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Zebra finches suna ɗaukar calls a matsayin categories masu ma'ana — amma wannan ba daidai yake da language ba

Wani bincike a Science ya gwada ko zebra finches suna jin calls daban kawai ne ko kuma suna tsara nasu vocal repertoire zuwa categories da ke ɗauke da behavioral meaning. A laboratory discrimination tasks, tsuntsayen sun koyi duk call-types 11, sun generalize categories zuwa sabbin vocalizers, kuma sun yi systematic errors tsakanin calls da ake amfani da su a makamantan contexts fiye da abin da acoustic similarity kaɗai zai yi hasashe. Wannan strong evidence ne ga categorical perception da operational kind of meaning. Ba shaida ba ce cewa finches suna da human-like language, syntax, open-ended words, ko wata hanyar conversation da mutane.

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Kalmar “ma’ana” tana yin aiki mai hankali a nan

Zebra finches ba sa bukatar izininmu kafin su sami rayuwar zamantakewa. Suna yin kira lokacin da suke jin yunwa, sun rabu da abokin hulɗa, suna neman aure, sun firgita, suna hulɗa da abokin zama, ko suna cikin rikici. Masana halayyar dabbobi za su iya ware waɗannan sautuka zuwa **call-types**: practical categories kamar alarm calls, contact calls ko begging calls, waɗanda ake fayyacewa da sifar sautin da kuma abin da tsuntsun yake yi lokacin da ya fitar da shi. Tambayar da ta fi wuya ita ce ko tsuntsayen da kansu suna rarraba kiraye-kirayen haka.

Wata takarda a Science ta yi ikirari mai ƙunci amma mai muhimmanci: manyan zebra finches suna iya rarraba call-types da ke cikin nasu vocal repertoire, kuma kuskuren da suke yi yana nuna cewa kiraye-kirayen da ke da alaƙa a behaviour suna kusa da juna a perceptual space na tsuntsayen fiye da abin da acoustics kaɗai zai yi hasashe.

A nan ne kalmar **semantic** ta shiga takardar. Ba tana nufin tsuntsayen suna da “kalmomi” a ma’anar harshen ɗan adam ba. Ba tana nufin syntax, conversation, ko wani dictionary ɓoye a kwakwalwar finch ba. A nan “ma’ana” operational ce: idan kira biyu ana amfani da su a makamantan social contexts, kuma tsuntsaye suna rikita su fiye da yadda kamannin sauti kaɗai zai iya bayyanawa, to behavioral category ɗin na bayyana yana tsara perception.

Tsabtataccen sigar ba “tsuntsaye suna da harshe” ba ce. Ita ce: zebra finches suna bayyana suna ɗaukar nasu kiraye-kiraye a matsayin functional categories, kuma wasu daga cikin categories ɗin suna yin kama da suna ɗauke da ma’ana a ƙuntataccen, testable sense na gwaji ɗin.

Zebra finches (*Taeniopygia guttata*) tsuntsaye ne masu matukar zamantakewa da ke da rich repertoire na kiraye-kiraye, wanda ya sa suka zama useful model wajen nazarin yadda dabbobi ke rarraba vocal signals.

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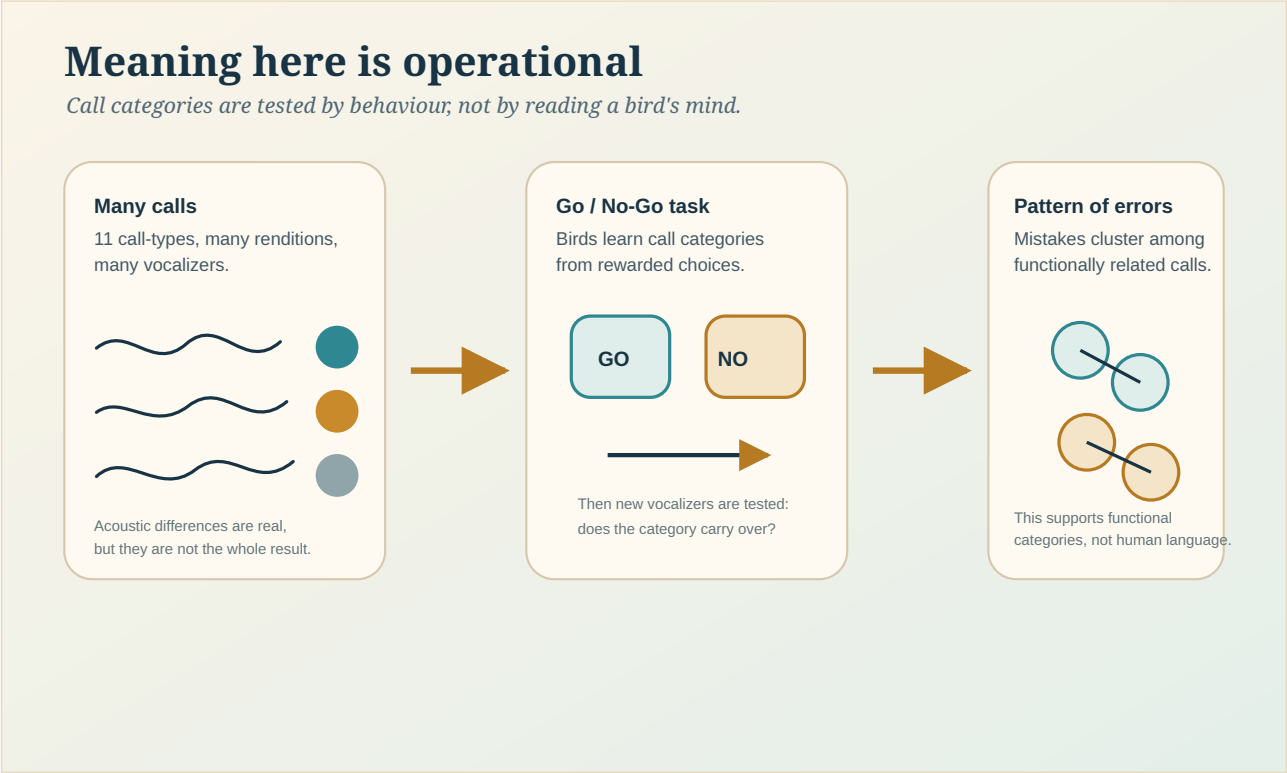

Draft shaida-chain slide domin review: renditions da yawa na call-types 11 suna shiga Go/No-Go discrimination task; babban sakamakon shi ne tsuntsayen suna generalize categories zuwa sabbin vocalizers kuma kuskurensu yana taruwa bisa call function, ba acoustic similarity kaɗai ba.

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Abin da marubutan suka gwada

Marubutan sun fara daga wani existing ethological map na zebra finch repertoire. Wannan species tana da kusan **ethogram-based call-types 11**: kiraye-kirayen da ke da alaƙa da contact, pair bonding da nest behavior, alarm, aggression ko non-affiliative behavior, begging, da male song.

Mutane ne suka yi wannan classification. Yana haɗa acoustic features, context ɗin da ake fitar da sauti a ciki, da abin da sautin yake yawan yi a social life. Amma human ethogram ba lallai ya zama mental map na dabba ba. Binciken ya tambayi tambayoyi uku da suke da alaƙa.

Na farko, zebra finches suna iya bambance duk waɗannan call-types?

Na biyu, suna generalize category na call-type zuwa vocalizers da ba su taɓa ji ba, maimakon su haddace individual examples kawai?

Na uku, idan suka yi kuskure, kuskuren yana bin acoustic similarity kaɗai ne, ko kuma yana bin behavioral meaning na kiraye-kirayen?

Muhimmin abu shi ne gwaji ɗin bai nemi tsuntsu ya bayyana ma'anar kira ba. Yana tambayar ko halin tsuntsun a controlled task yana ɗauke da statistical footprint na categories da meaning.

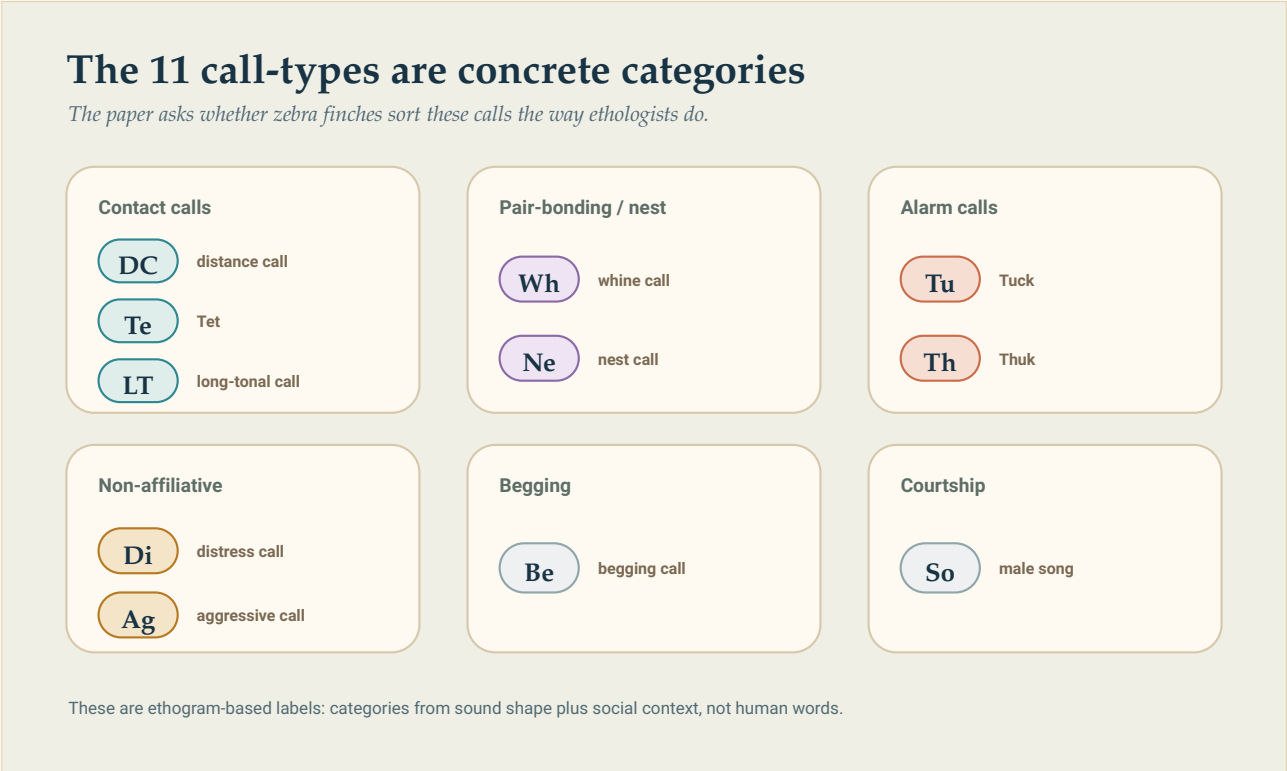
Yadda gwaji ɗin yake aiki

Terms uku suna ɗaukar nauyi sosai a wannan takarda.

Call-type category ne na sautin zebra finch. Takardar ta yi amfani da **ethogram-based** call-types, wato categories da aka gado daga behavioral catalogue: yadda sautin yake a acoustically, lokacin da tsuntsaye ke fitar da shi, da irin social situation da yake ciki. **Vocalizer** kawai individual bird ne da ya fitar da recorded call. **Acoustic shape** measurable sound pattern ne; **behavioral function** kuma abin da ake amfani da call ɗin a kai a al'ada.

Call-types 11 da aka gwada a takardar ba abstract labels ba ne. Su ne repertoire da marubutan suka nemi tsuntsayen su bambance:

- **Contact calls:** distance call (DC), Tet (Te), long-tonal call (LT).
- **Pair-bonding and nest behavior:** whine call (Wh), nest call (Ne).
- **Alarm calls:** Tuck (Tu), Thuk (Th).
- **Non-affiliative calls:** distress call (Di), aggressive call (Ag).
- **Begging:** begging call (Be).
- **Courtship:** male song (So).



Call-types 11 da aka gwada a takardar, an haɗa su bisa broad social function. Labels ɗin ethogram-based categories ne daga source takarda: ba "kalmomi" ba ne, amma suna ba mai karatu concrete repertoire ɗin da tsuntsayen suka yi discrimination a kai.

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Babban task ɗin shi ne **Go/No-Go auditory discrimination**. Tsuntsu ya danna lit key domin fara playback na seconds shida. A rewarded call, abin da ya dace shi ne ya jira: bayan sautin ya ƙare, food hopper ya tashi kuma tsuntsun ya sami iri. A non-rewarded call, jiran bai ba da komai ba; abin da ya fi efficiency shi ne ya sake danna key yayin playback, ya katse sautin, sannan ya fara wani gwaji. Don haka interruptions na tsuntsun suna bayyana wane sautuka yake ɗauka a matsayin "ba rewarded category ba."

Ga kowane test, call-type ɗaya ne aka yi reward, sauran goma kuma ba a yi reward ba. Daga nan marubutan suka canza rewarded call-type, suna wucewa ta dukan repertoire. Sun kuma yi amfani da renditions da yawa daga vocalizers da yawa, tare da kaɗan daga exact repeats. Wannan yana da muhimmanci: tsuntsun ba zai iya haddace recording ɗaya kawai ba. Domin ya yi kyau, dole ne ya koyi abin da ya sa wani sauti ya shiga call-type ɗin duk da muryoyin tsuntsaye daban da examples daban.

"Perceptual space" da ya zo daga baya ba brain scan ba ne kuma ba literal map a cikin dabba ba. Map ne da aka infer daga kuskure. Idan call-types biyu suna rikicewa sau da yawa, ana sa su kusa da juna a wannan behavioral map. Marubutan sun kwatanta wannan da acoustic map da aka gina daga sound features kaɗai. Ikirarin ya zama mai ban sha'awa ne kawai idan error map na tsuntsayen ya karkata zuwa call function, ba similar sound kawai ba.

Abin da suka gano

Tsuntsayen sun iya bambance dukan repertoire. An gwada adult zebra finches 12, males shida da females shida, a call-types 11. Kusan duk tests sun yi nasara: **127 daga 131** na call-type discrimination tests sun kasance significant. Ƙananan gazawa ɗin sun shafi specific birds da specific call-types; overall pattern shi ne kowane call-type an bambance shi fiye da chance.

Wannan yana da muhimmanci saboda repertoire ɗin ba jerin isolated beeps masu tsafta ba ne. Wasu call-types suna clustered acoustically, wasu kuma suna gradation zuwa juna. Duk da haka tsuntsayen sun koyi categories ɗin.

Sun generalize categories zuwa sabbin vocalizers. A gwaji na biyu, tsuntsaye sun koyi bambance call-types biyu daga ƙaramin set na vocalizers. Washegari, an ƙara sabbin vocalizers da reward rule ɗin ɗaya. Tsuntsayen sun classified waɗannan sabbin calls daidai tun farkon test, kafin su sami lokaci su koyi kowane sabon example ta reward feedback. Wannan yana goyon bayan categorical perception na call-type, ba haddace individual sounds kawai ba.

Category ɗin ya iya rinjayar sabon reward rule. Mafi ƙarfi behavioral trick ya zo lokacin da marubutan suka sa task ɗin ya zama incongruent. Calls daga sabbin vocalizers aka ba su reward contingency akasin wanda tsuntsayen suka koya ga wannan call-type. Idan tsuntsayen suna bin sababbin acoustic examples kawai, ya kamata su adapt nan da nan. Amma a farko, responses sun bi previously learned call-type category kuma suka haifar da systematically wrong reward decisions. A cikin yini, tsuntsayen suka koyi arbitrary new rule a hankali. Wannan shi ne abin da ake tsammani idan natural call-type category tana da ƙarfi har ta shiga tsakani.

Kuskuren ba acoustic kawai ba ne. Marubutan sun kwatanta acoustic space, da aka gina daga classifier confusions tsakanin call sounds, da perceptual space, da aka gina daga behavioral errors na tsuntsaye. Spaces ɗin biyu suna da alaƙa: sound har yanzu yana da muhimmanci. Amma call-types da ke cikin behavioral ko semantic hyper-category ɗaya sun fi kusa da juna a perceptual space na tsuntsayen fiye da a acoustic space. Takardar ta kira wannan **semantic magnet effect**.

A lambobi, grouping bisa semantic hyper-category ya kasance kusan **sau 2.43 mafi ƙarfi** a perceptual map fiye da acoustic map. A sauƙaƙe: kuskuren tsuntsayen yana karkata zuwa functional meaning, ba similar sound kawai ba.

Abin da "semantic" yake nufi a nan

Wannan shi ne ɓangaren da yake buƙatar kulawa mafi yawa. A everyday language, "semantic" yana saurin zama "kalmomi." Ba wannan ne takardar ta tabbatar ba.

Binciken ya yi amfani da "semantic" a behavioral da comparative-cognition sense. Call-type yana da putative meaning saboda yana da alaƙa da social function: alarm, contact, begging, aggression, pair bonding, courtship. Idan tsuntsaye suna rikita call-types biyu daga broad social category ɗaya fiye da abin da acoustics ya yi hasashe, perceptual space ɗinsu yana samun shape daga wannan functional category.

Wannan sakamako ne mai muhimmanci. Yana nuna tsuntsun ba spectrogram kawai yake ji ba. Tsuntsun yana ɗaukar species-specific calls a matsayin behaviorally organized categories.

Amma har yanzu indirect ne. Marubutan ba za su iya karanta zuciyar dabbar ba, kuma sun faɗi haka. Suna infer internal representation daga behavior: discrimination, generalization, da systematic errors.

Analogy mai amfani ba "kalmomin finch" ba ne. Ya fi kama da wannan: auditory system na tsuntsun yana bayyana yana canza tazarar da yake ɗauka tsakanin calls bisa abin da ake amfani da waɗannan calls a kai.

Abin da wannan *ba ya* tabbatar

- Ba ya nuna **human-like language**. Babu syntax, grammar, compositional meaning, ko open-ended vocabulary a wannan sakamakon.
- Ba ya nuna zebra finches suna da "kalmomi." Call-types species-specific vocal categories ne da ke da alaƙa da behavioral contexts, ba symbolic labels da za a iya sake haɗawa freely ba.
- Ba ya nuna conversation da mutane, ko wani decoded channel na magana da tsuntsaye.
- Ba ya ba da direct access ga mental states. Ana infer meaning daga task behavior da error structure, ba a lura da shi kai tsaye a cikin tunanin tsuntsu ba.
- Ba ya nuna tsuntsayen sun fahimci sabbin meanings. Generalization zuwa sabbin vocalizers generalization ne na call-type category tsakanin sounds na individuals daban.
- Ba ya warware yadda waɗannan categories ke development. Binciken ya gwada adult birds; yadda exposure da development suke tsara semantic magnet effect har yanzu aikin gaba ne.

Yaya ƙarfin shaidar yake?

Ga categorical perception na call-types, shaidar tana da ƙarfi. Design ɗin ya nemi tsuntsaye su bambance dukan repertoire, ya yi amfani da renditions da yawa daga vocalizers da yawa, kuma ya haɗa generalization test inda newly heard vocalizers aka classified bisa call-type. Incongruent reward condition na da amfani musamman saboda yana nuna category na iya tsoma baki cikin sabon arbitrary rule.

Ga operational kind of semantic perception, shaidar tana da kyau amma ta fi inferential. Semantic magnet effect ba metaphor kawai ba ne: marubutan sun kwatanta acoustic da behavioral distance maps kuma suka gano behaviorally related call-types suna cluster da ƙarfi a perception fiye da a acoustics. Wannan yana goyon bayan ra'ayin cewa call function yana tsara perception.

Ga human-like meaning, shaidar ba ta nan, kuma ba ta buƙatar kasancewa. Takardar ta fi ban sha'awa idan muka bar ta specific. Animal communication ba sai ta yi kama da human speech ba kafin ta zama mai daraja.

Me ya sa yake da muhimmanci

Public temptation a bayyane yake. Idan tsuntsu yana jin call a matsayin meaningful, kanun labarai na gaba zai so ya ce muna decoding animal language. Wannan tsalle yana tsallake sashen kimiyya mafi wuya.

Sakamakon da ya fi hankali ya fi kyau. Yana nuna yadda researchers za su iya gwada "meaning" ba tare da yin pretending cewa suna translating mind na dabba ba. Za su iya tambaya ko dabbobi suna agree da categories na human ethologists. Za su iya tambaya ko sababbin examples ana rarraba su bisa category. Za su iya tambaya ko errors suna bin acoustic similarity ko social function. Wannan wata hanya ce ta sa tsohuwar tambaya — shin animal calls suna nufin wani abu ga dabbobin kansu? — ta zama sharper experimentally.

Haka kuma yana motsa mu daga false ladder inda humans ke da language, sauran komai kuma noise ne. Zebra finches suna da ƙaramin, species-specific vocal repertoire. A cikin wannan repertoire, binciken yana nuna tsuntsayen suna perceive structured categories da ke da alaƙa da social use. Wannan ba harshenmu ba ne. Communication system nasu ne, an gwada shi a kan nasa terms.

Taƙaitaccen bayani mai tsabta

Wani bincike a Science ya gwada adult zebra finches a call-types 11 da ke cikin vocal repertoire nasu. A auditory Go/No-Go tasks, tsuntsayen sun bambance duk call-types, sun generalize learned categories zuwa calls daga sabbin vocalizers, kuma a incongruent condition sun fara bin call-type categories ko da wannan ya sa suka yi wrong reward decisions. Daga nan marubutan suka kwatanta acoustic similarity da behavioral errors, suka gano call-types da ake amfani da su a makamantan social contexts suna cluster da ƙarfi a perceptual space na tsuntsayen fiye da acoustic space. Wannan yana goyon bayan categorical perception da operational form na semantic perception: tsuntsayen suna bayyana suna tsara nasu calls bisa functional categories, ba sound kaɗai ba. Ba ya nuna human-like language, syntax, words, direct access ga mental states, ko conversation da tsuntsaye.

Binciken No-BS

Abin da takardar ta nuna: Adult zebra finches suna iya bambance call-types 11 na repertoire ɗinsu da aka gina daga ethogram; suna generalize call-type categories zuwa sabbin vocalizers; kuma systematic errors ɗinsu suna samun shape daga behavioral ko semantic categories fiye da acoustic similarity kaɗai.

Abin da yake mai yiwuwa amma ba a tabbatar ba: Zebra finches suna da internal representations na call meaning; similar neural maps suna underlying behavioral "semantic magnet" effect; development da exposure suna tsara waɗannan categories a hanyoyi masu kama da sauran learned perceptual categories.

Abin da ba ta nuna ba: Human-like language; grammar; open-ended words; symbolic reference a ma'anar ɗan adam; direct shaida na subjective mental states; wata hanya da mutane za su yi magana da zebra finches.

Manyan iyakoki: Aikin ya yi amfani da laboratory operant tasks da **adult birds 12**, ba natural field interactions ba; "semantic" ana infer ɗinsa daga behavior da error structure; development har yanzu open question ne; sakamakon ya shafi fixed species-specific repertoire, ba flexible compositional language ba.

Yaya yawan amincewa ya dace ga mai karatu na gama gari? Babba cewa zebra finches suna iya categorize da discriminate call-types nasu a wannan task. Mai kyau cewa errors ɗinsu suna nuna functional categories, ba acoustic similarity kaɗai ba. Karami cewa wannan shaida ce ta bird language a ma'anar ɗan adam. Matsayin da ya dace: strong animal-cognition sakamako game da meaningful vocal categories, ba Dolittle moment ba.

Majiyoyi

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Author manuscript in PMC — PMCID PMC12721838
https://pmc.ncbi.nlm.nih.gov/articles/PMC12721838/

Behavioral data and analysis code — Zenodo
https://zenodo.org/records/13623969

Zebra finch acoustical database — Figshare
https://doi.org/10.6084/m9.figshare.11905533.v1