Distinct synaptic transfer functions in same-type photoreceptors

Article  (Supplemental Material)

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Figure 1 - Eye-region-specific structural tuning of a ribbon synapse in UV-cones

(a) UV-cone  (b) Acute zone  (c) Nasal  (d) Dorsal  (e) Eye regions

Visual space
"outwards"

"fow, up"

"down"

Retina
Dorsal
Acute zone
Nasal

2 μm  2 μm

500 nm

(d) Ribbon geometry

(e) Release site length (μm)

(f) Ribbons per cone

(g) Vesicle pools

(h) Vesicles / μm³ vs. Distance from ribbon (nm)

(i) Acute Zone  Nasal  Dorsal
Figure S1, related to Figure 1 - Statistical comparison of spatial vesicle distributions

(a) S versus N

(b) S versus D

(c) N versus D
Figure 2 - Simultaneous in vivo imaging of synaptic calcium and release

a

b

UV-cones
jRGec01a

HCs
iGluSnFR

5 µm

c

Acute Zone (AZ)

Dorsal (D)

Nasal (N)

Ca2+
Glu.

Ca2+
Glu.

Ca2+
Glu.

UV light

2 s

10 s

2 s

d

Example single cone averages
Figure 3 - Physiology quantification

a) Scaled & de-noised averages

Ca²⁺

Glu.

UV light

b) Adaptation = Tr. * (Tr.+ Sus.)

Max. activation

Base-line

Transience

n.s.

Max. activation

Sustain

AZ

N

D

0.2 c.u.

0.5 v.u.

10 s

2 s

0.2 c.u.

0.5 v.u.

Calcium

Glutamate

Max. activation

Baseline

AZ

N

D

Calcium

Glutamate

Adaptation

Glutamate: 1st dark-flash

All dark-flashes

AZ

N

D

n.s.

n.s.

n.s.

Calcium measured with GCaMP6f

Max-scaled

Dark-flash responses

AZ

N

D

3 SD

1 s

1 s

Rise (s)

Decay (s)

Delay (s)

AZ

N

D

n.s.

n.s.

n.s.

n.s.
Figure S2 - related to Figures 2 and 3

(a) Images showing different regions labeled as SyjRGeco1b, SFiGluSnFR, and a merge image. A scale bar indicates 5 μm.

(b) Graph showing baseline-subtracted fluorescence (a.u.) plotted against distance along a transsect (μm). Two curves are represented: SyjRGeco1b and SFiGluSnFR.

(c) Graphs showing Ca²⁺ and Glu. activity over time. The traces are labeled for AZ, Nasal, Dorsal, and UV light conditions. The 5SD scale bar is shown at the top right.

(d) Graphs showing means superimposed Ca²⁺ and Glu. activity over time. The traces are labeled for UV light conditions. The 2 SD scale bar is shown at the top right.
Figure S3 - related to Figures 2 and 3

(a) Raw Calcium

- Baseline corrected and scaled
- Averaged
- Lowpass filtered
- Deconvolved

(b) Raw Glutamate

- Scaled
- Averaged
- Lowpass filtered
- Shifted
Figure 4 - A model of calcium evoked release from the ribbon

(a) UV-cone pedicle

(b) Inference of model parameters

(c) AZ, N, D

(d) Release (norm.)

(e) Calcium handling

(f) Full models (self)

(g) Full models (non-self)

(h) Linear models (self)
Figure S4 - related to Figure 4

a

Ca²⁺ offset (c.u.)
(“invert. baseline”)

Release Ca²⁺-dep.
(slope, a.u.)

Release rate max.
($10^3$ v.u.⁻¹), e

RRP size
(v.u.)

RRP refill rate max.
($10^3$ v.u.⁻¹), i

b

AZ-calcium
N-calcium
D-calcium

Best models

Relevant loss

Mean squared error

c

Best models
Figure 5 - Sobol Indexes

(a) Acute Zone

(b) Nasal

(c) Dorsal

Graphs showing time series data labeled with various parameters such as X0, JExo, JIP, RRP, JIP, RRP, IP, and IP, with time intervals marked at 10 s.
Figure 6 - General rules of ribbon tuning: Basic response parameters

(a) Max. activation

(b) Transience

(c) Sustain

(d) RRP size; \( \text{Ca}^{2+} \) offset; \( \text{tau} = 0.3; 0.6 \)
Max. release = 0.6

(e) Max. activation

(f) Sustain

(g) Interactive online model of ribbon release

Simulation of Vesicle Release

Stimulus: Fixed Step
Stimulus Frequency [Hz]: 0.60
Frequency slider is only valid for certain stimuli.
RRP Size: 5.00
IP Size: 7.80
Max. Release Rate: 0.55
Ca offset [a.u.]: 0.20
Ca kernel [tau]: 0.45
Time resolution [ms]: 32

Set to AZ values
Set to N values
Set to D values
Figure 7 - General rules of ribbon tuning: Event detection and high-frequency encoding

**a** Off-Detection Index ($I_{On}$)  
Release model  
Noise  
Stimulus ($Ca^{2+}$ tau = 0.5)  
Event to be detected

**b**

[Graph showing RRP size = 4, IP size = 8, Max. release = 0.6, Ca$^{2+}$ offset = 0.3]

**c**

[Graph showing RRP size, IP size, Max. release]

**d**

[Graph showing RRP size, IP size, Max. release]

**e** On-Detection Index ($I_{On}$)  
Release model  
Noise  
Stimulus

**f**

[Graph showing RRP size, IP size, Max. release]

**g**

[Graph showing RRP size, IP size, Max. release]

**h**

[Graph showing RRP size, IP size, Max. release]

**i**

[Graph showing RRP size = 4.0, IP size = 8.0, Max. release = 0.6]

**j**

[Graph showing RRP size = 4.0, IP size = 8.0, Ca$^{2+}$ tau = 0.5]

**k**

[Graph showing RRP size = 4.0, IP size = 8.0, Ca$^{2+}$ offset = 0.3, Ca$^{2+}$ tau = 0.5]

**h**

High-frequency Index (HFI)

Power $p$  
Frequency $f$ (Hz)

$HFI = \sum p_i \cdot f_i$