See the sound, hear the light

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"Perceptual phenomenon in which stimulation of one sensory pathway leads to automatic, involuntary experiences in a second sensory pathway."

SYNESTHESIA 0123456789

Grapheme-color synesthesia

I. Connections between senses

II. Connection between acoustic and electric senses

III. Product design inspired by synesthesia

Temperature - color Sully, 1879

https://shannon-brinkley.com/blogs/shannon-brinkley-studio-1/8 2019 1/7



Illust: https://shannon-brinkley.com/

Taste/olfaction - touch

"Texture" of wine



https://www.winemag.com/2010/11/18/sparkler-pairings-for-your-next-holiday-soiree/ 2019 1/7

Photo: https://www.winemag.com/

https://en.wikipedia.org/wiki/Wine_tasting_descriptors

Vision-audition

"Harmony of colors like harmony of sounds" - Aristotle 6th cent. B.C.

On Associations of Light and Sound: The Mediation of Brightness, Pitch, and Loudness Lawrence E. Marks

The American Journal of Psychology Vol. 87, No. 1/2 P180 2019 1/7



Marks, 1974

Vision-audition



Marks, 1975

On Colored-Hearing Synesthesia: Cross-Modal Translations of Sensory Dimensions Lawrence E Marks Psychological Bulletin 82(3) P319 2019 1.7

Why cross-modal perception?

• The brain may combine information from different sense modalities to enhance the speed and accuracy of detection of objects and events, and the choice of appropriate responses.

 Objects and events in the environment typically produce a correlated input to several sensory modalities at once.

Evans & Treisman, 2010

Biologists further wonder...

- Brain mechanisms?
- Nature or nurture? (Innate or learned?)
- Human-specific? (Counterpart in animals?)

Visual - Auditory Connection: Frequency Code in Animal Communication

Strength/Aggression



Low & rough Large vocal organ Large body size "Dangerous"

ttps://soyunperro.com/los-perros-ensenan-los-dientes/ 2019 1/7

Weakness/Submission

https://www.youtube.com/watch?v=S84KhEYMt1Y 2019 1/7



High & pure

Small vocal organ Small body size "Harmless"

Mammals, birds, frogs: Morton, 1977; Ohala, 1984

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i. Electric fishii. Electric communication

III. Product design inspired by synesthesia

Electric fish

Zap!: The Electric Eel and Other Electric Animals (Armed and Dangerous (Paperback)) Greg Roza 表紙 2019 1/7



Zap!: The Electric Eel and Other Electric Animals; Greg Roza ; PowerKids Press, 2011



Each **species** of electric fish uses its electricity in different ways. Some shock to kill their prey. Other electric fish use their power to shock to scare away predators that get too close. Still others send out electric signals to talk with other fish of their species. There are even fish that use their electricity to find their way in dark or muddy water.

Darwin's "headache"



Charles Darwin (1809-1882) "The electric organs of fishes offer another case of special difficulty; it is impossible to conceive by what steps these wondrous organs have been produced...

The electric organs offer another and even more serious difficulty; for they occur in only about a dozen fishes, of which several are widely remote in their affinities..."

-On the Origin of Species

Electric organ: muscle-derived generator



Voltaic pile: artificial electric organ ~Invention of serial battery connection~

https://commons.wikimedia.org/wiki/Alessandro_Giuseppe_Antonio_Anas sio_Volta#/media/File:Alessandro_Volta.jpeg_2019_2/12



Alessandro Volta (1745-1827)



https://commons.wikimedia.org/wiki/File:Pile_de_Volta.jpg 2019 2/12

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-On the Origin of Species



Gallant et al., 2014

Electric eel (1sp.)

Strongly electric fish (~50-1000 V)

- Predation
- Protection





(~50 spps.)

Electric ray (~40 spp.)

Weakly electric fish (< 10 V)

Gymnotiformes > 200 spp.



Sternopygus macrurus





https://alchetron.com/Eigenmannia 2019 3/26

Eigenmannia virescens (Glass Knifefish)

Brachyhypopomus pinnicaudatus





Weakly electric fish (< 10 V) http://pages.nbb.com/l.edu/neu/~2019 3/26

Mormyriformes >200 spp.





Hippopotamyrus pictus



Brienomyrus brachyistius (Black whale)

https://source.wustl.edu/2011/04/jump-in-communication-skills-led-to-species explosion-among-electric-fishes/ 2019 3/18



Isichthys henryi



Petrocephalus sp.

Weakly electric organs

Active electrolocation

Communication



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http://pages.nbb.cornell.edu/neurobio/hopkins/media/AP-Silence%20Clip/2007_10_04_8-7_B_129-200_AP.swf 2019 3/26 Electric communication of black whale (Brienomyrus brachyistius)



Carl Hopkins Lab, Cornel Univ.

Two components of electric communication

Pulse waveform: 'Who'





Carlson, 2002; Baker et al., 2013

Pulse waveform: species/sex/individual



Frequency Code for pulse waveform



Bruce A.Carlson(2002). Electric signaling behavior and the mechanisms of electric organ discharge production in mormyrid fish Journal of Physiology-Paris Volume 96, Issues 5-6, September-December 2002, Pages 405-419 Fig. 2. (B) 1 ms

Carlson, 2000

Two components of electric communication





Precise sequence of pulse intervals conveys different messages



Carlson, 2002; Wong & Hopkins, 2007

High-frequency Bursts for Aggression

Bruce A.Carlson(2002). Electric signaling behavior and the mechanisms of electric organ discharge production in mormyrid fish *Journal of Physiology-Paris Volume 96, Issues 5-6*, September-December 2002, Pages 405-419 Fig. 4.



"Agressive" Sounds in Animals

Eugene.S.Morton (1977) "On the Occurrence and Significance of Motivation-Structural Rules in Some Bird and Mammal Sounds" The American Naturalist Vol.111,No981 855-869

AVIAN SOUNDS USED IN HOSTILE OR "FRIENDLY," APPEASING CONTEXTS

Species (family)	Aggressive	Nonaggressive
White pelican, Pelicanus erythrorhynchus (Pelicanidae)	Harsh nasal growls*	Not given
Mallard, Anas platyrhynchos (Anatidae)	Loud harsh $gaeck$ (\mathcal{Q})	Soft whimpers: kn and $auais$ (\mathfrak{S})
Sparrow hawk, Falco sparverius (Falconidae)	Harsh <i>chitter</i>	Whine
Bobwhite, Colinus virginianus (Phasianidae)	Loud, rasping "caterwauling"	Tseep; squee
Ring-necked pheasant, Phasianus colchicus (Phasianidae)	Hoarse krrrrah	Squeak (Q)
Solitary sandpiper, Tringa solitaria (Scolopacidae)	Harsh, metallic sound	Rising shrill whistle
Stilt sandpiper, Micropalama himantopus (Scolopacidae)	Trrrr	Toi, weet
Cassin auklet, Ptychoramphus aleutica (Alcidae)	Growled krrr krrr	Kreek
Orange-chinned parakeet, Brotogeris jugularis (Psittacidae)	rrrrr	Low intensity "chirp"
Burrowing owl, Spectyto cunicularia (Strigidae)	rasp	eep
Red-headed woodpecker, Melanerpes erythrocephalus (Picidae) .	Chatter, rasp	Not given
Harlequin antbird, Rhegmatorhina berlepschi (Formicariidae)	Growling chauhh	chee
Chestnut-backed antbird, Myrmeciza exsul (Formicariidae)	Snarling nasal chiangh	Musical chirps: cheup
Eastern kingbird, Tyrannus tyrannus (Tyrannidae)	Harsh zeer	High-pitched tee
Barn swallow, Hirundo rustica (Hirundinidae)	Deep harsh stutter	Whine call
Purple martin, Progne subis (Hirundinidae)	zwrack	sweet
Mexican jay, Aphelocoma ultramarina (Corvidae)	Not given	Variable <i>weet</i>
Scrub jay, A. coerulescens (Corvidae)	Harsh rattle	whew, scree
Dwarf jay, A. nana (Corvidae)	Harsh rasp	shreeup
Common crow, Corvus brachyrhynchos (Corvidae)	Growl	Soft and plaintive
Carolina chickadee, Parus carolinensis (Paridae)	Click-rasp	Lisping tee, soft dee, high see
Blue-gray gnatcatcher, Polioptila caerulea (Sylviidae)	peew	speee
American redstart, Setophaga ruticilla (Parulidae)	Snarl	zeeep, high-pitched titi
Yellow-headed blackbird, Xanthocephalus xanthocephalus	The sub- second second second	soop, ingn pronou our
(Internate)	Harsh, nasal rann-rann	pree pree pree
Brown towhoo <i>Binile fuscus</i> (Frincillidae)	Nasping harsh hoarse notes	Sseeeeeeet
Common no hell Accuthic fammag (Fringillidae)	Sharing throaty notes	Seeep, squeal duet
A frican willage measurabind Placeus eventlatus (Placeidae)	Harsh chen chen chen	sweeeee
Airican vinage weaverbird, 1 loceus cucultus (1 loceidae)	narsn growi	look! see!; high squeal

* Verbal or onomatopoetic (italics) renditions of sounds quoted from source author's descriptions.

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Collaboration with a Product Designer

https://www.nzu.ac.jp/course/life/nzu_designgirls/ 2019 3/18



http://www.chubu.jida.or.jp/sotuten/sotuten_2017_jidash o 2019 3/18



Syoko Sekiya Nagoya Zokei U.



Listen to Color

https://www.ted.com/talks/neil_harbisson_i_listen_to_color/transcript 2019 3/19



TED Ideas worth spreading

WATCH DISCOVER ATT



How neiro works: 1. Color strip from picture





https://www.nzu.ac.jp/course/life/nzu_designgirls/ 2019 3/18



How neiro works: 2. Color-to-sound conversion



Illustration: https://aviator-sunglasses.net/wp-content/uploads/2015/09/visible_light_spectrum.jpg

Oh, boy...



Challenges for neiro

- Does not sound like music!
 - Music theory (Scale/Phrase/Chord progression...)
 - Translation of "Mood" or "Style"



Ryuichi Nariyama

- How to compress 2D data down to 1D?
 - e.g. Eye tracking
 - Vector cues in the picture



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https://www.futurity.org/mormyrid-fish-brains-1917102/ 2019 3/18