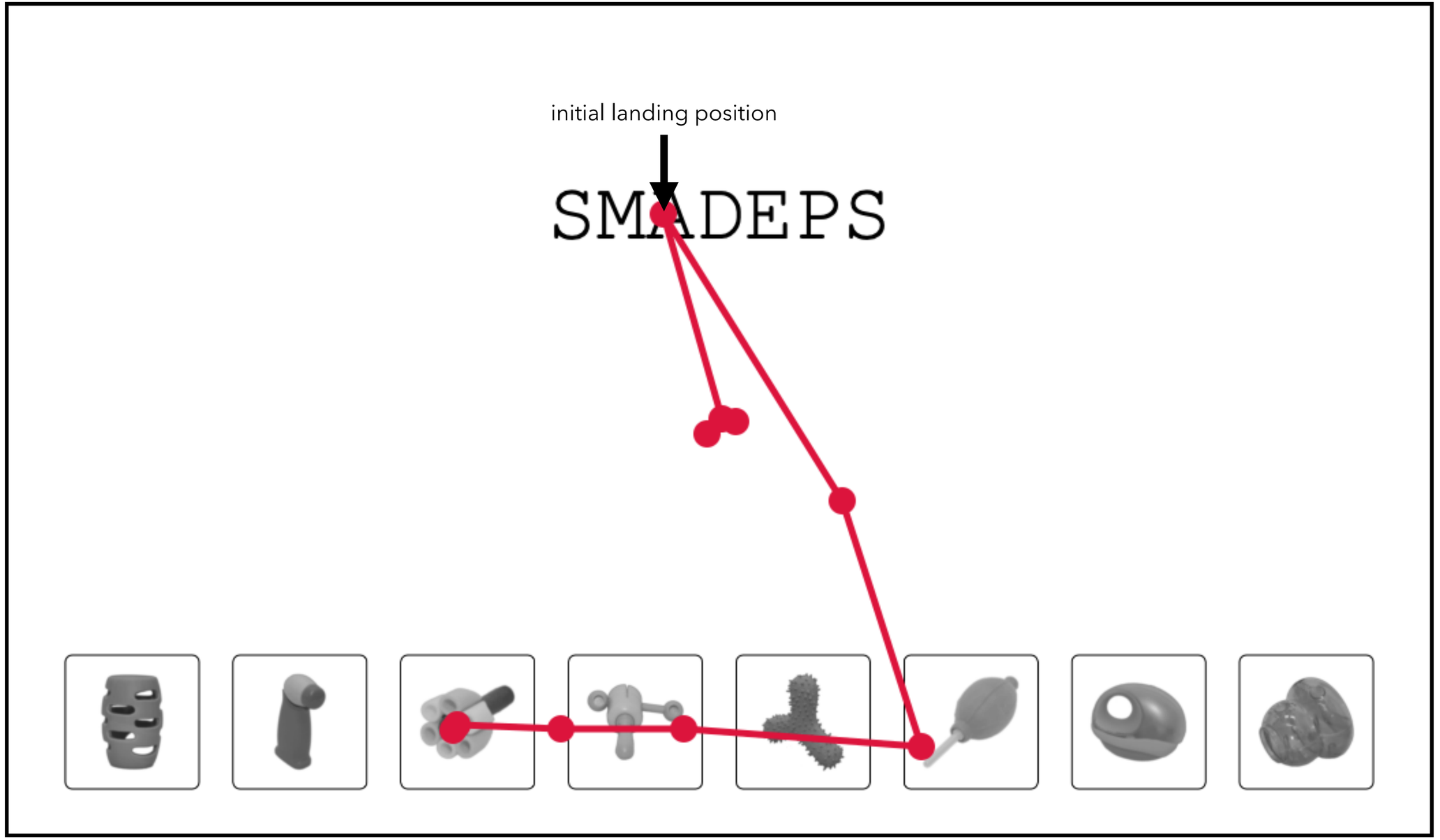

1.0
0.8
0.6
0.4
0.2
0.0
Uncertainty (bits)
1
2
3
4
5
6
7
Fixation position

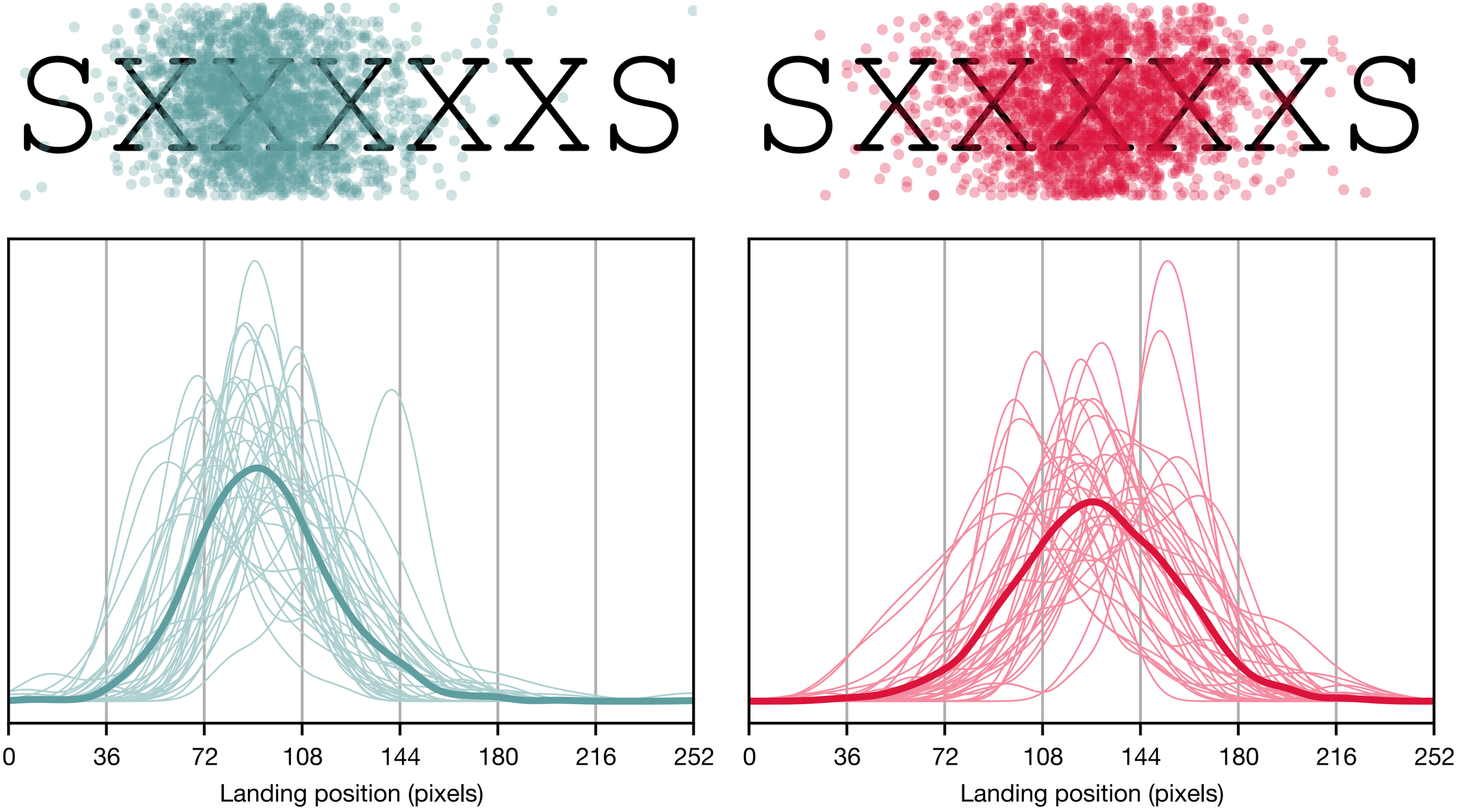

SXXXXXXS

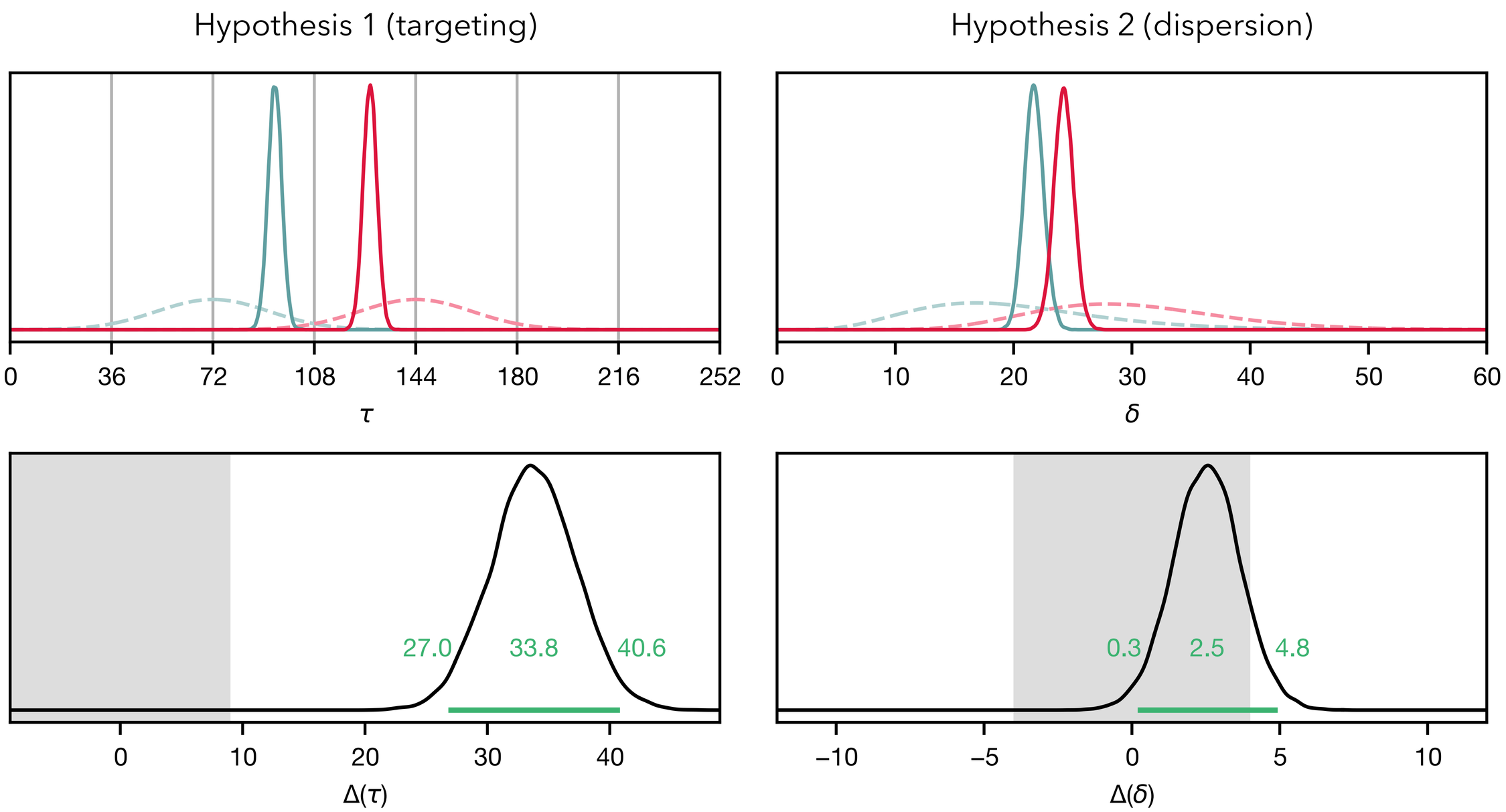
Experiment 2

SMADEPS

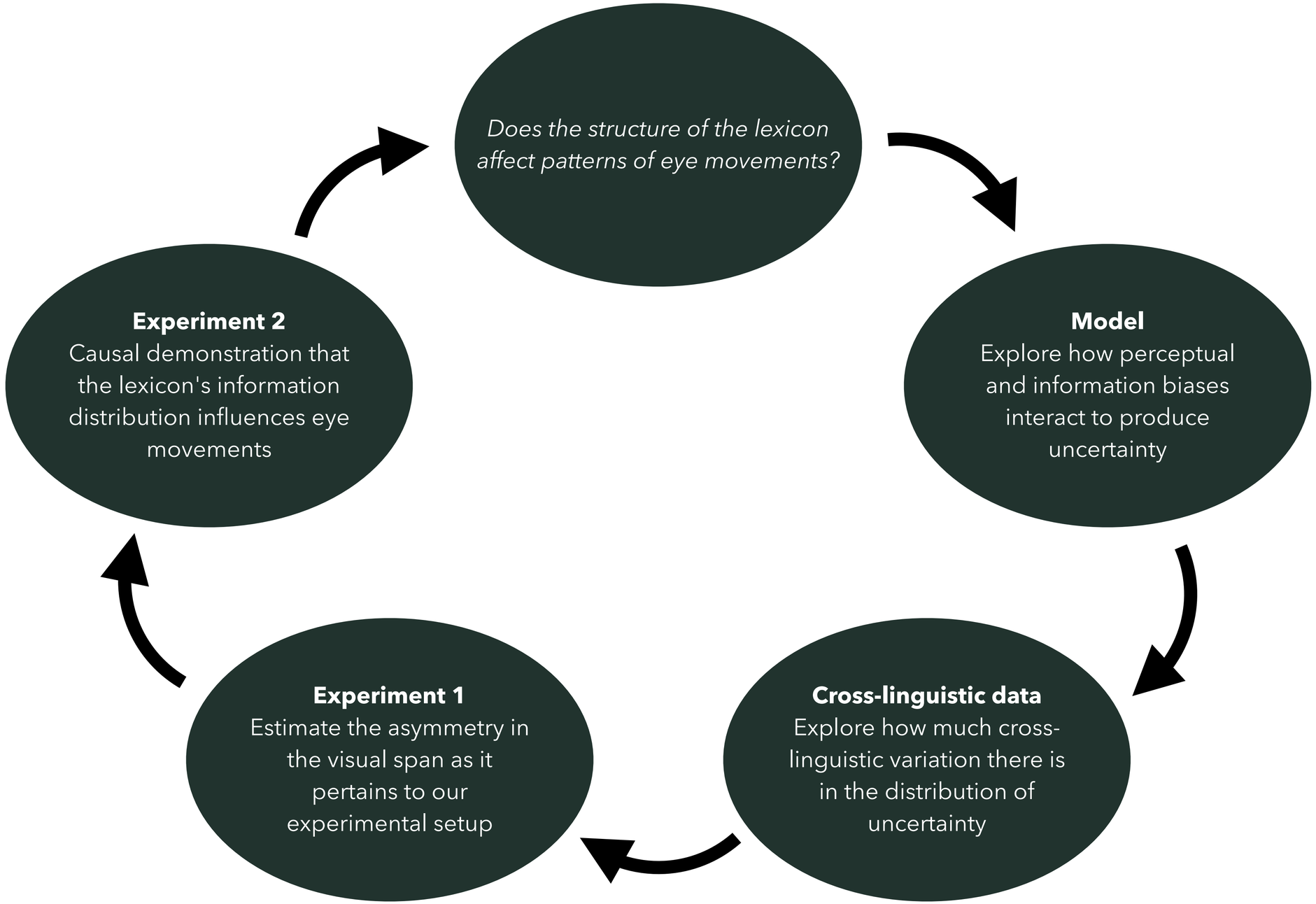


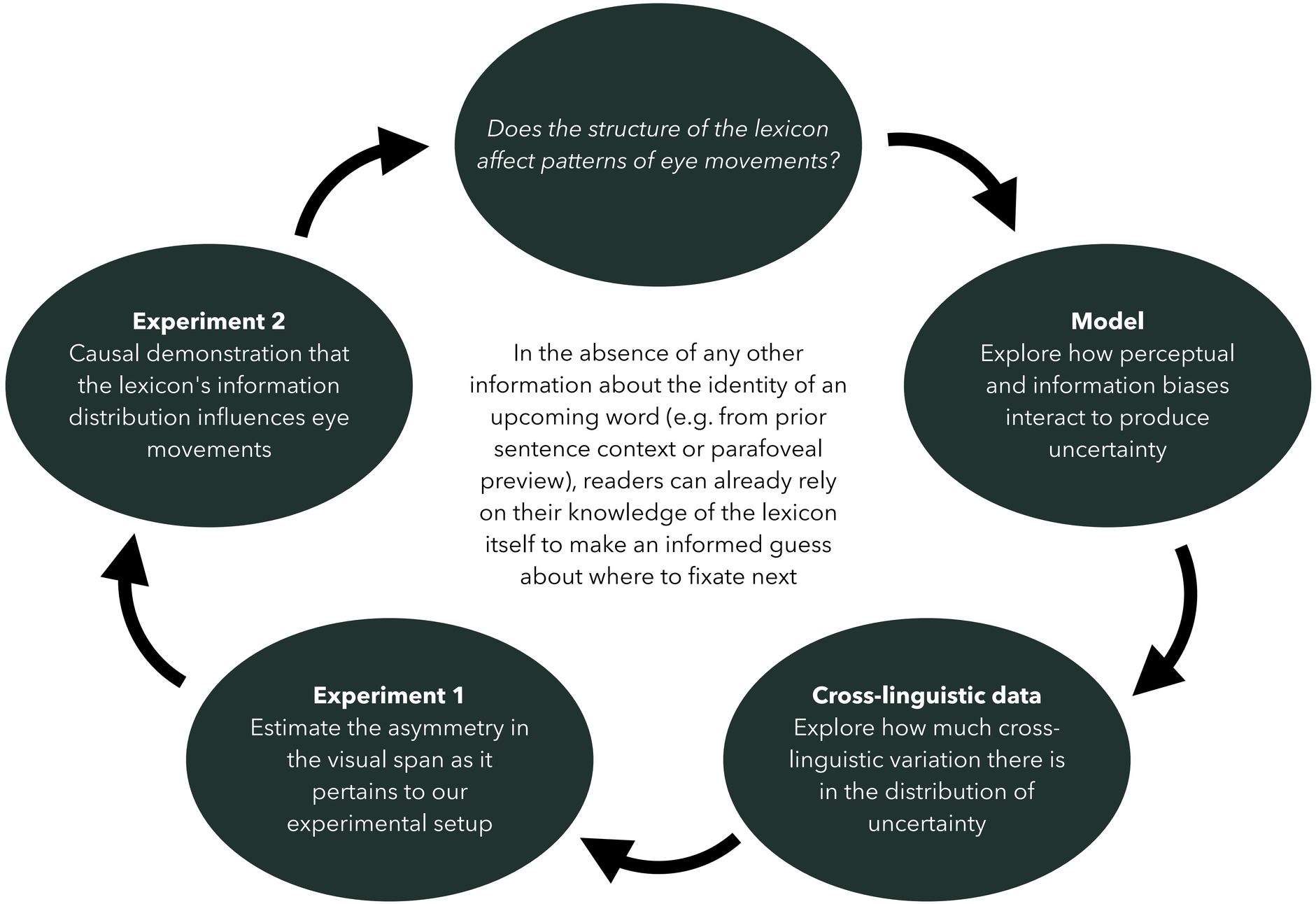

initial landing position
SMADEPS


SXXXXXXS
SXXXXXXS
0
36
72
108
144
180
216
252
Landing position (pixels)
0
36
72
108
144
180
216
252
Landing position (pixels)


Hypothesis 1 (targeting)
Hypothesis 2 (dispersion)
0
36
72
108
144
180
216
252
τ
0
10
20
30
40
50
60
δ
27.0
33.8
40.6
0
10
20
30
40
Δ(τ)
0.3
2.5
4.8
−10
−5
0
5
10
Δ(δ)

Does the structure of the lexicon affect patterns of eye movements?


Does the structure of the lexicon affect patterns of eye movements?
Model
Explore how perceptual and information biases interact to produce uncertainty
Cross-linguistic data
Explore how much cross-linguistic variation there is in the distribution of uncertainty
Experiment 1
Estimate the asymmetry in the visual span as it pertains to our experimental setup
Experiment 2
Causal demonstration that the lexicon's information distribution influences eye movements


Does the structure of the lexicon affect patterns of eye movements?
Model
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Experiment 1
Estimate the asymmetry in the visual span as it pertains to our experimental setup
Experiment 2
Causal demonstration that the lexicon's information distribution influences eye movements
In the absence of any other information about the identity of an upcoming word (e.g. from prior sentence context or parafoveal preview), readers can already rely on their knowledge of the lexicon itself to make an informed guess about where to fixate next