01-Groq.com API for Dev set

In this notebook, we will make API calls to Groq.com to summarize the article (up to 20k characters) in the mini (10% random sampling) dev set.

We would use Mixtral 8x7B as it has very good performance scores, and it's open source.

In [1]:
```
# !pip install groq
```

In [2]:
```
# load api key
import json
import urllib.parse

with open('./data/credentials.json') as f:
    login = json.load(f)

api_key = login["GROQ_API_KEY"]
print(len(api_key))
```

```
56
```

In [3]:
```
from groq import Groq

client = Groq(
    api_key=api_key,
)
```

In [4]:
```
completion = client.chat.completions.create(
    model="mixtral-8x7b-32768",
    messages=[
        {
            "role": "user",
            "content": "Answer in 1 sentence: What's the capital city of Alberta?"
        },
    ],
    temperature=1,
    max_tokens=1024,
    top_p=1,
    stream=True,
    stop=None,
)

for chunk in completion:
    print(chunk.choices[0].delta.content or "", end="")
```

```
The capital city of Alberta is Edmonton.
```

In [5]:
```
# test some summarization
s = 'The evolutionary origins of the hypoxia-sensitive cells that trigger amniote r
s
```

Out[5]:
```
'The evolutionary origins of the hypoxia-sensitive cells that trigger amniote resp
iratory reflexes – carotid body glomus cells , and ‘pulmonary neuroendocrine cell
s’ ( PNECs ) - are obscure . Homology has been proposed between glomus cells , whi
ch are neural crest-derived , and the hypoxia-sensitive ‘neuroepithelial cells’ (
NECs ) of fish gills , whose embryonic origin is unknown . NECs have also been lik
ened to PNECs , which differentiate in situ within lung airway epithelia . Using g
enetic lineage-tracing and neural crest-deficient mutants in zebrafish , and physi
cal fate-mapping in frog and lamprey , we find that NECs are not neural crest-deri
ved , but endoderm-derived , like PNECs , whose endodermal origin we confirm . We
discover neural crest-derived catecholaminergic cells associated with zebrafish ph
aryngeal arch blood vessels , and propose a new model for amniote hypoxia-sensitiv
e cell evolution: endoderm-derived NECs were retained as PNECs , while the carotid
body evolved via the aggregation of neural crest-derived catecholaminergic ( chrom
affin ) cells already associated with blood vessels in anamniote pharyngeal arches
. '
```

In [6]:
```
prompt = f"[INST] Simplify and summarize in 200 to 300 words:  {s} [/INST]"
```

In [7]:
```
# test pause
import time
print("Hello")
time.sleep(2)
print("World")
```

```
Hello
World
```

In [8]:
```
SLEEP_TIME = 10 # pause between requests
```

In [9]:
```
# put into a function
def send_sumarize_request(content, model=client, min_words=250, max_words=500, quie
    """
        summarize the content
        input: context (text), model (groq_api client), max_words (int)
        output: summarized text
    """
    if not quiet:
        print("Sending request for text =", content[:100])

    result = ""
    prompt = f'Simplify and summarize in minimum {min_words} to maximum {max_words}
    try:
        completion = client.chat.completions.create(
            model="mixtral-8x7b-32768",
            messages=[
                {
                    "role": "user",
                    "content": prompt
                },
            ],
            temperature=0.8,
            max_tokens=2048,
            top_p=1,
            stream=True,
            stop=None,
        )
```

```
        for chunk in completion:
            result += chunk.choices[0].delta.content or ""
    except Exception as err:
        print("Skipping, error : ", err)
        result = ""


    # pause to avoid hitting bandwidth limit (~ 14K token / minute)
    print(f"Pausing for {SLEEP_TIME} secs...")
    time.sleep(SLEEP_TIME)
    print("OK")

    return result
```

In [10]:
```
send_sumarize_request(s)
```

```
Pausing for 10 secs...
OK
```

Out[10]:
```
'The evolutionary origins of hypoxia-sensitive cells responsible for amniote respi
ratory reflexes, specifically carotid body glomus cells and pulmonary neuroendocri
ne cells (PNECs), are unclear. Although glomus cells are neural crest-derived, it
has been suggested that they share a common origin with hypoxia-sensitive neuroepi
thelial cells (NECs) found in fish gills, whose embryonic origin is unknown. NECs
have also been compared to PNECs, which differentiate in situ within lung airway e
pithelia. However, through the use of genetic lineage-tracing, neural crest-defici
ent mutants in zebrafish, and physical fate-mapping in frog and lamprey, it has be
en determined that NECs are not neural crest-derived, but instead, endoderm-derive
d, like PNECs, whose endodermal origin has now been confirmed. The study also disc
overed neural crest-derived catecholaminergic cells associated with zebrafish phar
yngeal arch blood vessels. Therefore, the study proposes a new model for the evolu
tion of amniote hypoxia-sensitive cells: endoderm-derived NECs were retained as PN
ECs, while the carotid body evolved via the aggregation of neural crest-derived ca
techolaminergic (chromaffin) cells already associated with blood vessels in anamni
ote pharyngeal arches.'
```

In [11]:
```
import pandas as pd
```

In [12]:
```
# load in some data

dev_df_filename = "../../data/mini_dataset/eLife_val_mini.jsonl"
df = pd.read_json(dev_df_filename,
                  orient="records",
                  lines=True
                 )
df.head()
```

Out[12]:

	lay_summary	article	headings	keywords	id
0	It can take several months , or even years , f...	Mature neural networks synchronize and integra...	[Abstract, Introduction, Results, Discussion, ...	[neuroscience]	elife-69011-v2
1	Many of our decisions are made on the basis of...	Many decisions are thought to arise via the ac...	[Abstract, Introduction, Results, Discussion, ...	[neuroscience]	elife-17688-v1
2	Oculo-Cerebro-Renal syndrome of Lowe (Lowe sy...	Mutations in the inositol 5-phosphatase OCRL c...	[Abstract, Introduction, Results, Discussion, ...	[cell biology]	elife-02975-v2
3	When an embryo develops , its cells must work ...	Gradients of signaling proteins are essential ...	[Abstract, Introduction, Results, Discussion, ...	[developmental biology]	elife-38137-v3
4	Our genomes contain a record of historical eve...	Similarity between two individuals in the comb...	[Abstract, Introduction, Results, Discussion, ...	[evolutionary biology, genetics and genomics]	elife-15266-v1

In [13]:
```
import random
random.seed(42)
k = random.randint(0, len(df) - 1)
item = df.iloc[k]
item
```

Out[13]:
```
lay_summary    Spoken language is colored by fluctuations in ...
article        Individuals with congenital amusia have a life...
headings       [Abstract, Introduction, Results, Discussion, ...
keywords                                              [neuroscience]
id                                                    elife-53539-v2
Name: 20, dtype: object
```

In [14]:
```
item.article
```

Out[14]: "Individuals with congenital amusia have a lifelong history of unreliable pitch pr
ocessing . Accordingly , they downweight pitch cues during speech perception and i
nstead rely on other dimensions such as duration . We investigated the neural basi
s for this strategy . During fMRI , individuals with amusia (N = 15) and control
s (N = 15) read sentences where a comma indicated a grammatical phrase boundary
. They then heard two sentences spoken that differed only in pitch and/or duration
cues and selected the best match for the written sentence . Prominent reductions i
n functional connectivity were detected in the amusia group between left prefronta
l language-related regions and right hemisphere pitch-related regions , which refl
ected the between-group differences in cue weights in the same groups of listeners
. Connectivity differences between these regions were not present during a control
task . Our results indicate that the reliability of perceptual dimensions is linke
d with functional connectivity between frontal and perceptual regions and suggest
a compensatory mechanism . \n Congenital amusia is a rare condition characterized
by impaired perception of and memory for pitch (Peretz et al . , 2002) . Althoug
h congenital amusia presents as an auditory condition , auditory cortical response
s are normal (Moreau et al . , 2013; Norman-Haignere et al . , 2016) , as is sub
cortical encoding of pitch (Liu et al . , 2015b) . The dominant view of amusia's
neural basis is that connectivity between right inferior frontal cortex and right
auditory cortex is impaired , resulting in impaired conscious access to pitch info
rmation for guiding behavior (Hyde et al . , 2011; Albouy et al . , 2013; Leveque
et al . , 2016; Zendel et al . , 2015; see Peretz , 2016 for review) . While cong
enital amusia is believed to be innate , there is evidence that recovery is possib
le through training (Whiteford and Oxenham , 2018) . Although pitch is usually a
ssociated with music , it is also important for cueing categories in spoken langua
ge (de Pijper and Sanderman , 1994; Streeter , 1978) and conveying emotion in sp
eech (Frick , 1985) . In highly controlled laboratory tasks in which speech perc
eption judgments must be made based on pitch alone , only minor deficits have been
observed in amusia (Liu et al . , 2015a; Patel et al . , 2008) . In naturalistic
speech perception contexts , people with amusia rarely report any difficulties (L
iu et al . , 2010) . This may be because , in natural speech , pitch variation te
nds to co-occur with variation in other acoustic dimensions , such as duration and
amplitude . Our lab has shown that in such cases where multiple redundant cues are
available , English-speaking individuals with amusia tend to rely less on pitch th
an non-amusic controls , suggesting they may calibrate their perception by down-we
ighting the cues that are less reliable for them (Jasmin et al . , 2020a) . As f
or emotional prosody in speech , individuals with amusia can recognize emotions in
spoken sentences , but not in short samples such as isolated vowels (Pralus et al
. , 2019) , or when speech has been filtered to remove high-frequency non-pitch c
ues (Lolli et al . , 2015) . It is unknown how decreased reliance on a particula
r acoustic cue during speech perception (such as pitch cues in amusia) is reflec
ted in the brain . Previous neural studies of cue integration have focused on inte
gration of multiple modalities , for\xa0example the 'weighted connections' model o
f multisensory integration . In this model , the relative reliability of the modal
ities involved with perception of a stimulus is related to differential connectivi
ty strength (Beauchamp et al . , 2010; Rohe and Noppeney , 2018) . For example ,
when participants simultaneously view and feel touches to the hand , and reliabili
ty of visual and tactile perception is manipulated experimentally via introduction
of noise , connection strength (effective connectivity measured with functional M
RI and structural equation modeling) between unimodal and multimodal sensory area
s adjusts accordingly . More concretely , when visual information is degraded , th
e connection strength between lateral occipital cortex (a visual area) and intra
parietal sulcus (a multimodal area) decreases , and when tactile perception is m
ade noisier , connection strength between secondary somatosensory cortex and intra
parietal sulcus becomes weaker (Beauchamp et al . , 2010) . Similarly , effectiv
e connectivity between the (multimodal) superior temporal sulcus (STS) and vis

ual and auditory areas has shown similar modulations during processing of audiovis ual speech: connection strength between auditory cortex and the STS is weaker when noise has been introduced to the auditory speech , and conversely connection stren gth between visual cortex and STS is weaker if visual noise is introduced (Nath a nd Beauchamp , 2011) . Just as connectivity differences have been shown to reflec t the precision of different sensory modalities during multisensory integration , an analogous phenomenon may be at work within a single modality during multidimens ional integration . As mentioned , the acoustic speech signal carries multiple co- occurring acoustic dimensions (e . g . roughly described as voice pitch , duratio n , and amplitude) , which often provide redundant cues to disambiguate a linguis tic category (Patel , 2014; Winter , 2014; Jasmin et al . , 2020a) . Individuals with typical pitch perception have learned through a lifetime of experience with s peech acoustics that vocal pitch is a useful and reliable cue . By contrast , indi viduals with amusia , who have unreliable perception of and memory for pitch (ana logous to the 'noise' introduced in the multisensory integration studies cited abo ve) , would have learned that , for them , pitch is not a reliable cue for proces sing spoken language . Thus , by analogy to the multisensory weighting results des cribed above , we hypothesize that amusics may exhibit decreased connectivity betw een language regions and pitch-related areas during speech processing . The neural foundations of perceptual weighting in speech have thus far not been investigated in atypical individuals . Indeed , only one previous functional neuroimaging study has examined the neural processing of spoken material in people with amusia . In t his study , no group differences were detected in task-related activation or funct ional connectivity during processing of speech (whereas group differences were ob served during processing of tones; Albouy et al . , 2019) . However , the connect ivity analyses in this study focused on the silent retention interval in a task in which participants needed to maintain phonemic and not pitch-related information i n memory; the analyses also used broader bilateral ROIs within networks associated with language processing . It remains an open question how functional connectivity in amusic and non-amusic participants may differ during speech encoding in pitch-r elated language tasks within regions of interest selected with a whole-brain data- driven approach . To determine whether the relative reliability of auditory dimens ions in speech perception is reflected in functional connectivity , we used functi onal magnetic resonance imaging to scan 15 individuals with amusia and 15 controls . Participants matched spoken sentences with visually presented ones on the basis of the position of intonational phrase boundaries . These intonation changes were conveyed differently , in three conditions: Pitch-Informative (where only pitch c ues could be used to make the judgment) , Duration-Informative (where only durat ion cues could be used) or Both-Informative (both pitch and duration cues could be used; Jasmin et al . , 2020a; Jasmin et al . , 2020b) . Functional connectivit y was then examined using a data-driven approach that allowed us to identify the l argest group differences , without the need for regions of interest to be selected a priori . The benefit of this approach is that any set of regions could emerge , not only ones reported in previous literature . Crucially , task performance was m atched between the groups (based on prior behavioural testing; Jasmin et al . , 2 020a) , ensuring that any neural differences did not simply represent an inabilit y to perform the task . Finally , functional connectivity between these areas was analyzed with respect to prosodic cue weights obtained outside the scanner , and a lso compared to functional connectivity calculated from different scanning runs wi th a passive listening task . \n On each trial , participants read one visually pr esented text sentence , then heard two auditory versions of the sentence , only on e of which contained an acoustically conveyed phrase boundary in the same place as in the text sentence (see Figure 1 for schematic and example sentences) . Trials were scored as correct if a participant pressed the button associated with the aud itory sentence that correctly matched the text sentence . Proportions of correct j udgments (Figure 2) were subjected to a repeated-measures analysis of variance .

Overall , proportion correct across amusia and control groups was matched (main effect of Group , F (1 , 84) = 0 . 16 , p=0 . 69 , interaction of Group by Condition , F (2 , 84) = 0 . 374 , p=0 . 96) . This lack of interaction was predicted based on previous results obtained from a similar paradigm using out-of-scanner data but from the same participants (Jasmin et al . , 2020a) . There was a main effect of condition (F (2 , 84) = 3 . 32 , p=0 . 04) . Follow-up post-hoc testing indicated that performance in the Both-Informative condition (with pitch and duration cues simultaneously present) was more accurate than either Pitch-Informative (t (84) = 2 . 31 , p=0 . 023) or Duration-Informative (t (84) = 2 . 15 , p=0 . 03) , a result that was also predicted and which replicates the behavioral findings in Jasmin et al . , 2020a . One outlier control participant’s performance was less than 0 . 3 . Re-analysis of the data without this participant did not change the results pattern . Results from these analyses are available online (see Data Availability Statement for details) . A data-driven approach was taken to identify brain regions with the largest group- and condition-related differences in functional connectivity (see Materials\xa0and\xa0methods) . Comparing whole-brain connectedness values by group (Amusia vs . Controls) revealed four significant locations (where z of peak vertices\xa0>\xa04 . 61 , FDR-corrected p<0 . 05) that showed greater whole-brain connectedness for the control than for the amusia group (see Figure 3 , yellow crosses) . All group differences were located in the inferior frontal cortex: two left hemisphere vertices (inferior frontal gyrus p . triangularis and dorsolateral prefrontal cortex) and two right hemisphere vertices (inferior frontal gyrus p . triangularis and p . orbitalis) . There were no areas where whole-brain connectedness differed by Condition , or showed an interaction of Group and Condition . Follow-up testing was conducted on the four significant regions (Control\xa0>\xa0Amusia , collapsed across the three conditions) identified above to characterize the specific cortical regions driving these group connectivity differences (Berman et al . , 2016; Gotts et al . , 2012; Jasmin et al . , 2019; Song et al . , 2015) . Relative to control participants , amusic participants' left inferior frontal gyrus seed region showed particularly notable decreases in connectivity with the right posterior superior temporal and inferior parietal cortex , as well as with the right posterior superior temporal sulcus (Figure 3A) . Analysis of subcortical connectivity indicated that there was also weaker connectivity with the right nucleus accumbens (Table 1) . The left dorsolateral prefrontal cortex in amusic participants showed decreased functional connectivity with the mid portions of the right superior temporal gyrus , posterior part of the right middle temporal gyrus extending into the inferior bank of the superior temporal sulcus , and the right anterior insula (Figure 3A) . Several subcortical structures - bilateral caudate nucleus and putamen , bilateral pallidum , bilateral cerebellum , and bilateral thalamus - also showed significantly reduced (FDR-corrected) connectivity with the seed in amusics (Table 1) . The right pars triangularis seed showed Control\xa0>\xa0Amusic connectivity with right dorsolateral prefrontal cortex and left posterior superior temporal gyrus (Figure 3B) . It also showed decreased connectivity with left nucleus accumbens . Right pars orbitalis showed decreased connectivity with right dorsolateral prefrontal cortex (Figure 3B) . There was also decreased connectivity with the left thalamus (Table 1) . Of the 30 participants in this study , 21 took part in an experiment that measured the degree to which they relied on pitch versus duration to categorize prosody , that\xa0is , their ‘normalized prosodic cue weights’ , which ranged from 0 to 1 , with values greater than 0 . 5 indicating greater reliance on pitch than duration , and values less than 0 . 5 indicating greater reliance on duration than pitch (Experiment 1 , Jasmin et al . , 2020a) . These cue weights were assessed with respect to the functional connectivity results reported above . Across this subset of participants , normalized cue weights were correlated with L-DLPFC\xa0<=>\xa0R insula connectivity (Spearman R\xa0=\xa00 . 78 , p=0 . 000037) , and L-DLPFC\xa0<=>\xa0R auditory\xa0cortex connectivity (Spearman R\xa0=\xa00 . 75 , p=0 . 000154; Figure 4) .

This indicated that participants who relied least on pitch information to process speech had the weakest functional connectivity between these areas , while those who relied most on pitch had the strongest . Although analyzing the control and amusic groups independently results in extremely small sample sizes , this pattern also held (albeit with ‘marginal significance’) within the 11 control participants alone , for both auditory cortex connectivity (R\xa0=\xa00 . 58 , p=0 . 06) and insular connectivity (R\xa0=\xa00 . 55 , p=0 . 08) . Both these correlations were in the predicted direction , suggesting that even non-amusics may perform dimensional reweighting of acoustic dimensions and functional connectivity . Correlations within the (much more variable) amusic group alone were weaker and non-significant (although again , the group size is very small) . To ensure that\xa0the pattern of connectivity we observed between groups (decreased right auditory cortex and right insula with L-DLPFC connectivity) was not due to intrinsic , task-irrelevant differences in neural architecture , the data from the language task was compared to that collected during passive listening to tone sequences . Whereas during speech perception amusic subjects showed reduced functional connectivity between left frontal and right insula/auditory ROIs relative to controls (p=0 . 0001 for both ROIs; in line with the whole-brain imaging analyses) , this pattern did not hold during passive listening to tones (Amusia vs Control connectivity , p=0 . 29 , Group (Amusic , Control) by Task (Speech Perception , Passive Tone Listening) interaction p=0 . 045 for the insula ROI; Amusia vs Control p=0 . 30 , Group by Task interaction p=0 . 035 for the auditory cortex ROI - see Figure 5) . These interactions suggest that our neural connectivity results are specifically linked to speech perception , rather than reflecting an overall connectivity difference between groups regardless of task state . Although we were concerned with functional connectivity rather than activation , we also tested for differences in activation levels between groups and conditions . False Discovery Rate correction was used to correct for multiple comparisons across both hemispheres for each test (Group , Condition and Group X Condition) . No significant differences were detected for the main effects of group and condition , nor the interaction of those factors . \n We found that individuals with amusia , who have been previously shown to rely less on pitch than controls to process spoken language (Jasmin et al . , 2020a) , exhibited decreased functional connectivity between left frontal areas and right hemisphere pitch-related regions . In our task , participants matched spoken sentences with visually presented sentences based on pitch , duration , or both these acoustic dimensions together . Using a data-driven approach , we identified four regions in left and right inferior frontal cortex for which the amusic group exhibited decreased functional connectivity with several other sites in frontal , temporal and occipital cortex . The most prominent of these results was decreased connectivity between left frontal regions classically implicated in language processing (left IFG and DLPFC) and right hemisphere regions —in the superior temporal gyrus and sulcus , Heschl’s gyrus , and anterior insula—that have been implicated in pitch processing (Lee et al . , 2011; Garcea et al . , 2017; Warren et al . , 2003; Hohmann et al . , 2018) . We suggest that this decreased connectivity between right hemisphere pitch and left hemisphere frontal cortices may relate to the unreliability of the amusics’ perception of and memory for pitch . This is similar to the ‘weighted connections’ model of multisensory integration , where a more (or less) reliable modality is given a stronger (or weaker) weight (Beauchamp et al . , 2010) . Congenital amusia is often described as a disorder related to structural and functional connectivity within the right hemisphere , particularly between right inferior frontal cortices and right posterior temporal cortex (see Peretz , 2016 for review) . Consistent with this proposal , we found in the present study that right inferior frontal cortex exhibited strongly decreased functional connectivity in the amusia group , and follow-up seed testing revealed that right auditory areas were involved as well . However , we also found that sites in left frontal cortex also showed large decreases in connectivity in amusia , also most prominently

with right hemisphere auditory areas . Our results are consistent with an account that right hemisphere auditory areas are not only abnormally connected to right frontal areas (as observed during tonal tasks) but are less integrated with frontal left hemisphere regions when processing speech and language . Our null results for group differences in activation during speech processing are consistent with prior reports that amusics and controls do not differ in pitch representations within sensory regions . For example , the extent of pitch-responsive regions within auditory cortex has been shown to be similar in participants with amusia and controls (Norman-Haignere et al . , 2016) . Brainstem encoding of pitch in speech and musical stimuli is similarly unimpaired in individuals with amusia (Liu et al . , 2015b) . Moreover , in oddball EEG paradigms , amusics show similar pre-attentive mismatch negativity responses to small pitch deviants , but impaired attention-dependent P300 responses (Moreau et al . , 2009; Peretz et al . , 2009; Mignault Goulet et al . , 2012; Moreau et al . , 2013) . These findings , along with the fact that amusics show intact non-volitional behavioral responses (unconscious pitch shifts) when presented with pitch-altered feedback of their own voice (Hutchins and Peretz , 2012) , have been interpreted as evidence that amusia is a disorder of pitch awareness rather than one of low-level pitch processing (Peretz et al . , 2009) , with differences in structural connectivity as one possible foundation of this putative impaired pitch awareness (Hyde et al . , 2006; Loui et al . , 2009; but see Chen et al . , 2015) . Our interpretation of differences in functional connectivity between amusics and controls diverges somewhat from these previous approaches: we argue that down-weighting of pitch information during perceptual categorization in both speech and music is adaptive , inasmuch as amusics have learned that pitch is an unreliable source of evidence relative to other perceptual dimensions . The evidence above suggesting that encoding of pitch in the brainstem and auditory cortex and pre-attentive responses to pitch changes are unaffected in amusia can be interpreted as suggesting that the fundamental deficit in amusia may not be increased perceptual noise or decreased pitch awareness but difficulties with retention of pitch information in memory (see Tillmann et al . , 2016 for review) . Our task arguably taxed working memory resources: in a similar paradigm performed by the same participants in quiet listening conditions (Jasmin et al . , 2020a) , the mean reaction time measured from the end of the second auditory stimulus was 1 . 64 s , indicating that participants needed some time to compare both auditory presentations and make their judgments . This interpretation is consistent with evidence suggesting that amusics have difficulty with pitch sequence processing tasks even when discrimination thresholds are accounted for (Tillmann et al . , 2009) , as well as the finding that delaying the time interval between standard and comparison tones exacerbates pitch discrimination impairment in individuals with amusia (Williamson et al . , 2010) . Moreover , the pitch awareness account of amusia cannot explain the Jasmin et al . , 2020a finding that pitch cues are downweighted only during longer-scale suprasegmental speech perception , while pitch weighting is not different between amusics and controls during shorter-scale segmental speech perception , despite pitch cues being arguably more subtle in the segmental condition . However , this finding can be explained by the pitch memory account , as the suprasegmental task requires detection of and memory for pitch patterns within a complex sequence , while the segmental task does not . Furthermore , an account of amusia which suggests that the disorder primarily stems from differences in structural connectivity cannot account for the recent finding that functional connectivity patterns do not differ between amusics and controls during a verbal memory task (Albouy et al . , 2019) , as well as our finding that amusics and controls show similar functional connectivity patterns during passive listening to tone sequences . We suggest , therefore , that amusics neglect pitch because they have implicitly learned that their memory for pitch is unreliable , and that this down-weighting of pitch is reflected in decreased functional connectivity between right auditory areas and downstream task-relevant areas which integrate information from

perceptual regions . One way to test this hypothesis would be to examine functiona l connectivity during perceptual categorization of consonant-vowel syllables as vo iced versus unvoiced based on a pitch cue (F0 of the following vowel) and a dura tional cue (voice onset time) . We predict , based on our previous findings (Ja smin et al . , 2020a) , that functional connectivity will not differ between amus ics and controls on this task , a finding which would not be predicted by the pitc h awareness account of amusia . We note that a previous fMRI study on amusia detec ted group differences in functional connectivity during passive listening to tones . That study used task-defined seed voxels in bilateral auditory cortex and found , in the amusia group , increased connectivity between left and right auditory cor tex , but decreased connectivity between right auditory cortex and right inferior frontal gyrus (Hyde et al . , 2011) . The present study does not necessarily cla sh with these findings , as we used different seed ROIs selected with a different procedure . We did not observe any differences in functional connectivity between conditions in our speech task . This may be because our functional imaging protoco l was timed to capture the peak in the BOLD signal corresponding to the presentati on of the second auditory stimulus . Participants never knew (even implicitly) w hich acoustic dimension might be useful on any given trial until after they had he ard both spoken sentences and needed to compare them to make their response . Furt hermore , pitch fluctuations in the stimuli were above participants' thresholds , even in the Duration-Informative condition (where the standard deviation of F0 ov er each spoken utterance was , on average , 2 . 7 semitones) , and so it is unsur prising that functional connectivity did not change on a trial-by-trial basis , an d instead the same 'neural strategy' was employed to process speech regardless of the trial type . Several other future directions are suggested by our results , pa rticularly for examining cue weighting during auditory/speech perception . In the multimodal integration studies mentioned above (Beauchamp et al . , 2010; Nath an d Beauchamp , 2011) , reliability of two different sensory modalities was manipul ated experimentally by severely degrading input channels with noise , resulting in changes in connectivity . Similarly , aspects of speech could be selectively maske d with noise in order to make them less reliable , which in turn could cause corre sponding changes in functional or effective connectivity . Indeed , behavioral wor k has indicated that when fundamental frequency (pitch) or durational aspects of speech are manipulated to be unreliable cues , categorization behavior shifts such that participants place less relative weight on the dimension that has been made l ess reliable (Holt and Lotto , 2010) . Certain groups , such as tone language sp eakers , are known to have fine-grained pitch perception abilities , and tend to p lace greater weight on pitch even when processing speech from a second , non-tonal language that they have learned (e . g . English; Yu and Andruski , 2010; Zhang a nd Francis , 2010 , Zhang et al . , 2008; Qin et al . , 2017; Jasmin et al . , 202 0a) . Given the increased reliability of their pitch perception , tone language s peakers may exhibit correspondingly high connectivity strength between right hemis phere auditory regions and left hemisphere 'language regions' when pitch cues are present (more so than native non-tonal language speakers) . Expert musicians als o have extensive pitch-related experience and training and could also serve as a p opulation to examine in future work . \n Participants , 15 individuals with amusia (10 F , age\xa0=\xa060 . 2\xa0±\xa09 . 4 , range\xa0=\xa043–74) and 15 controls (10 F , age\xa0=\xa061 . 3\xa0±\xa010 . 4 , range\xa0=\xa038–74) , were recruite d from the UK and were native British English speakers . The amusic group sample s ize reflected the maximum number of participants that could be screened and tested during our data collection period . The control group sample size was matched to t his . All participants gave informed consent , and ethical approval was obtained f rom the relevant UCL and Birkbeck ethics committees . Amusia status was obtained u sing the Montreal Battery for the Evaluation of Amusia (MBEA) . Participants wit h a composite score (summing the Scale , Contour and Interval tests scores) of 6 5 or less were classified as having amusia (Peretz et al . , 2003) . We also not

e that the amusics defined using the MBEA had higher pitch thresholds than control s (Wilcoxon Rank Sum W\xa0=\xa029 , p=0 . 001) but did not differ from controls in tone duration discrimination (W\xa0=\xa0129 , p=0 . 74) , speech-in-noise thr eshold (W\xa0=\xa0155 . 5 , p=0 . 17) , or audiometric hearing thresholds (t (28) = 1 . 33 , p=0 . 20; see Jasmin et al . , 2020a for detailed methods for thes e procedures) . The stimuli were 42 compound sentences that consisted of a pre-po sed subordinate clause followed by a main clause (see Figure 1 for an example , a nd Jasmin et al . , 2020a , Jasmin et al . , 2020b for details) . There were two versions of each sentence: (1) an ‘early closure’ version , where the verb of th e subordinate clause was used intransitively and the following noun was the subjec t of a new clause [‘After Jane dusts , the dining table [is clean]”]; and (2) , ‘late closure’ , where the verb was transitive and took the following noun as its object , moving the phrase boundary to a slightly later position in the sentence [‘After Jane dusts the dining table , [it is clean]”] . The words in both versions of the sentence were identical from the start of the sentence until the end of the second noun (‘After Jane dusts the dining table …”) , and only the lexically ide ntical portions of the sentences were presented to participants; thus the two stim uli did not differ in words spoken . A native British English speaking male (who had previously trained as an actor) recorded early closure and late closure versi ons of each sentence in a sound-proofed room . The recordings were cropped such th at only the portions with the same words remained , and silent pauses after phrase breaks were removed . Synthesized versions of these sentences were created with ST RAIGHT voice-morphing software (Kawahara and Irino , 2005) . First , the two ver sions of the sentence were manually time-aligned by marking corresponding ‘anchor points’ in the two recordings . Then , morphed speech was synthesized by varying t he degree to which the early closure and late closure recordings contributed durat ion and pitch information . We synthesized pairs of stimuli in three conditions: (1) In the Pitch-Informative condition , the stimulus pair had exactly the same du rational properties (that is , the length of phonemes , syllables , and words was the average between the two original recordings) but the vocal pitch indicated ea rly or late closure at a morphing level of 80%; (2) in the Duration-Informative condition , vocal pitch in the stimulus pair was identical (at 50% between both v ersions) but the durational characteristics indicated early or late closure at a morphing level of 80%; (3) in the Both-Informative condition , both pitch and ti me cued early or late closure simultaneously at 80% . The morphed speech varied on ly in duration and pitch , while all other aspects of the acoustics (such as ampl itude and spectral characteristics other than pitch) were the same , held constan t at 50% between the two original recordings during morphing . This stimulus set i s freely available (Jasmin et al . , 2020b) . Across all stimuli , F0 (vocal pi tch) differences between early and late closure versions were large , with a mean of maximum difference of 7 . 7 semitones and range of 4 . 0–12 . 6 semitones . Thu s , even the stimulus pair with the smallest pitch difference (4 . 0 semitones) exceeded the\xa0~1 . 5 semitone pitch change detection threshold of the ‘most impa ired’ participant in the amusia group (Jasmin et al . , 2020a) , which increased the chances that the amusia group would not suffer from poor performance , thereby avoiding a performance-related confound with our experimental design (see Church et al . , 2010 for discussion) . Subjects were scanned with a Siemens Avanto 1 . 5 Tesla magnetic resonance imaging scanner with a 32-channel head coil , with soun ds presented via Sensimetrics S14 earbuds , padded around the ear with NoMoCo memo ry foam cushions . Functional data were collected using a slow event-related desig n with sparse temporal sampling to allow presentation of auditory stimuli in quiet . We used an echo planar image sequence , with 40 slices , slice time 85 ms , slab tilted to capture the entire cerebrum and dorsal cerebellum , ascending sequential acquisition; 3\xa0×\xa03\xa0×\xa03 mm voxel size; silent stimulus and response per iod\xa0=\xa08 . 7 s , volume acquisition time\xa0=\xa03 . 4 s , total inter-trial interval\xa0=\xa012 . 1 s , flip angle\xa0=\xa090 degrees , bandwidth\xa0=\xa02298

Hz/pixel , echo time (TE) =\xa050 ms . After collecting functional runs , a high -resolution T1-weighted structural scan was collected (MPRAGE , 176 slices , sagi ttal acquisition , 2x GRAPPA acceleration , 1 mm isotropic voxels , acquisition ma trix\xa0=\xa0224\xa0×\xa0256) . Each run began with three dummy scans to allow ma gnetic stabilization . Each trial (repetition time) lasted 12 . 1 s . The start of each trial was triggered by a pulse corresponding to the start of a volume acqu isition (which acquired neural data from the previous trial , at a delay) . At t \xa0=\xa01 s into the trial , the sentence appeared on the screen; before scanning participants were instructed to read each sentence silently to themselves . At t\x a0=\xa05 s (plus or minus a random 100 ms jitter) participants heard a spoken ve rsion of the first part of the sentence . At t\xa0=\xa07 . 4 s (plus or minus 100 ms jitter) the second version was presented . The two spoken versions contained t he same words but their pitch and/or timing characteristics cued a phrase boundary that occurred earlier or later in the sentence . Following this , there were appro ximately 2 s of silence during which the participant responded with the button box , before the scanner began acquiring the next volume at t\xa0=\xa012 . 1 s . Parti cipants performed three blocks of 42 trials (14 each of Pitch-Informative , Durat ion-Informative , and Both-Informative) with 8 Rest trials interspersed within ea ch block . Following data collection for this task and the structural scan , parti cipants took part in two task-free fMRI scanning runs in which they watched a sile nt film (The General , starring Buster Keaton , or an episode of the Planet Earth series played without sound) while being presented auditorily with semi-random to ne sequences . Stimuli consisted of sequences of ‘pips’ - 30 ms 6-harmonic complex tones . The fundamental frequencies of the pips were either 440 , 466 . 16 , 493 . 88 or 523 . 25 Hz , and the time between tone onsets was 0 . 075 , 0 . 125 , 0 . 1 75 , or 0 . 225 s . The transition probabilities (determining whether pip N+1 had the same pitch or duration properties as pitch N) were set at either 0 . 1 and 0 . 9 for duration and either 0 . 3 and 0 . 7 for pitch . These two transition param eters were ‘crossed’ to create four design cells , and 25 random sequences were ge nerated for each cell . MRI scanning parameters were identical to those used in th e active , prosody task , except the time between volume acquisitions was 17 . 1 s . Participants listened to 100 tone sequences across two runs (50 per run) . Mat lab code used to create the stimuli can be found online (see Data Availability St atement) . Image preprocessing was performed with FreeSurfer 6 . 0 . 0 (Fischl , 2012) and AFNI-SUMA 18 . 1 . 18 (Cox , 1996) . Anatomical images were registere d to the third echo planar image of the first run using Freesurfer’s bbregister an d processed with FreeSurfer’s automated pipeline for segmenting tissue types , gen erating cortical surface models , and parcellating subcortical structures . Masks of inferior colliculi were obtained by manually examining individual subjects’ ana tomical images and selecting a single EPI voxel located at its centre , bilaterall y . Freesurfer cortical surface models were imported to AFNI with the @SUMA_Make_S pec_FS program . Then a standard pre-processing pipeline using AFNI’s afniproc . p y program was used: all echo planar image volumes were aligned to the third repeti tion time of the first run using AFNI’s 3DAllineate , intersected with the cortica l surface with SUMA , smoothed along the surface with a 2D 6-mm-FWHM kernel , and converted to a standard mesh (std . 141) for group analyses , separately for eac h hemisphere , where each vertex in the mesh (198812 per hemisphere) is aligned to the 'same' location in the cortex across subjects , using curvature-based morph ing . Preprocessing of the passive listening experiment data was identical . The m agnitude of transient head motion was calculated from the six motion parameters ob tained during image realignment and aggregated as a single variable using AFNI's @ 1dDiffMag to calculate a Motion Index (Berman et al . , 2016; Gotts et al . , 201 2; Jasmin et al . , 2019) . This measure is similar to average Frame Displacement over a scan (Power et al . , 2012) and is in units of mm per repetition time . T he difference in average motion between the groups was small (amusia group mean m otion\xa0=\xa00 . 31 mm/TR; control group mean\xa0=\xa00 . 28 mm/TR) and amounted

to 32 micrometers (~1/30th of a millimeter) per TR . The mean and distribution o f motion did not differ statistically between groups (two sample t-test p=0 . 70 , two-tailed) . Given the previous reports (described above) of changes in conn ection strength between unimodal and multimodal areas in response to noise (Beauc hamp et al . , 2010; Nath and Beauchamp , 2011) , we chose a connectivity-based a nalysis approach for our study . Beta series correlation (Rissman et al . , 2004) is a technique for examining functional connectivity and its modulation by task , using correlations in trial-by-trial responses . It has been shown to be more po werful than alternatives such as generalized psycho-physiological interaction (gP PI) for event-related designs (Cisler et al . , 2014) . In a beta series analys is , one beta weight is calculated for each trial in the experiment (rather than for each condition) . All the trial-wise betas associated with a given condition are then serially ordered to form a ‘beta series’ . Finally , using the beta serie s in the same way as a standard BOLD fMRI time series , functional connectivity (measured as Pearson correlations) is calculated between seed regions of interest and the rest of the brain . Differences in functional connectivity can then be exa mined by comparing groups , comparing conditions , or examining the interaction of these factors . Our experiment used a slow event-related design with a long repeti tion time (12 . 1 s) and sparse temporal sampling (with volume acquisition sepa rated by silent periods) . Therefore , the time between acquisitions was long eno ugh for the haemodynamic response to return to baseline , and each echo planar ima ge acquisition corresponded to exactly one trial (Figure 1) . For this reason , we did not convolve the echo planar image time series with a basis function during subject-level statistical analysis (Hall et al . , 1999) . In the design matrix for obtaining trial-wise betas , 126 column regressors were used (one for each no n-rest trial) . Each column vector was of length 150 (corresponding to all trial s , including rest trials) and had a single ‘one’ in the position where the trial associated with that column occurred , while zeros were located in every other pos ition . Polynomials up to second degree were also included in the model , on a run -wise basis , to remove the mean and any linear or quadratic trends . Fitting the trial regressors on a subject-wise basis resulted in cortical surface models of be ta weights for each of the 126 trials , at each vertex on the reduced-vertex icosa hedral cortical surface , with beta weights reflecting the neural response associa ted with that trial . As noted above , trial-wise betas were then serially ordered to form beta series separately for each of the three experimental conditions (Pit ch-Informative , Duration-Informative , and Both-Informative) (Rissman et al . , 2004) . Because there were 30 participants , this procedure resulted in a total o f 90 beta series (30 participants\xa0×\xa03 conditions=90 beta series) . As for the passive tone listening data , because all ‘trials’ were of the same type , it was not necessary to separate them into conditions and perform a first-level model to obtain betas . However , polynomials up to second degree were detrended from th e pre-processed data (as was done with the task data) . Beta series analysis req uires initial seed voxels , vertices , or regions to be identified , whose trial-t o-trial changes in activity are then compared to those of the rest of the brain . Rather than choose a priori seeds derived from the literature , which used mainly musical tasks or resting state , we used a data-driven approach to search for the largest group and condition differences in functional connectivity (Berman et al . , 2016; Cole et al . , 2010; Gotts et al . , 2012; Jasmin et al . , 2019; Meoded et al . , 2015; Song et al . , 2015; Steel et al . , 2016; Stoddard et al . , 201 6; Watsky et al . , 2018) . To do this , we first calculated the ‘whole-brain con nectedness’ of each cortical vertex (a procedure available in AFNI as the 3dTCorr Map function) . The whole-brain connectedness of a given vertex is defined as the Pearson correlation of activity within that vertex/voxel and the average signal ac ross all neural gray matter in the rest of the brain . Mathematically , this is eq uivalent to calculating thousands of Pearson correlations , of a given vertex/voxe l series and every other vertex/voxel series in the brain , and then taking the me

an of those correlations (Cole et al . , 2010) , then repeating the process for every individual voxel/vertex . As such , it represents the global connectedness (or ‘global correlation’) of a vertex/voxel . To calculate whole-brain connectedness , first , the average of trial-wise betas in gray matter across the brain was calculated in volume space , separately for each subject and for each condition , by running first-level (subject) models . The statistical models were identical to those conducted on the cortical surface , described above , but were performed on volumetric Talairach images instead of the cortical surfaces . The reason for this choice was so that voxels in cortex and subcortex would contribute equally to our measure of global (whole-brain) connectivity . First , the\xa0average gray-matter beta value was calculated for each trial by intersecting each image in the beta series with a whole-brain gray matter mask (which excluded white matter and ventricles) and calculating the average beta value within the mask (Gotts et al . , 2012; Jasmin et al . , 2019) . Next , this gray matter average was correlated with each cortical surface vertex’s beta series , separately for each subject and condition , to obtain whole-brain connectedness maps . These values were then subjected to a statistical analysis based on our 2 (Group) ×\xa03 (Condition) experimental design . Linear mixed effects models (AFNI’s 3dLME) (Chen et al . , 2013) were constructed whose dependent variables were the vertex-wise whole-brain connectedness maps from each beta series . Group and Condition and their interaction were included as fixed effects . Participant was treated as a random intercept . Results of this step were corrected vertex-wise for multiple comparisons with False Discovery Rate (q\xa0<\xa00 . 05) , separately for each test (Main Effect of Group; Main Effect of Condition; Interaction of Group by Condition) by pooling the p-values from both hemispheres’ cortical surfaces . This False Discovery Rate threshold corresponded to uncorrected p<4\xa0×\xa010−6 for the Main Effect of Group . Four significant results (contiguous significant vertices) survived this threshold and were taken forward for the next analysis step . For the Main Effect of Condition and Interaction of Condition x Group , no results survived statistical correction at\xa0FDR (q\xa0<\xa00 . 05) . An analogous procedure was run on the passive tone listening data , in which whole-brain connectedness values were compared by group (amusic vs . control) in a linear mixed effects model . No significant FDR-corrected group differences were detected , nor at a reasonable uncorrected threshold of p<0 . 001 . A similar procedure was performed for subcortical structures . Beta series were obtained for each subject , structure , and experimental condition , from their standard Freesurfer subcortical parcellations by masking the EPI data within each structure and calculating the average of the voxels . Each structure’s beta series was then correlated with the whole-brain gray matter beta average , separately for each condition , and the resulting values were subjected to linear mixed effects models with the same factors as above . Tests for Main Effect of Condition , of Group , and the Interaction of these factors was performed . All p-values were greater than p>0 . 001 and no results survived an FDR-correction calculated over them . The first analysis step (seed definition , described above) identified which , if any , brain areas showed the largest connectivity differences between groups . However , this step is insufficient to localize the other specific regions driving this pattern . An analogy is in Analysis of Variance , where a significant omnibus test indicates a difference exists , but follow-up testing is required to determine where in the model differences exist (Gotts et al . , 2012) . Thus , to locate the regions driving this pattern , we undertook a second step: follow-up seed-to-whole-brain testing (Cole et al . , 2010; Gotts et al . , 2012; Jasmin et al . , 2019) . Each seed region was examined with respect to its connectivity pattern with every cortical vertex and subcortical structure . For each of the 90 beta series (30 subjects by three conditions) , values within the seed vertices were averaged and then correlated with the beta series for every vertex in the brain . These correlations were Fisher Z-transformed and used as the dependent variables in linear mixed effects models (3dLME) with the same fixed and random

effects as above . For each of the seeds , we tested for the group difference (Amusia vs Control) in connectivity . Results were False Discovery Rate corrected to (q\xa0<\xa00 . 05) across all eight follow-up tests [four seeds\xa0×\xa02 hemispheres] corresponding to a threshold of p<0 . 00035 . Similarly , for the subcortical structures , each seed beta series was correlated with subcortical structure beta series , with resulting values subject to statistical testing . An FDR correction over all tests involving subcortex was applied . For display in figures , the data were converted from SUMA's standard mesh (std . 141) to Freesurfer's standard surface (fsaverage) using AFNI's SurfToSurf program and mapping values from the closest nodes (i . e . vertices) . To determine whether the functional connectivity patterns we observed were related to the importance placed on acoustic dimensions during prosodic categorization (cue weighting) , the functional connectivity results were analyzed with respect to previously acquired cue weights obtained behaviorally from a subset of participants (Jasmin et al . , 2020a) . The right anterior insula and right auditory cortex results were used as ROIs (Figure 3A) . The beta series for each ROI (averaged across vertices) was correlated with the beta series within the L-DLPFC seed area , separately for each condition , then averaged and Fisher Z-transformed . For the 21 participants for whom we had prosodic cue weight data (from Jasmin et al . , 2020a) , these cue weights were analyzed with respect to the functional connectivity between the L-DLPFC seed and the two ROIs using Spearman correlations . As described above , functional connectivity between L-DLPFC , and right auditory cortex and right insula was calculated using data from the passive tone listening task , using ROIs derived from the active speech perception task . After pre-processing and de-trending , the averaged value from the tone listening experiment within these ROIs was extracted , as well as the LDLPFC seed , for each experiment . Correlations between signal within the seed and the two ROIs was calculated and Fisher Z-transformed . As mentioned above , because all trials in the tone-listening experiment were analyzed as the same type , it was not necessary to use a first-level model to obtain trial-wise betas . Similarly for the data from the speech task , the average value within the seed region and both ROIs was extracted , separately for each of the 3 Beta series (Pitch- , Time- and Both-Informative) , and the seed and ROI series were correlated . The mean of these three correlation coefficients was calculated and Fisher Z-transformed . Finally , statistics were performed using a mixed ANOVA with Experiment (Speech or Tones) as the within-subject factor and Group (Amusia or Control) as the between-subject factor . A standard General Linear Model comparing activation strength (rather than connectivity) was also conducted . As in the General Linear Model for obtaining beta weights , no basis function was used , and polynomials up to second degree were included in the models . The data that support the findings of this study are openly available in the Birkbeck repository (https://researchdata . bbk . ac . uk/65/) , as are the speech stimuli (Jasmin et al . , 2020b; https://researchdata . bbk . ac . uk/37/) . The speech task can be demoed at the following link: (Gorilla Open Materials; https://gorilla . sc/openmaterials/102786) ."

In [15]:
```
# test summarizing the abstract
paras = item.article.split("\n")
abstract = paras[0]
abstract
```

Out[15]:
```
'Individuals with congenital amusia have a lifelong history of unreliable pitch pr
ocessing . Accordingly , they downweight pitch cues during speech perception and i
nstead rely on other dimensions such as duration . We investigated the neural basi
s for this strategy . During fMRI , individuals with amusia ( N = 15 ) and control
s ( N = 15 ) read sentences where a comma indicated a grammatical phrase boundary
. They then heard two sentences spoken that differed only in pitch and/or duration
cues and selected the best match for the written sentence . Prominent reductions i
n functional connectivity were detected in the amusia group between left prefronta
l language-related regions and right hemisphere pitch-related regions , which refl
ected the between-group differences in cue weights in the same groups of listeners
. Connectivity differences between these regions were not present during a control
task . Our results indicate that the reliability of perceptual dimensions is linke
d with functional connectivity between frontal and perceptual regions and suggest
a compensatory mechanism . '
```

In [16]:
```
print("Summary based on abstract:\n----------------------")
send_sumarize_request(abstract)
```

```
Summary based on abstract:
----------------------
Pausing for 10 secs...
OK
```

Out[16]:
```
'Individuals with congenital amusia, a lifelong condition characterized by unrelia
ble pitch processing, rely on other dimensions such as duration during speech perc
eption. A study investigating the neural basis for this strategy used fMRI to comp
are functional connectivity in individuals with amusia (N = 15) and controls (N =
15) as they read sentences with grammatical phrase boundaries and then heard two s
entences that differed only in pitch and/or duration cues, selecting the best matc
h for the written sentence. Results showed prominent reductions in functional conn
ectivity in the amusia group between left prefrontal language-related regions and
right hemisphere pitch-related regions, reflecting the between-group differences i
n cue weights. These connectivity differences were not present during a control ta
sk, indicating a specific compensation mechanism. The study suggests that the reli
ability of perceptual dimensions is linked with functional connectivity between fr
ontal and perceptual regions and that individuals with amusia develop a compensato
ry mechanism to rely on other dimensions such as duration during speech perception
due to their unreliable pitch processing.'
```

In [17]:
```
print("Summary based on full article:\n----------------------")
s_full = send_sumarize_request(item.article)
print(len(s_full))
print(len(s_full.split()))
print(s_full)
```

Summary based on full article:

Pausing for 10 secs...
OK
4484
633
Congenital amusia is a rare condition characterized by a lifelong history of unreliable pitch processing, resulting in a strategy of downweighting pitch cues during speech perception and relying on other dimensions such as duration. A study using fMRI found that individuals with amusia exhibited prominent reductions in functional connectivity between left prefrontal language-related regions and right hemisphere pitch-related regions, reflecting the between-group differences in cue weights. These connectivity differences were not present during a control task. The results suggest a compensatory mechanism for the reduced reliability of perceptual dimensions. While congenital amusia is believed to be innate, recovery is possible through training. Pitch is important for cueing categories in spoken language, conveying emotion in speech, and is usually associated with music. In highly controlled laboratory tasks, only minor deficits have been observed in amusia, and in naturalistic speech perception contexts, people with amusia rarely report any difficulties. This may be because, in natural speech, pitch variation tends to co-occur with variation in other acoustic dimensions. Our lab has shown that in such cases where multiple redundant cues are available, English-speaking individuals with amusia tend to rely less on pitch than non-amusic controls, suggesting they may calibrate their perception by down-weighting the cues that are less reliable for them. As for emotional prosody in speech, individuals with amusia can recognize emotions in spoken sentences but not in short samples such as isolated vowels. It is unknown how decreased reliance on a particular acoustic cue during speech perception is reflected in the brain. Previous neural studies of cue integration have focused on integration of multiple modalities and the 'weighted connections' model of multisensory integration, where the relative reliability of the modalities involved with perception of a stimulus is related to differential connectivity strength. For example, when participants simultaneously view and feel touches to the hand, and reliability of visual and tactile perception is manipulated experimentally via the introduction of noise, connection strength between unimodal and multimodal sensory areas adjusts accordingly. Similarly, effective connectivity between the superior temporal sulcus and visual and auditory areas has shown modulations during processing of audiovisual speech, where connection strength between auditory cortex and the STS is weaker when noise has been introduced to the auditory speech, and conversely connection strength between visual cortex and STS is weaker if visual noise is introduced. An analogous phenomenon may be at work within a single modality during multidimensional integration, such as the acoustic speech signal carrying multiple co-occurring acoustic dimensions which often provide redundant cues to disambiguate a linguistic category. Individuals with typical pitch perception have learned through a lifetime of experience with speech acoustics that vocal pitch is a useful and reliable cue, but individuals with amusia, who have unreliable perception of and memory for pitch, would have learned that, for them, pitch is not a reliable cue for processing spoken language. Thus, by analogy to the multisensory weighting results, it is hypothesized that amusics may exhibit decreased connectivity between language regions and pitch-related areas during speech processing. The neural foundations of perceptual weighting in speech have not been investigated in atypical individuals. A study using fMRI scanned 15 individuals with amusia and 15 controls and found that during speech encoding, there were no group differences in task-related activation or functional connectivity during processing of speech. However, functional connectivity between these areas was analyzed with respect to prosodic cue weights obtained outside the scanner and showed that across this subset of participants, normalized cue weights were correlated with L-DLPFC<=>R insula connectivity and L-DLPFC<=>R auditory cortex connectivity, indicating that participants who relied least on pit

ch information to process speech had the weakest functional connectivity between the se areas, while those who relied most on pitch had the strongest. These results sugg est that even non-amusics may perform dimensional reweighting of acoustic dimensions and functional connectivity.

In [18]:
```
#
```

In [19]:
```
print("Gold lay_summary:\n----------------------")
print(len(item.lay_summary))
print(len(item.lay_summary.split()))
item.lay_summary
```

```
Gold lay_summary:
----------------------
2652
469
```

Out[19]:
```
'Spoken language is colored by fluctuations in pitch and rhythm . Rather than spea king in a flat monotone , we allow our sentences to rise and fall . We vary the le ngth of syllables , drawing out some , and shortening others . These fluctuations , known as prosody , add emotion to speech and denote punctuation . In written lan guage , we use a comma or a period to signal a boundary between phrases . In speec h , we use changes in pitch – how deep or sharp a voice sounds – or in the length of syllables . Having more than one type of cue that can signal emotion or transit ions between sentences has a number of advantages . It means that people can under stand each other even when factors such as background noise obscure one set of cue s . It also means that people with impaired sound perception can still understand speech . Those with a condition called congenital amusia , for example , struggle to perceive pitch , but they can compensate for this difficulty by placing greater emphasis on other aspects of speech . Jasmin et al . showed how the brain achieves this by comparing the brain activities of people with and without amusia . Partici pants were asked to read sentences on a screen where a comma indicated a boundary between two phrases . They then heard two spoken sentences , and had to choose the one that matched the written sentence . The spoken sentences used changes in pitch and/or syllable duration to signal the position of the comma . This provided liste ners with the information needed to distinguish between "after John runs the race , . . . " and "after John runs , the race . . . " , for example . When two brain r egions communicate , they tend to increase their activity at around the same time . The brain regions are then said to show functional connectivity . Jasmin et al . found that compared to healthy volunteers , people with amusia showed less functio nal connectivity between left hemisphere brain regions that process language and r ight hemisphere regions that process pitch . In other words , because pitch is a l ess reliable source of information for people with amusia , they recruit pitch-rel ated brain regions less when processing speech . These results add to our understa nding of how brains compensate for impaired perception . This may be useful for un derstanding the neural basis of compensation in other clinical conditions . It cou ld also help us design bespoke hearing aids or other communication devices , such as computer programs that convert text into speech . Such programs could tailor th e pitch and rhythm characteristics of the speech they produce to suit the percepti on of individual users .'
```

In [20]:
```
# apply to all rows in eval miniset
text_cap = 20_000  # temporarily limit to 20k characters, set to -1 for full text

print("Summarization process started...")
```

```
df["groq_mistral_summary"] = df["article"].apply(lambda text: send_sumarize_request
print("Completed")
```

```
Summarization process started...
Sending request for text = Mature neural networks synchronize and integrate spatiote
mporal activity patterns to support cogniti
Pausing for 10 secs...
OK
Sending request for text = Many decisions are thought to arise via the accumulation
of noisy evidence to a threshold or bound .
Pausing for 10 secs...
OK
Sending request for text = Mutations in the inositol 5-phosphatase OCRL cause Lowe s
yndrome and Dent's disease . Although OCRL
Pausing for 10 secs...
OK
Sending request for text = Gradients of signaling proteins are essential for inducin
g tissue morphogenesis . However , mechanis
Pausing for 10 secs...
OK
Sending request for text = Similarity between two individuals in the combination of
genetic markers along their chromosomes ind
Pausing for 10 secs...
OK
Sending request for text = Latent Epstein-Barr virus ( EBV ) infection is causally l
inked to several human cancers . EBV expres
Pausing for 10 secs...
OK
Sending request for text = Dynamic post-translational modification of RNA polymerase
II ( RNAPII ) coordinates the co-transcrip
Pausing for 10 secs...
OK
Sending request for text = Swi2/Snf2 ATPases remodel substrates such as nucleosomes
and transcription complexes to control a wi
Pausing for 10 secs...
OK
Sending request for text = Accurate chromosome segregation depends on coordination b
etween cohesion resolution and kinetochore-
Pausing for 10 secs...
OK
Sending request for text = Streptococcus pneumoniae is a leading cause of invasive d
isease in infants , especially in low-incom
Pausing for 10 secs...
OK
Sending request for text = C4 photosynthesis has independently evolved from the ance
stral C3 pathway in at least 60 plant linea
Pausing for 10 secs...
OK
Sending request for text = Host shutoff is a common strategy used by viruses to repr
ess cellular mRNA translation and concomita
Pausing for 10 secs...
OK
Sending request for text = The transcription factor RpaA is the master regulator of
circadian transcription in cyanobacteria ,
Pausing for 10 secs...
OK
Sending request for text = Coiled coils are the best-understood protein fold , as th
eir backbone structure can uniquely be desc
Pausing for 10 secs...
```

```
OK
Sending request for text = Hemoglobin ( Hb ) represents a model protein to study mol
ecular adaptation in vertebrates . Although
Pausing for 10 secs...
OK
Sending request for text = We report a functional switching valve within the female
genitalia of the Brazilian cave insect Neot
Pausing for 10 secs...
OK
Sending request for text = Previous studies tracking AMPA receptor ( AMPAR ) diffusi
on at synapses observed a large mobile extr
Pausing for 10 secs...
OK
Sending request for text = Histone acetylation and deposition of H2A . Z variant are
integral aspects of active transcription .
Pausing for 10 secs...
OK
Sending request for text = Membrane nanodomains have been implicated in Ras signalin
g , but what these domains are and how they
Pausing for 10 secs...
OK
Sending request for text = This is an analysis of how magnetic fields affect biologi
cal molecules and cells . It was prompted b
Pausing for 10 secs...
OK
Sending request for text = Individuals with congenital amusia have a lifelong histor
y of unreliable pitch processing . Accordin
Pausing for 10 secs...
OK
Sending request for text = NCOA4 is a selective cargo receptor for the autophagic tu
rnover of ferritin , a process critical for
Pausing for 10 secs...
OK
Sending request for text = ISG15 is an interferon-stimulated , linear di-ubiquitin-l
ike protein , with anti-viral activity . Th
Pausing for 10 secs...
OK
Sending request for text = Temporal experience of odor gradients is important in spa
tial orientation of animals . The fruit fly
Pausing for 10 secs...
OK
Completed
```

In [21]:
```python
# check how many rows have blank result (some errors)
empty_df = df.query("groq_mistral_summary.str.strip() == ''")
print(len(empty_df))
```

```
0
```

In [22]:
```python
# attempt to retry for blank rows (due to some errors)
retry = True
if retry:
    print("Retrying for empty results...")
    for i in range(len(df)):
        item = df.iloc[i]
        if item["groq_mistral_summary"] == "":
```

```
            print("Item =", i)
            text = item["article"]
            df.at[i, "groq_mistral_summary"] = send_sumarize_request(text[:text_cap
    print("Completed")
```

```
Retrying for empty results...
Completed
```

In [23]:
```
df
```

Out[23]:

	lay_summary	article	headings	keywords	id	groq_mistral_summ
0	It can take several months , or even years , f...	Mature neural networks synchronize and integra...	[Abstract, Introduction, Results, Discussion, ...	[neuroscience]	elife-69011-v2	The developmer neural networks f an im
1	Many of our decisions are made on the basis of...	Many decisions are thought to arise via the ac...	[Abstract, Introduction, Results, Discussion, ...	[neuroscience]	elife-17688-v1	The article discu how decisions are m
2	Oculo-Cerebro-Renal syndrome of Lowe (Lowe sy...	Mutations in the inositol 5-phosphatase OCRL c...	[Abstract, Introduction, Results, Discussion, ...	[cell biology]	elife-02975-v2	Mutations in inositol 5-phospha OCR
3	When an embryo develops , its cells must work ...	Gradients of signaling proteins are essential ...	[Abstract, Introduction, Results, Discussion, ...	[developmental biology]	elife-38137-v3	The distributio signaling proteins,
4	Our genomes contain a record of historical eve...	Similarity between two individuals in the comb...	[Abstract, Introduction, Results, Discussion, ...	[evolutionary biology, genetics and genomics]	elife-15266-v1	The article discusses use of genetic mar
5	Over 90% of adults around the world are infect...	Latent Epstein-Barr virus (EBV) infection is...	[Abstract, Introduction, Results, Discussion, ...	[microbiology and infectious disease, cancer b...	elife-22509-v2	Epstein-Barr virus (E is a widespr hum
6	Genes are sections of DNA that encode the inst...	Dynamic post-translational modification of RNA...	[Abstract, Introduction, Results, Discussion, ...	[chromosomes and gene expression, computationa...	elife-11215-v2	The C-terminal don (CTD) of F polymeras
7	An organism's DNA contains thousands of genes ...	Swi2/Snf2 ATPases remodel substrates such as n...	[Abstract, Introduction, Results, Discussion, ...	[structural biology and molecular biophysics]	elife-07432-v2	The Swi2/Snf2 ATPa are a large and div
8	Human reproductive cells—eggs and sperm—are pr...	Accurate chromosome segregation depends on coo...	[Abstract, Introduction, Results, Discussion, ...	[chromosomes and gene expression, cell biology]	elife-01133-v1	In mammalian oocy Shugoshin-like pro
9	Microorganisms live in most	Streptococcus pneumoniae is	[Abstract, Introduction,	[microbiology and infectious	elife-26255-	The bacter Streptoco

	lay_summary	article	headings	keywords	id	groq_mistral_summ
	parts of our body ...	a leading cause of...	Results, Discussion, ...	disease, genetics...	v2	pneumoniae, a le
10	Plants rely on carbon for their growth and sur...	C4 photosynthesis has independently evolved fr...	[Abstract, Introduction, Results, Discussion, ...	[plant biology]	elife-00961-v1	C4 photosynthes complex trait foun
11	Proteins carry out diverse activities in our c...	Host shutoff is a common strategy used by viru...	[Abstract, Introduction, Results, Discussion, ...	[computational and systems biology, microbiolo...	elife-18311-v2	Influenza A virus (IA a negative-sense
12	The cycle of day and night is one of the most ...	The transcription factor RpaA is the master re...	[Abstract, Introduction, Results, Discussion, ...	[short report, biochemistry and chemical biolo...	elife-23210-v1	The transcription fa RpaA is the master
13	Proteins are made up of building blocks called...	Coiled coils are the best-understood protein f...	[Abstract, Introduction, Results and discussio...	[structural biology and molecular biophysics]	elife-11861-v2	Coiled coils are v understood pro fol
14	In humans and other mammals , a protein in the...	Hemoglobin (Hb) represents a model protein t...	[Abstract, Introduction, Results, Discussion, ...	[biochemistry and chemical biology]	elife-47640-v1	Hemoglobin (Hb) tetrameric allost p
15	In dry caves of southeastern Brazil , live a g...	We report a functional switching valve within ...	[Abstract, Introduction, Results, Discussion, ...	[evolutionary biology]	elife-39563-v2	The Brazilian cave in Neotrogla has a fu
16	Forgetting is a common experience in our every...	Previous studies tracking AMPA receptor (AMPA...	[Abstract, Introduction, Results, Discussion, ...	[structural biology and molecular biophysics, ...	elife-27744-v3	The study used su resolution microsc t
17	Cells contain a large number of proteins that ...	Histone acetylation and deposition of H2A . Z ...	[Abstract, Introduction, Results, Discussion, ...	[chromosomes and gene expression, genetics and...	elife-56325-v1	In Drosophila, Domino (D chromatin re
18	The Ras family of proteins play an important r...	Membrane nanodomains have been implicated in R...	[Abstract, Introduction, Results, Discussion, ...	[structural biology and molecular biophysics, ...	elife-46393-v2	The paper reveals l membrane organiza

	lay_summary	article	headings	keywords	id	groq_mistral_summ
19	How biological systems interact with magnetic ...	This is an analysis of how magnetic fields aff...	[Abstract, Introduction, Results, Discussion, ...	[short report, physics of living systems, neur...	elife-17210-v3	The analysis preser here evaluates rec
20	Spoken language is colored by fluctuations in ...	Individuals with congenital amusia have a life...	[Abstract, Introduction, Results, Discussion, ...	[neuroscience]	elife-53539-v2	Individuals congenital amus condi
21	The cells of nearly all organisms need iron as...	NCOA4 is a selective cargo receptor for the au...	[Abstract, Introduction, Results, Discussion, ...	[cell biology]	elife-10308-v1	NCOA4 is a selec cargo receptor mec
22	Listeria monocytogenes is a bacterium that can...	ISG15 is an interferon-stimulated , linear di-...	[Abstract, Introduction, Results, Discussion, ...	[cell biology, microbiology and infectious dis...	elife-06848-v1	ISG15 is an interfer stimulated, linear di
23	Fruit flies are attracted to the smell of rott...	Temporal experience of odor gradients is impor...	[Abstract, Introduction, Results, Discussion, ...	[short report, neuroscience]	elife-06651-v2	The fruit fly, Drosop melanogaster, is c

In [24]:
```
output_path = "./data/output/mini_dev_set/"
output_filename = "elife_groq_mistral_summary.csv"

print("Writing to file ", output_filename)
df.to_csv(output_path+output_filename,
          index = False
         )
print("Completed")
```

```
Writing to file  elife_groq_mistral_summary.csv
Completed
```

In [25]:
```
output_filename = "elife_groq_mistral_summary.json"

print("Writing to file ", output_filename)
df.to_json(output_path+output_filename,
           orient="records",
           )
print("Completed")
```

```
Writing to file  elife_groq_mistral_summary.json
Completed
```

In [26]:
```
# process the PLOS dataset:
dev_df_filename = "../../data/mini_dataset/PLOS_val_mini.jsonl"
```

```
df = pd.read_json(dev_df_filename,
                  orient="records",
                  lines=True
                 )
df.head()
```

Out[26]:

	lay_summary	article	headings	keywords	id
0	Yersinia pestis , the bacterial agent of plagu...	Fleas can transmit Yersinia pestis by two mech...	[Abstract, Introduction, Results, Discussion, ...	[united states, invertebrates, medicine and he...	journal.ppat.1006859
1	The genome of all vertebrates is heavily colon...	Endogenous retroviruses (ERVs) are remnants ...	[Abstract, Introduction, Results, Discussion, ...	[viruses, sheep, virology]	journal.ppat.0030170
2	The molecular mechanisms underlying directed c...	The Drosophila embryonic gonad is assembled fr...	[Abstract, Introduction, Results, Discussion, ...	[]	journal.pgen.1003720
3	Contrary to the long-standing belief that no n...	Recently , we presented a study of adult neuro...	[Abstract, Introduction, Model, Results, Discu...	[computational biology/computational neuroscie...	journal.pcbi.1001063
4	Embryonic stem cells have two remarkable prope...	Understanding the transcriptional regulation o...	[Abstract, Introduction, Results, Discussion, ...	[developmental biology, cell biology, mammals,...	journal.pgen.0030145

In [27]:

```
# apply to all rows in eval miniset
text_cap = 20_000  # temporarily limit to 20k characters, set to -1 for full text

print("Summarization process started...")
df["groq_mistral_summary"] = df["article"].apply(lambda text: send_sumarize_request
print("Completed")
```

```
Summarization process started...
Sending request for text = Fleas can transmit Yersinia pestis by two mechanisms , ea
rly-phase transmission ( EPT ) and biofilm-
Pausing for 10 secs...
OK
Sending request for text = Endogenous retroviruses ( ERVs ) are remnants of ancient
retroviral infections of the host germline
Pausing for 10 secs...
OK
Sending request for text = The Drosophila embryonic gonad is assembled from two dist
inct cell types , the Primordial Germ Cells
Pausing for 10 secs...
OK
Sending request for text = Recently , we presented a study of adult neurogenesis in
a simplified hippocampal memory model . The
Pausing for 10 secs...
OK
Sending request for text = Understanding the transcriptional regulation of pluripote
nt cells is of fundamental interest and wil
Pausing for 10 secs...
OK
Sending request for text = The current model of hepatitis C virus ( HCV ) production
involves the assembly of virions on or nea
Pausing for 10 secs...
OK
Sending request for text = Secondary amphiphilicity is inherent to the secondary str
uctural elements of proteins . By forming e
Pausing for 10 secs...
OK
Sending request for text = Herein , we studied a virulent isolate of the leading bac
terial pathogen Streptococcus pneumoniae in
Pausing for 10 secs...
OK
Sending request for text = HIV is known to spread efficiently both in a cell-free st
ate and from cell to cell , however the rel
Pausing for 10 secs...
OK
Sending request for text = An increasing number of genetic variants have been identi
fied for many complex diseases . However ,
Pausing for 10 secs...
OK
Sending request for text = The Saccharomyces cerevisae RAD3 gene is the homolog of h
uman XPD , an essential gene encoding a DNA
Pausing for 10 secs...
OK
Sending request for text = A budget proposal to stop the U . S . Centers for Disease
Control and Prevention ( CDC ) funding in
Pausing for 10 secs...
OK
Sending request for text = Insulator or enhancer-blocking elements are proposed to p
lay an important role in the regulation of
Pausing for 10 secs...
OK
Sending request for text = Ebolaviruses , highly lethal zoonotic pathogens , possess
longer genomes than most other non-segment
Pausing for 10 secs...
```

```
OK
Sending request for text = Studies of the furious and paralytic forms of canine rabi
es at the early stage of disease have shown
Pausing for 10 secs...
OK
Sending request for text = Replication fork integrity , which is essential for the m
aintenance of genome stability , is monitor
Pausing for 10 secs...
OK
Sending request for text = Polyarthritis and rash caused by Sindbis virus ( SINV ) ,
was first recognised in northern Europe ab
Pausing for 10 secs...
OK
Sending request for text = With the post-genomic era came a dramatic increase in hig
h-throughput technologies , of which transc
Pausing for 10 secs...
OK
Sending request for text = Centromeres are the attachment points between the genome
and the cytoskeleton: centromeres bind to k
Pausing for 10 secs...
OK
Sending request for text = Humans are a diploid species that inherit one set of chro
mosomes paternally and one homologous set o
Pausing for 10 secs...
OK
Sending request for text = In contrast to HIV infection in humans and SIV in macaque
s , SIV infection of natural hosts includin
Pausing for 10 secs...
OK
Sending request for text = Individuals choose their mates so as to maximize reproduc
tive success , and one important component
Pausing for 10 secs...
OK
Sending request for text = Breast cancers that are “triple-negative” for the clinica
l markers ESR1 , PGR , and HER2 typically b
Pausing for 10 secs...
OK
Sending request for text = Pathogen-associated secretion systems translocate numerou
s effector proteins into eukaryotic host ce
Pausing for 10 secs...
OK
Sending request for text = The inference of regulatory interactions and quantitative
models of gene regulation from time-series
Pausing for 10 secs...
OK
Sending request for text = Soil-transmitted helminth ( STH ) infections ( i . e . ,
Ascaris lumbricoides , hookworm , and Trich
Pausing for 10 secs...
OK
Sending request for text = Prompt post-exposure prophylaxis ( PEP ) is essential in
preventing the fatal onset of disease in pe
Pausing for 10 secs...
OK
Sending request for text = Uganda has active foci of both chronic and acute HAT with
the acute zoonotic form of disease classic
Pausing for 10 secs...
```

```
OK
Sending request for text = Dietary restriction ( DR ) extends lifespan in various sp
ecies and also slows the onset of age-relat
Pausing for 10 secs...
OK
Sending request for text = The unique capability of acetogens to ferment a broad ran
ge of substrates renders them ideal candida
Pausing for 10 secs...
OK
Sending request for text = Arabidopsis thaliana cryptochrome 2 ( CRY2 ) mediates lig
ht control of flowering time . CIB1 ( CRY2-
Pausing for 10 secs...
OK
Sending request for text = Enteric bacterial pathogens cause food borne disease , wh
ich constitutes an enormous economic and he
Pausing for 10 secs...
OK
Sending request for text = High-altitude hypoxia ( reduced inspired oxygen tension d
ue to decreased barometric pressure ) exert
Pausing for 10 secs...
OK
Sending request for text = Machupo virus ( MACV ) , a New World arenavirus , is the
etiological agent of Bolivian hemorrhagic f
Pausing for 10 secs...
OK
Sending request for text = Serological tests for IgM and IgG are routinely used in c
linical laboratories for the rapid diagnosi
Pausing for 10 secs...
OK
Sending request for text = Toll/interleukin-1 receptor ( TIR ) domains in Toll-like
receptors are essential for initiating and
Pausing for 10 secs...
OK
Sending request for text = Protein modifications play a major role for most biologic
al processes in living organisms . Amino-te
Pausing for 10 secs...
OK
Sending request for text = Exosomes can transfer genetic materials between cells . T
heir roles in viral infections are beginnin
Pausing for 10 secs...
OK
Sending request for text = According to recent experimental evidence , the interacti
on between chromatin loops , which can be c
Pausing for 10 secs...
OK
Sending request for text = Predicting the dynamic behavior of a large network from t
hat of the composing modules is a central p
Pausing for 10 secs...
OK
Sending request for text = The 5-year survival of non-small cell lung cancer patient
s can be as low as 1% in advanced stages .
Pausing for 10 secs...
OK
Sending request for text = The mechanisms and treatment of psychomotor retardation ,
which includes motor and cognitive impairm
Pausing for 10 secs...
```

```
OK
Sending request for text = Natural selection drives populations towards higher fitne
ss , but crossing fitness valleys or platea
Pausing for 10 secs...
OK
Sending request for text = The nuclear pore complex ( NPC ) regulates molecular traf
fic across the nuclear envelope ( NE ) . Se
Pausing for 10 secs...
OK
Sending request for text = Staphylococcus aureus is an opportunistic pathogen that c
olonizes the skin and mucosal surfaces of m
Pausing for 10 secs...
OK
Sending request for text = The Type II Secretion System ( T2SS ) is a molecular mach
ine that drives the secretion of fully-fold
Pausing for 10 secs...
OK
Sending request for text = Burkholderia pseudomallei is a mostly saprophytic bacteri
um , but can infect humans where it causes
Pausing for 10 secs...
OK
Sending request for text = Offspring of Schistosoma mansoni-infected women in schist
osomiasis-endemic areas may be sensitised i
Pausing for 10 secs...
OK
Sending request for text = Hox proteins play fundamental roles in controlling morpho
genetic diversity along the anterior–poster
Pausing for 10 secs...
OK
Sending request for text = The antiproliferative response to anticancer treatment is
the result of concurrent responses in all
Pausing for 10 secs...
OK
Sending request for text = Horizontal acquisition of DNA by bacteria dramatically in
creases genetic diversity and hence success
Pausing for 10 secs...
OK
Sending request for text = HIV-1 vaccines designed to date have failed to elicit neu
tralizing antibodies ( Nabs ) that are capa
Pausing for 10 secs...
OK
Sending request for text = Approaches based on linear mixed models ( LMMs ) have rec
ently gained popularity for modelling popul
Pausing for 10 secs...
OK
Sending request for text = Transient associations among neurons are thought to under
lie memory and behavior . However , little
Pausing for 10 secs...
OK
Sending request for text = Polarized growth is maintained by both polarized exocytos
is , which transports membrane components t
Pausing for 10 secs...
OK
Sending request for text = Miltefosine , an anti-cancer drug that has been successfu
lly repositioned for treatment of Leishmani
Pausing for 10 secs...
```

```
OK
Sending request for text = In neurons polarized trafficking of vesicle-bound membran
e proteins gives rise to the distinct molec
Pausing for 10 secs...
OK
Sending request for text = The consensus that complexity begets stability in ecosyst
ems was challenged in the seventies , a res
Pausing for 10 secs...
OK
Sending request for text = Vibrio cholerae is a bacterial pathogen that colonizes th
e chitinous exoskeleton of zooplankton as w
Pausing for 10 secs...
OK
Sending request for text = Marburg virus , the Kaposi's sarcoma-associated herpesvir
us ( KSHV ) and Dengue virus all activate ,
Pausing for 10 secs...
OK
Sending request for text = The development of new drugs against Chagas disease is a
priority since the currently available medi
Pausing for 10 secs...
OK
Sending request for text = Bistability plays a central role in the gene regulatory n
etworks ( GRNs ) controlling many essential
Pausing for 10 secs...
OK
Sending request for text = Even in the absence of an adaptive immune system in murin
e models , lymphatic dilatation and dysfunc
Pausing for 10 secs...
OK
Sending request for text = Plant-pathogenic Xanthomonas bacteria secrete transcripti
on activator-like effectors ( TALEs ) into
Pausing for 10 secs...
OK
Sending request for text = The evolution of new gene networks is a primary source of
genetic innovation that allows bacteria to
Pausing for 10 secs...
OK
Sending request for text = Two-component signaling systems are ubiquitous in bacteri
a , Archaea and plants and play important r
Pausing for 10 secs...
OK
Sending request for text = The bacterial replication cycle is driven by the DnaA pro
tein which cycles between the active ATP-bo
Pausing for 10 secs...
OK
Sending request for text = The rat demyelination ( dmy ) mutation serves as a unique
model system to investigate the maintenanc
Pausing for 10 secs...
OK
Sending request for text = Leishmaniasis is an important disease that affects 12 mil
lion people in 88 countries , with 2 millio
Pausing for 10 secs...
OK
Sending request for text = To gain a more detailed picture of cryptococcosis in Thai
land , a retrospective study of 498 C . neo
Pausing for 10 secs...
```

OK
Sending request for text = Scabies is one of the commonest dermatological conditions globally; however it is a largely underexp
Pausing for 10 secs...
OK
Sending request for text = The type III interferon (IFNλ) receptor IL-28R is abundantly expressed in the respiratory tract an
Pausing for 10 secs...
OK
Sending request for text = Neural networks with a single plastic layer employing reward modulated spike time dependent plastici
Pausing for 10 secs...
OK
Sending request for text = Genome-wide association studies (GWAS) have been fruitful in identifying disease susceptibility lo
Pausing for 10 secs...
OK
Sending request for text = Leishmaniasis is endemic in 98 countries with an estimated 350 million people at risk and approximat
Pausing for 10 secs...
OK
Sending request for text = IKAROS is a critical regulator of hematopoietic cell fate and its dynamic expression pattern is requ
Pausing for 10 secs...
OK
Sending request for text = Mitochondria originated from proteobacterial endosymbionts , and their transition to organelles was
Pausing for 10 secs...
OK
Sending request for text = Genetic factors play an important role in the etiology of both sporadic and familial breast cancer .
Pausing for 10 secs...
OK
Sending request for text = Understanding complex networks of protein-protein interactions (PPIs) is one of the foremost chall
Pausing for 10 secs...
OK
Sending request for text = Buruli ulcer (BU) , caused by infection with Mycobacterium ulcerans , is a chronic necrotizing hum
Pausing for 10 secs...
OK
Sending request for text = The mosquito Aedes aegypti , vector of dengue , chikungunya and yellow fever viruses , is an importa
Pausing for 10 secs...
OK
Sending request for text = Mean-field approximations are a powerful tool for studying large neural networks . However , they do
Pausing for 10 secs...
OK
Sending request for text = A major problem in biology is to understand how complex tissue shapes may arise through growth . In
Pausing for 10 secs...
OK
Sending request for text = Ophthalmo-acromelic syndrome (OAS) , also known as Waardenburg Anophthalmia syndrome , is defined
Pausing for 10 secs...

```
OK
Sending request for text = The Drosophila genes spalt major ( salm ) and spalt-relat
ed ( salr ) encode Zn-finger transcription
Pausing for 10 secs...
OK
Sending request for text = Sensory systems adapt their neural code to changes in the
sensory environment , often on multiple ti
Pausing for 10 secs...
OK
Sending request for text = While the roles of rpoSBb and RpoS-dependent genes have b
een studied extensively within the mammal ,
Pausing for 10 secs...
OK
Sending request for text = Two-cysteine peroxiredoxins are ubiquitous peroxidases th
at play various functions in cells . In Lei
Pausing for 10 secs...
OK
Sending request for text = Microbial metabolism of plant polysaccharides is an impor
tant part of environmental carbon cycling ,
Pausing for 10 secs...
OK
Sending request for text = Glanders , caused by the gram-negative bacterium Burkhold
eria mallei , is a highly infectious zoonot
Pausing for 10 secs...
OK
Sending request for text = Observations gained from model organisms are essential ,
yet it remains unclear to which degree they
Pausing for 10 secs...
OK
Sending request for text = The 3D organization of chromosomes is crucial for regulat
ing gene expression and cell function . Man
Pausing for 10 secs...
OK
Sending request for text = Toxoplasma is an obligate intracellular parasite that rep
licates in mammalian cells within a parasit
Pausing for 10 secs...
OK
Sending request for text = The BMP signaling pathway has a conserved role in dorsal-
ventral axis patterning during embryonic de
Pausing for 10 secs...
OK
Sending request for text = The mitochondrial protein repertoire varies depending on
the cellular state . Protein component modi
Pausing for 10 secs...
OK
Sending request for text = The dissociation mechanism of the thioredoxin ( Trx ) mix
ed disulfide complexes is unknown and has b
Pausing for 10 secs...
OK
Sending request for text = Pathophysiological mechanisms are still incompletely unde
rstood for leprosy , an urgent public healt
Pausing for 10 secs...
OK
Sending request for text = Metagenomic sequencing of patient samples is a very promi
sing method for the diagnosis of human infe
Pausing for 10 secs...
```

```
OK
Sending request for text = Environmental exposures filtered through the genetic make
-up of each individual alter the transcript
Pausing for 10 secs...
OK
Sending request for text = Every instant of perception depends on a cascade of brain
processes calibrated to the history of sen
Pausing for 10 secs...
OK
Sending request for text = Examples of animals evolving similar traits despite the a
bsence of that trait in the last common anc
Pausing for 10 secs...
OK
Sending request for text = Human papillomaviruses ( HPVs ) are DNA viruses associate
d with major human cancers . As such there
Pausing for 10 secs...
OK
Sending request for text = Orofacial clefting is amongst the most common of birth de
fects , with both genetic and environmental
Pausing for 10 secs...
OK
Sending request for text = The mechanisms of hypoxic injury to the developing human
brain are poorly understood , despite being
Pausing for 10 secs...
OK
Sending request for text = Filarial nematodes maintain a mutualistic relationship wi
th the endosymbiont Wolbachia . Depletion o
Pausing for 10 secs...
OK
Sending request for text = Genetic reassortment between influenza A viruses ( IAVs )
facilitate emergence of pandemic strains ,
Pausing for 10 secs...
OK
Sending request for text = The Saccharomyces cerevisiae polo-like kinase Cdc5 promot
es adaptation to the DNA damage checkpoint
Pausing for 10 secs...
OK
Sending request for text = Sequences of higher frequency A and lower frequency B ton
es repeating in an ABA- triplet pattern are
Pausing for 10 secs...
OK
Sending request for text = Recent interest in male-based sterile insect technique (
SIT ) and incompatible insect technique ( I
Pausing for 10 secs...
OK
Sending request for text = Hematophagous mosquitos and ticks avoid host hemostatic s
ystem through expression of enzyme inhibito
Pausing for 10 secs...
OK
Sending request for text = In mammals , dosage compensation is achieved by doubling
expression of X-linked genes in both sexes
Pausing for 10 secs...
OK
Sending request for text = The opportunistic human fungal pathogen , Candida albican
s , undergoes morphological and transcripti
Pausing for 10 secs...
```

```
OK
Sending request for text = Egress of newly assembled herpesvirus particles from infe
cted cells is a highly dynamic process invo
Pausing for 10 secs...
OK
Sending request for text = The variants of human influenza virus have caused , and c
ontinue to cause , substantial morbidity an
Pausing for 10 secs...
OK
Sending request for text = Protozoan parasites of the genus Leishmania alternate bet
ween flagellated , elongated extracellular
Pausing for 10 secs...
OK
Sending request for text = To further investigate the importance of insulin signalin
g in the growth , development , sexual matu
Pausing for 10 secs...
OK
Sending request for text = Primate lentivirus nef is required for sustained virus re
plication in vivo and accelerated progressi
Pausing for 10 secs...
OK
Sending request for text = The RNA polymerase II ( Pol II ) is a eukaryotic enzyme t
hat catalyzes the synthesis of the messenge
Pausing for 10 secs...
OK
Sending request for text = Visual object recognition and sensitivity to image featur
es are largely influenced by contextual inp
Pausing for 10 secs...
OK
Sending request for text = Lectin-like bacteriotoxic proteins , identified in severa
l plant-associated bacteria , are able to s
Pausing for 10 secs...
OK
Sending request for text = The genomic GC-content of bacteria varies dramatically ,
from less than 20% to more than 70% . This
Pausing for 10 secs...
OK
Sending request for text = The expansion of CAG/CTG repeats is responsible for many
diseases , including Huntington's disease (
Pausing for 10 secs...
OK
Sending request for text = Research on Neglected Tropical Diseases ( NTDs ) has incr
eased in recent decades , and significant n
Pausing for 10 secs...
OK
Sending request for text = Chagas disease is the most important vector-borne disease
in Latin America . Regional initiatives ba
Pausing for 10 secs...
OK
Sending request for text = The weight with which a specific outcome feature contribu
tes to preference quantifies a person’s ‘ta
Pausing for 10 secs...
OK
Sending request for text = Rice is an important monocotyledonous crop worldwide; it
differs from the dicotyledonous plant Arabi
Pausing for 10 secs...
```

```
OK
Sending request for text = The long noncoding MALAT1 RNA is upregulated in cancer ti
ssues and its elevated expression is associ
Pausing for 10 secs...
OK
Sending request for text = The majority of HIV-1 infections in women occur through v
aginal intercourse , in which virus-contain
Pausing for 10 secs...
OK
Sending request for text = The evolutionary origins of genetic robustness are still
under debate: it may arise as a consequence
Pausing for 10 secs...
OK
Sending request for text = Histone chaperones CAF-1 and Asf1 function to deposit new
ly synthesized histones onto replicating DN
Pausing for 10 secs...
OK
Sending request for text = Vaccination is an effective method to protect against inf
ectious diseases . An important considerati
Pausing for 10 secs...
OK
Sending request for text = Changes in genomic DNA methylation patterns are generally
assumed to play an important role in the e
Pausing for 10 secs...
OK
Sending request for text = The PR interval on the electrocardiogram reflects atrial
and atrioventricular nodal conduction time
Pausing for 10 secs...
OK
Sending request for text = Inhibitory interneurons play critical roles in shaping th
e firing patterns of principal neurons in m
Pausing for 10 secs...
OK
Sending request for text = The BRCA Challenge is a long-term data-sharing project in
itiated within the Global Alliance for Geno
Pausing for 10 secs...
OK
Sending request for text = The small GTPase RAS is among the most prevalent oncogene
s . The evolutionarily conserved RAF-MEK-MA
Pausing for 10 secs...
OK
Sending request for text = Recent years have seen the development of numerous method
ologies for reconstructing transmission tre
Pausing for 10 secs...
OK
Sending request for text = Hyperendemic circulation of all four types of dengue viru
s ( DENV-1-4 ) has expanded globally , fuel
Pausing for 10 secs...
OK
Completed
```

In [28]:
```
# check how many rows have blank result (some errors)
empty_df = df.query("groq_mistral_summary.str.strip() == ''")
print(len(empty_df))
```

```
0
```

In [29]:
```
# attempt to retry for blank rows (due to some errors)
retry = True
if retry:
    print("Retrying for empty results...")
    for i in range(len(df)):
        item = df.iloc[i]
        if item["groq_mistral_summary"] == "":
            print("Item =", i)
            text = item["article"]
            df.at[i, "groq_mistral_summary"] = send_sumarize_request(text[:text_cap
    print("Completed")
```

```
Retrying for empty results...
Completed
```

In [30]:
```
df.head()
```

Out[30]:

	lay_summary	article	headings	keywords	id	gr
0	Yersinia pestis , the bacterial agent of plagu...	Fleas can transmit Yersinia pestis by two mech...	[Abstract, Introduction, Results, Discussion, ...	[united states, invertebrates, medicine and he...	journal.ppat.1006859	
1	The genome of all vertebrates is heavily colon...	Endogenous retroviruses (ERVs) are remnants ...	[Abstract, Introduction, Results, Discussion, ...	[viruses, sheep, virology]	journal.ppat.0030170	
2	The molecular mechanisms underlying directed c...	The Drosophila embryonic gonad is assembled fr...	[Abstract, Introduction, Results, Discussion, ...	[]	journal.pgen.1003720	
3	Contrary to the long-standing belief that no n...	Recently , we presented a study of adult neuro...	[Abstract, Introduction, Model, Results, Discu...	[computational biology/computational neuroscie...	journal.pcbi.1001063	re
4	Embryonic stem cells have two remarkable prope...	Understanding the transcriptional regulation o...	[Abstract, Introduction, Results, Discussion, ...	[developmental biology, cell biology, mammals,...	journal.pgen.0030145	

In [31]:
```
output_path = "./data/output/mini_dev_set/"
output_filename = "plos_groq_mistral_summary.csv"

print("Writing to file ", output_filename)
df.to_csv(output_path+output_filename,
          index = False
```

```
        )
print("Completed")
```

```
Writing to file  plos_groq_mistral_summary.csv
Completed
```

In [32]:
```
output_filename = "plos_groq_mistral_summary.json"

print("Writing to file ", output_filename)
df.to_json(output_path+output_filename,
           orient="records",
           )
print("Completed")
```

```
Writing to file  plos_groq_mistral_summary.json
Completed
```

In [ ]:
```

```