SOP for understanding cough and labeling of continuous audio files using a multi-tier cough system

Hyfe Validation Documentation, 2023

This document contains **31** pages
Approximate reading time: 40 min.

This SOP contains a section on cough and a section on the software we use for labeling continuous audio recordings. Read the document in full at least twice to make sure you understand both parts.

DISCLAIMER: the audio content that is being annotated is highly confidential and anyone using these instructions must treat the audio content confidentially and be trained in how to Safeguard Confidential Information including completing online confidentiality training, link here.

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NOTE: the audio content might contain sensitive information that you must never cut out, export, share or use in any way besides the labeling instructions and/or as specified in the agreement.

I. Definition of cough

A cough is a reflex reaction to some stimulation or deformation in the airway. Cough is a common symptom of respiratory disease and irritation, by which the body expels material from the respiratory tract. Beyond its protective function, cough can also facilitate the transmission of multiple respiratory pathogens and is a good proxy of chronic disease progression which makes automated cough monitoring attractive for clinicians and scientists.

To understand the cough - it is important to go over 4 anatomical structures:

1. **Pharynx** (also called throat) - a passage from oral and nasal cavities in the head to the esophagus (for food and drinks) and larynx (for air).

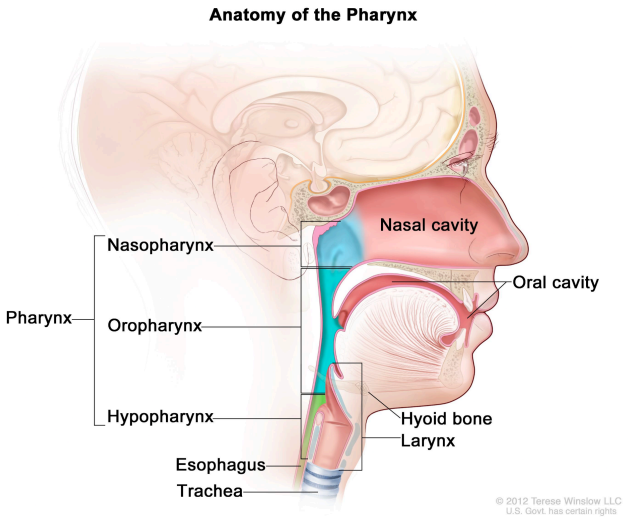


Fig. 1 *Anatomy of the pharynx (throat), taken from the [National Cancer Institute](#).*

2. **Larynx** - area containing vocal cords and used for breathing, swallowing, and talking.
3. **Epiglottis** - a small movable “lid” above the larynx. It prevents food and fluids from entering your windpipe *(also called trachea)*.

   During swallowing: the larynx elevates and moves forward, acts as a mechanical lever. This action causes the epiglottis to flap over the windpipe (trachea) and protect the airway.

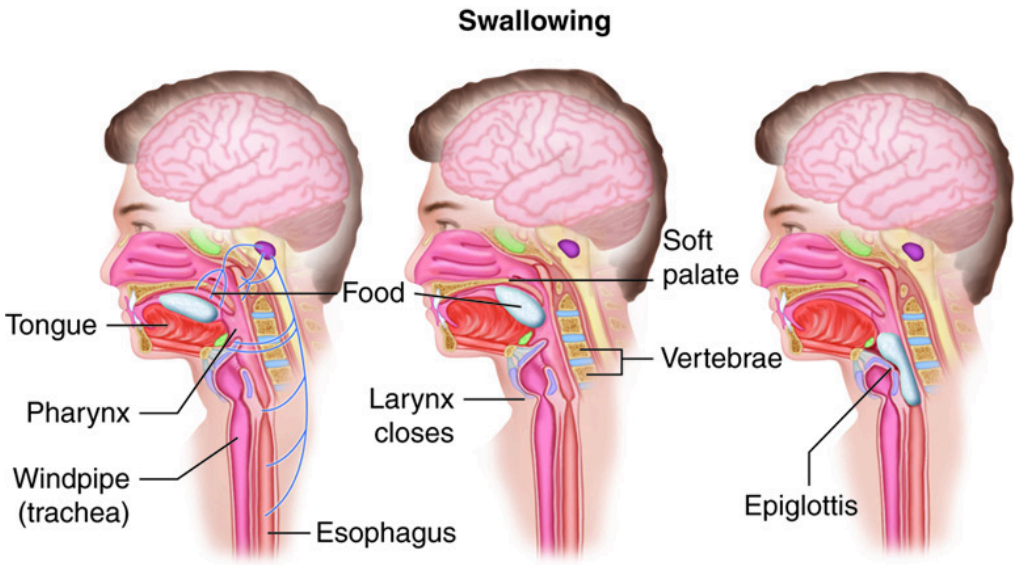


Fig. 2 *Anatomy of trachea (windpipe) and swallowing process, taken from the PharmaCampus.*

4. **Vocal cords** - two bands of muscle tissue, found in the larynx. Air from the lung passes through them to produce vocal sounds. *(see video of vocal cords here)*

II. How does a cough occur?

For a cough to occur - several events take place in sequence (video link):

- Vocal cords open wide, allowing additional air to be inhaled through the pharynx and larynx into the lungs.
- Epiglottis closes up the trachea and simultaneously abdominal and rib muscles contract = increasing the pressure behind the epiglottis.
- With increased pressure - epiglottis opens and air moves very quickly past the vocal cords and creates a “rushing” sound - this is called the expulsive phase of cough.

NOTE: these SOPs have two terms that need to be clearly defined:

- Explosive sound - defines any explosive sound, including coughs. Hyfe is using peak detection to record (any) explosive sounds and then checks if those sounds are coughs.
- Expulsive phase - defines an expulsive phase in a cough (expulsion of air), which is a relevant finding for us in identifying coughs while annotating continuous audio recordings.

III. Vocal cords in cough

As vocal cords are involved in the process of coughing, it is valuable to understand how the vibrations and movements of the vocal cords impact the cough sound.

A) Cough with a double sound **B)** Cough with a single sound

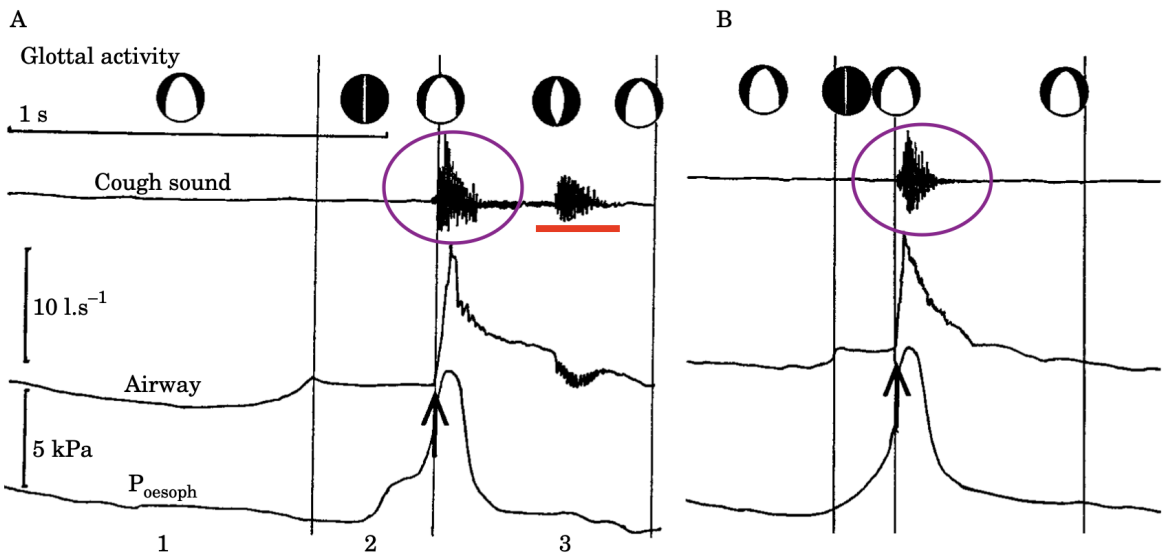


Fig. 3 *Vocal cords and sounds, taken from Korpas et al. [1].*
(refer to the image columns above - 3 expulsive cough phase)

For labeling audio files correctly, the most important part is to understand and identify the expulsive cough phase (circled in purple), and differentiate it with the vocal cough element (red underline) inside it - both will be labeled as one cough.

- In the expulsive phase of cough (first half of number 3, circled in purple) - at the moment of glottal opening - the first burst of sound happens.
- It is followed by a noisy interval with a steady-state flow of air (usually audible in the file) with the glottis wide open.
- Glottis narrows at the end of the expulsive phase, the vocal cords relax and vibrate - which generates the second, vocal phase of cough sound - vocal element of the cough (red underline in the picture A, second half of column 3). Note - this vocal element could be absent - as in picture B, we only see the expulsive cough phase.

The vocal cords do not take part in the first sound creation because they are widened to its maximum extent in order to provide a minimum resistance.

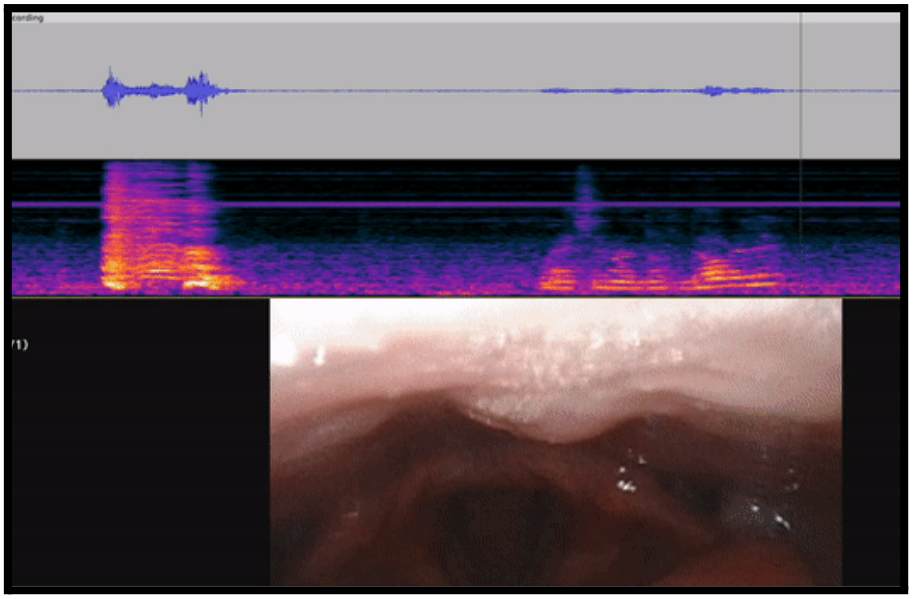


Fig. 4 *A video of vocal cords moving during 2 coughs in a row, each being a cough with a double sound (as depicted in Fig. 3 A - above), and Fig. 5 below, highlighting the expulsive cough phase (purple) and the vocal cough element (red).*

To listen to this example - watch the video (link).

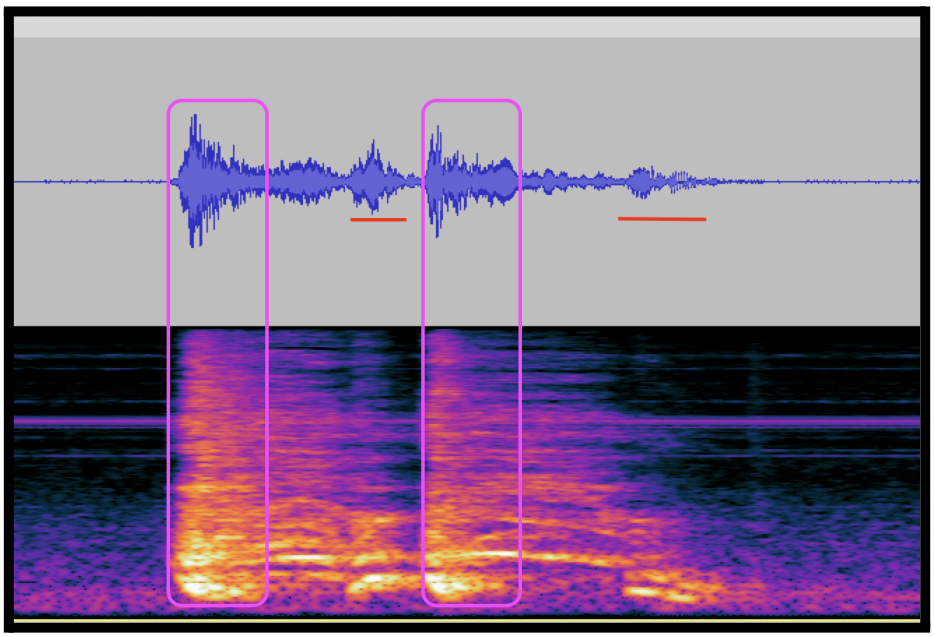


Fig. 5 *Expulsive cough phase and the* vocal cough element (red underline).

Sometimes, coughs have a vocal element at the beginning of the expulsive cough phase (Fig. 6 - listen to this sound (link)).

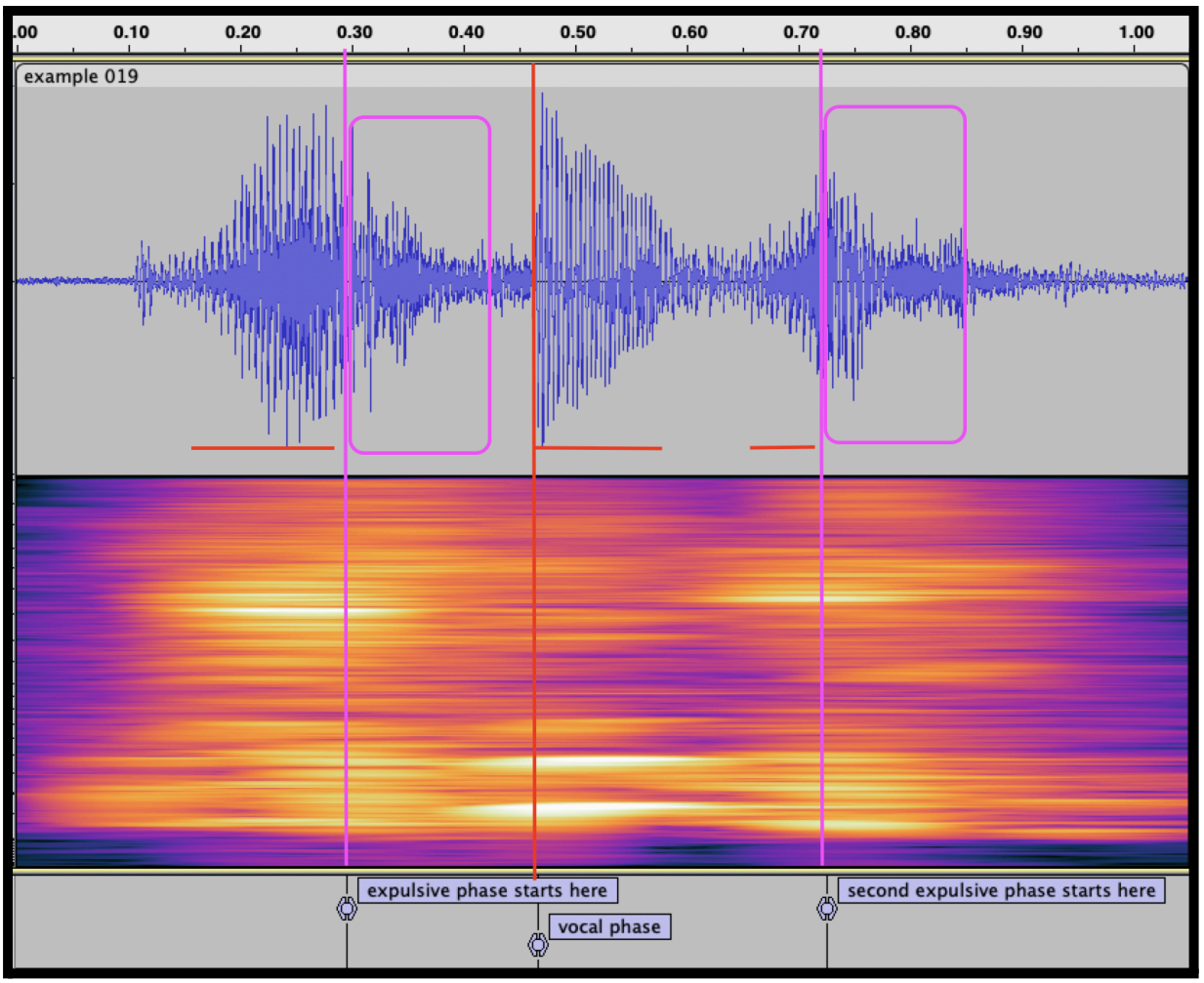


Fig. 6 *Two coughs, which start with a vocal element. Expulsive cough phases (purple) and the vocal cough elements (red underline)*. Listen to this sound (link).

All images depicting cough waves and spectrograms in this SOP are from the free audio editing software "Audacity", which we use for labeling of continuous sound recordings. Instructions for Audacity are provided below in section VII.

IV. Wave shape of cough sounds: expulsive & vocal

As described in relationship to vocal cord movement above, cough episodes commonly have two sounds:

1) The first, expulsive, cough sound - is irregular in sound wave shape (when zoomed in) due to the opening of the epiglottis.

   The intermediate segment (between the expulsive and vocal cough sounds) can be silent, can have air flowing, can be irregular or a continuation of the first sound into the vocal phase.

2) The second, vocal, cough sound - is **regular** in sound wave shape (smooth sine wave shape when zoomed in) due to vibration of the vocal cords, as they relax back into a neutral position.

Understanding that the first (expulsive in this case) cough sound and second (vocal in this case) cough sound - both from a single cough - "look" different on the sound wave and in the spectrogram will be helpful for labeling and differentiating between the coughs.

NOTE:
- Expulsive phase wave (purple in images above) - irregular in shape, jagged when zoomed-in;
- Vocal phase wave (red underline in images above) - regular in shape, smooth when zoomed-in.

At the zoom level shown in Fig. 7, below, we cannot distinguish the "irregular, jagged" wave shape from the "regular, smooth" wave shape in these cough elements (1 and 2).

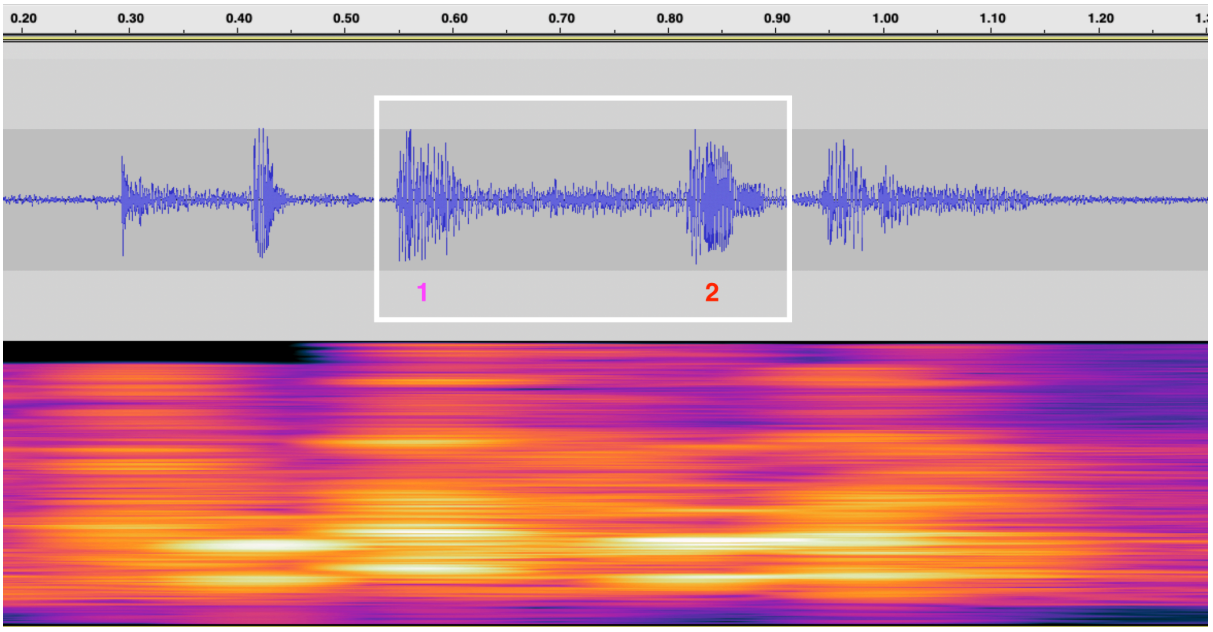


Fig. 7 *One cough in the white rectangle with an expulsive phase (marked 1) and a vocal phase (marked 2). Note this segment is zoomed-in with all sounds spanning 0.9s.*

With a more extreme zoom in (Fig. 8 and 9), you can clearly see how much more jagged and irregular the expulsive phase (1) is than the vocal phase (2).

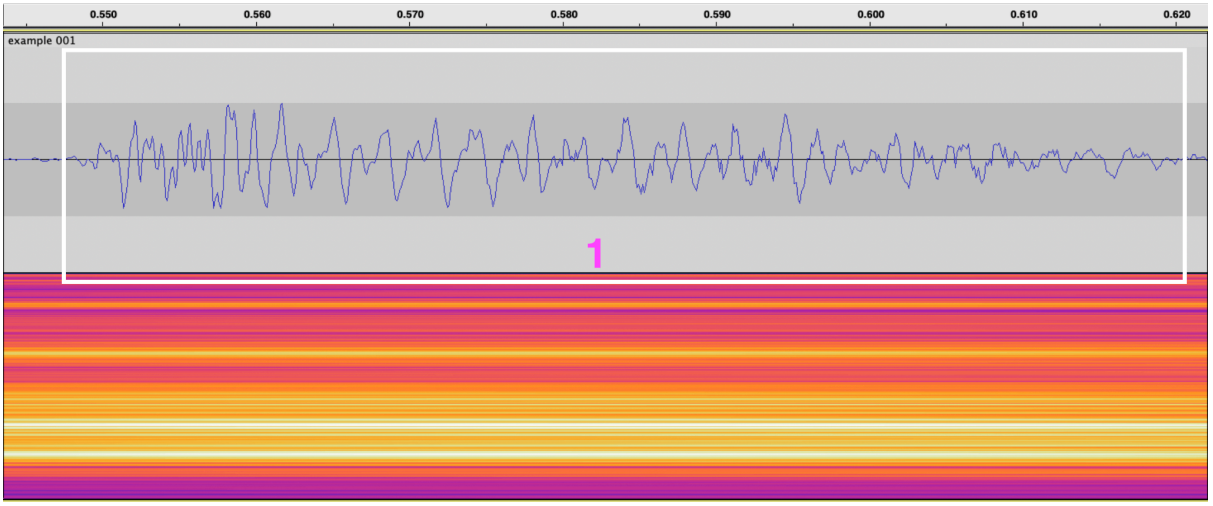


Fig. 8 *An expulsive phase of a cough - wave looks chaotic, irregular, jagged. Note this segment is zoomed-in with all sounds spanning 0.1s.*

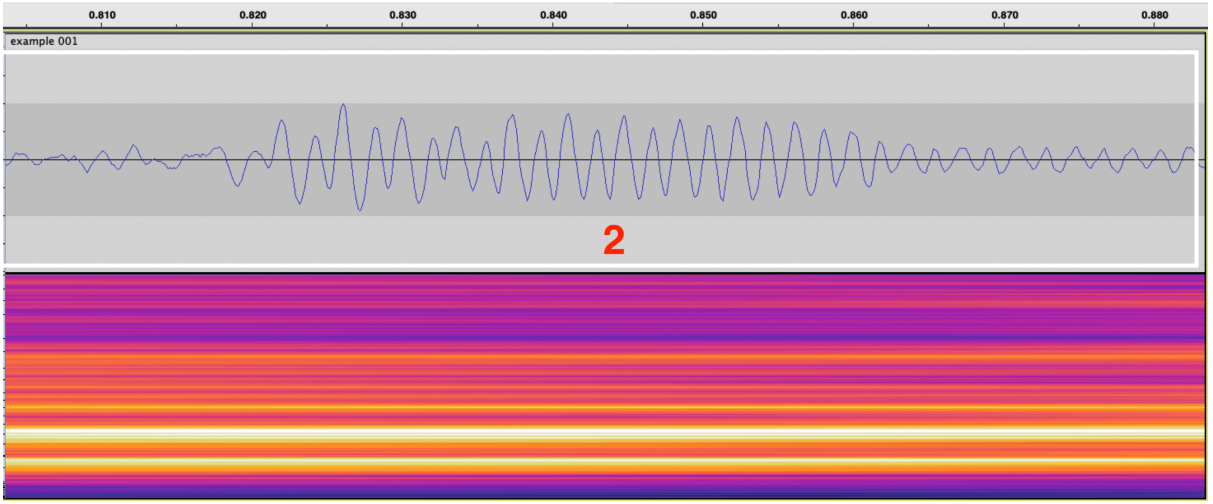


Fig. 9 *A vocal phase of a cough - wave looks regular and smooth. Note this segment is zoomed-in with all sounds spanning 0.1s.*

In contrast, **throat clear** is mostly purely vocal i.e., it contains no expulsive phase and can only expel material from the pharynx upward. Therefore, its **wave shape is expected to be regular and not jagged.**

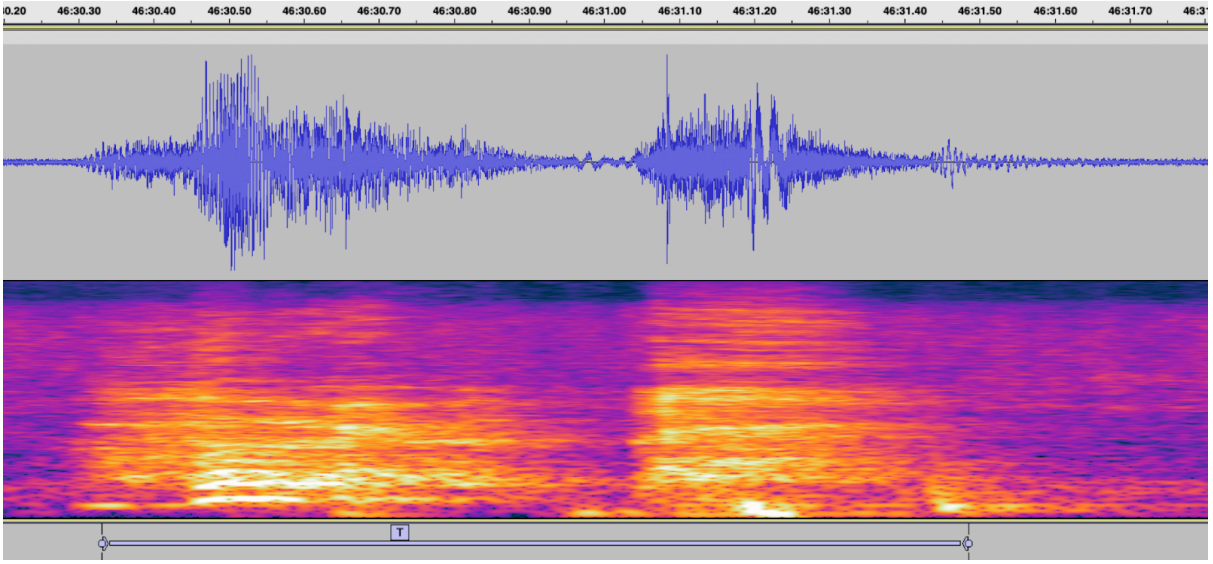


Fig. 10 *Two throat clearing sounds making a single episode (episode duration marked with "T"). This segment is zoomed-in with all sounds spanning 1s.*

However, during a throat clear - air expulsion can happen, too, therefore, irregular, jagged appearance can be present even in audibly obvious throat clearing sounds (Fig. 11).

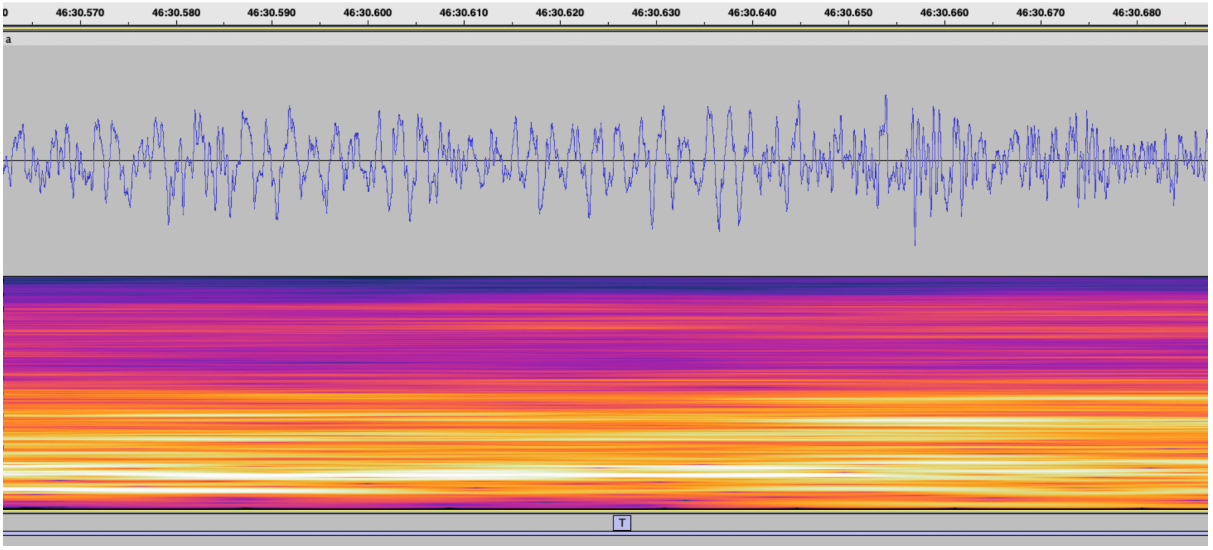


Fig. 11 *One of the throat clear sounds from Fig. 10 zoomed-in - a jagged, irregular sound wave. This segment is zoomed-in with all sounds spanning 0.1s.*

V. Classifying sounds from continuous sound recording using a multi-tier system

Firstly, we are interested in obvious sounds (sounds that would be recognised as such by anyone in the street): obvious cough, obvious throat clear, obvious sneeze, obvious cry. We classify these sounds into 4 categories, which could be supplemented by 2 optional tags. The primary signal for classification is the sound heard but in some cases a close examination of the waveform is instructive.

Table 1 Hyfe multi-tier labeling system criteria.

Label category	Explanation
COUGH	Definite cough: an indisputable cough –- explosive, robust, vigorous, and health-related – that is loud and close to the receiver. This is definitely a cough that Hyfe should always detect. Every cough sound (every expulsive phase) should be considered and labeled as a unique cough.
SNEEZE	Definite sneeze. These are generally obvious from the sound.
THROAT_CLEAR	Definite throat clear. This can be a difficult distinction, but is characterized by the lack of an expulsive air phase and (when zoomed-in) having a much smoother wave pattern. Throat clearing episodes should be labeled as a single label, unless there is at least 1s episode of non-throat clearing sound in between throat clearing sounds in the continuous audio, in which cases throat clearing episodes separated by >1s of other sounds should be labeled separately.
CRY	Definite sounds of someone crying - this will be mostly newborns, babies and young children. The episode of crying should be labeled continuously since the beginning to the end of the crying sound.

There are also 2 tags that could be assigned to each of the 4 label categories above: a distance tag and a confidence tag. Tags are complementary and there is no need to add a tag, unless the sound is considered to be far or the sound is not that obvious to be labeled as “cough”, “sneeze”, “throat_clear” or “cry”.

If the sound is distant (far) or muffled (obstructed) - add a tag “Far” to your label.

DISTANCE TAG	Explanation
Far	Definite but **distant (far) or muffled (obstructed)** target sound from the label categories but it is so quiet/echoed that the person must be far away or obstructed (e.g., muffled by a pocket).

If the sound is heard and you are not that sure if that was a cough or a throat clear; or if that was a cough or some mechanical noise with similar sound properties - add a confidence tag “Not Sure” to your label.

CONFIDENCE TAG	Explanation
Not Sure	Use if in doubt that a sound is a cough, a throat clear, a sneeze or crying. Some might say this is a cough, some might say not - use this confidence tag in such cases to indicate that you were not 100% sure.

In order to improve our understanding of and ability to detect coughs we are labeling the coughs duration by marking their beginning and end. Specifically, while zoomed in, label start and end as follows:

- For a label - “COUGH” - begin at the beginning of the cough sound before the highest peak of the expulsion phase (the irregular wave component described above and in Fig 7,8,9) to the end of the cough sound after the voiced phase dies out.
- For label “SNEEZE” - mark from the beginning of the sound until it ends.
- For label “THROAT_CLEAR” - mark from the beginning of the throat clearing until the end of the episode of throat clearing. Only in cases where two separate throat clearing sounds are separated by more than one (1s) second, mark such throat clearing episodes separately.
- For label “CRY” - mark from the beginning of the crying until the end of the episode of crying. Only in cases where two separate crying episodes are separated by more than one (1s) second, mark such crying episodes separately.

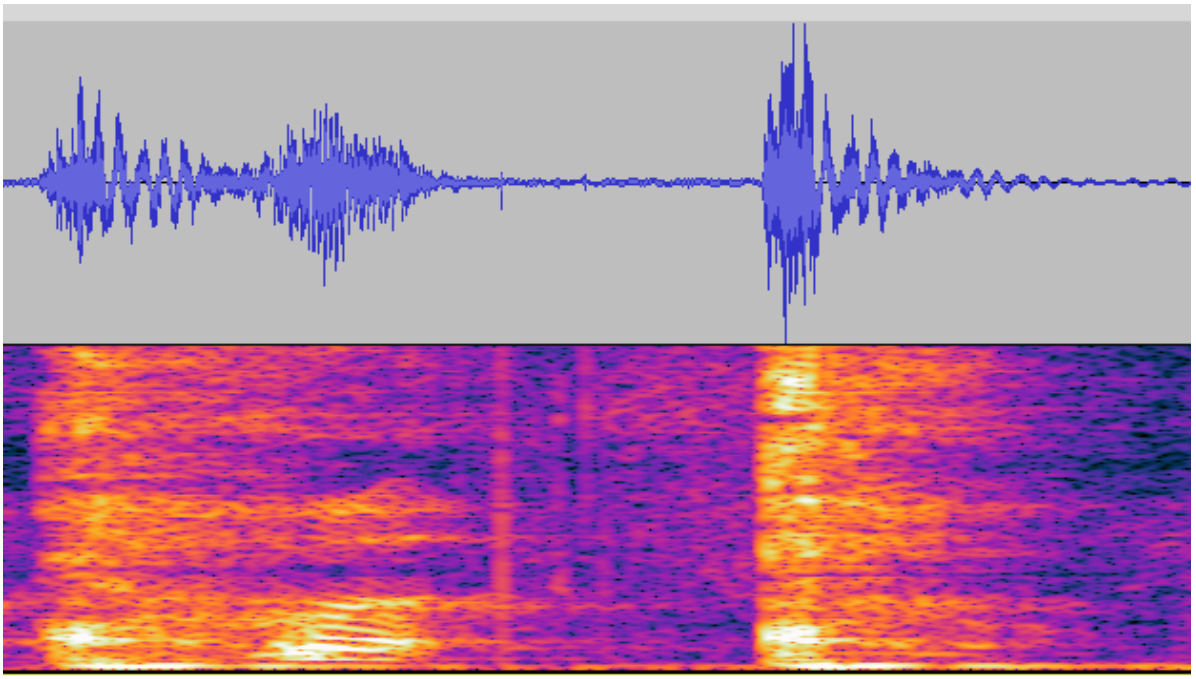
Labeling tips:

1) Always label obvious sounds with their respective labels, and use the “Not Sure” tag for the sounds that you are not sure about.
2) If you are unsure if the sound is a cough or a throat clear - listen if there is air expulsion, and zoom-in the wave (to 1-2s of audio on the screen) to see if it is smooth or jagged. Throat clears do not usually have air expulsions, and their waves are smooth, compared to a cough wave. However, there might be ambiguous sounds and ambiguous appearances of the waves - use “Not Sure” in such cases.

Examples of “COUGH”

- **Obvious “COUGH” sound example 1 (link).**

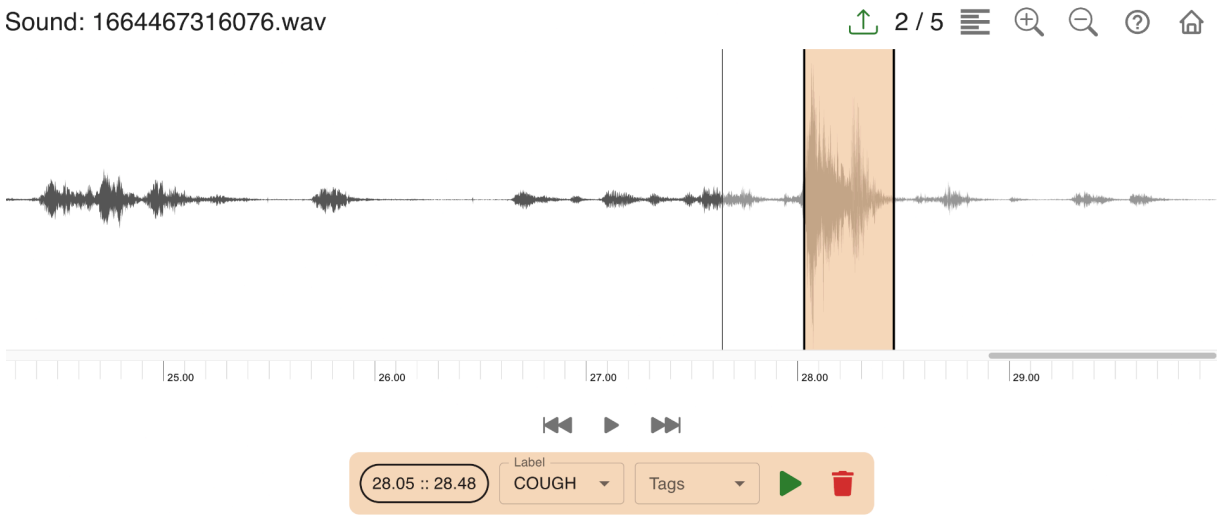
Sound wave and spectrogram image (zoomed-in to ~1s on the screen) - this image is for illustrative purposes.



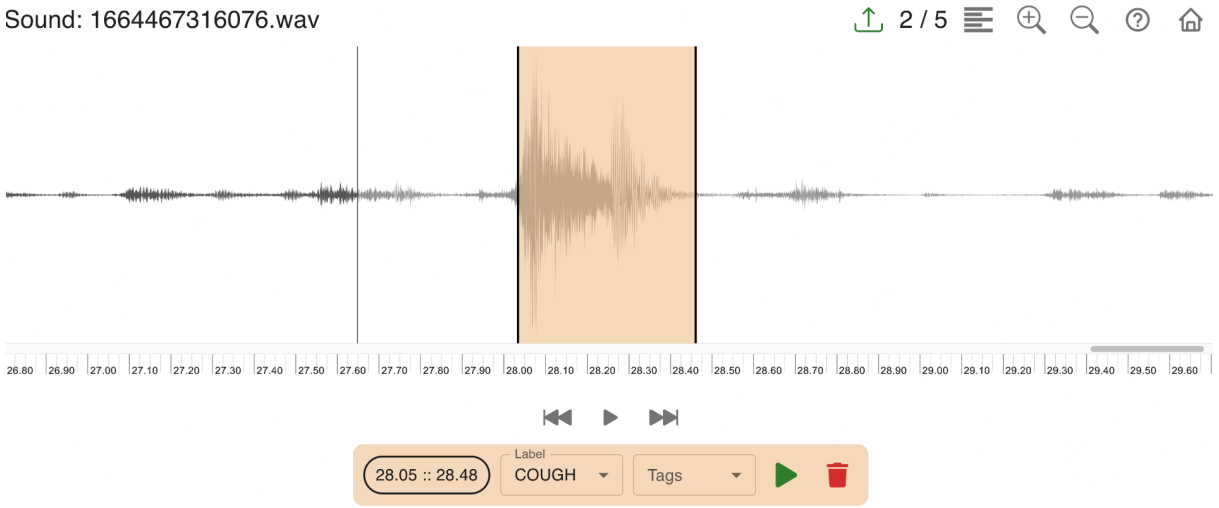
These are two coughs (we hear two expulsive sounds) - which should be labeled as two separate labels “COUGH”. The first cough here has a “vocal” component (which is included in the label) whereas the second cough does not have a “vocal” component.

- **Obvious “COUGH” sound example 2 (link)**

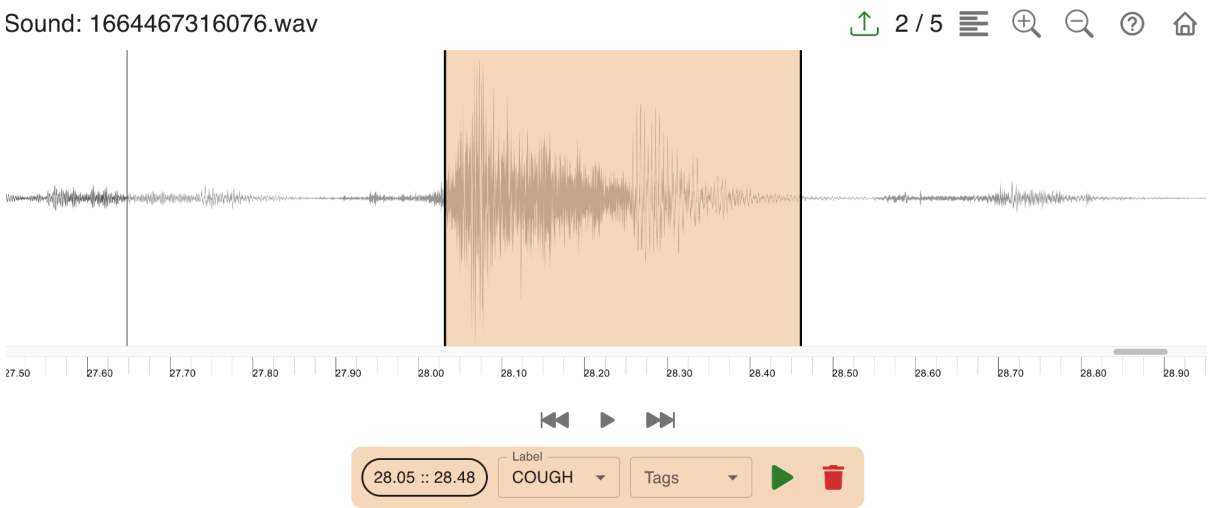
Sound wave image from the Hyfe web labeling app, which will be used for labeling continuous audio.



The above label is being placed at the zoom level of having ~5s of audio on the screen. This can be done quite accurately by experienced labelers and for those starting to label - we recommend to zoom-in the audio more for marking the beginning and end of the target sound (see below the same sound zoomed-in).



The above has ~3s on the screen, and the below - even more extreme zoom for precise label placement has ~2s on the screen.



We request the labels to be placed at the zoom level not bigger than ~4-5s of audio on the screen, ideally ~2-3s of audio on the screen.

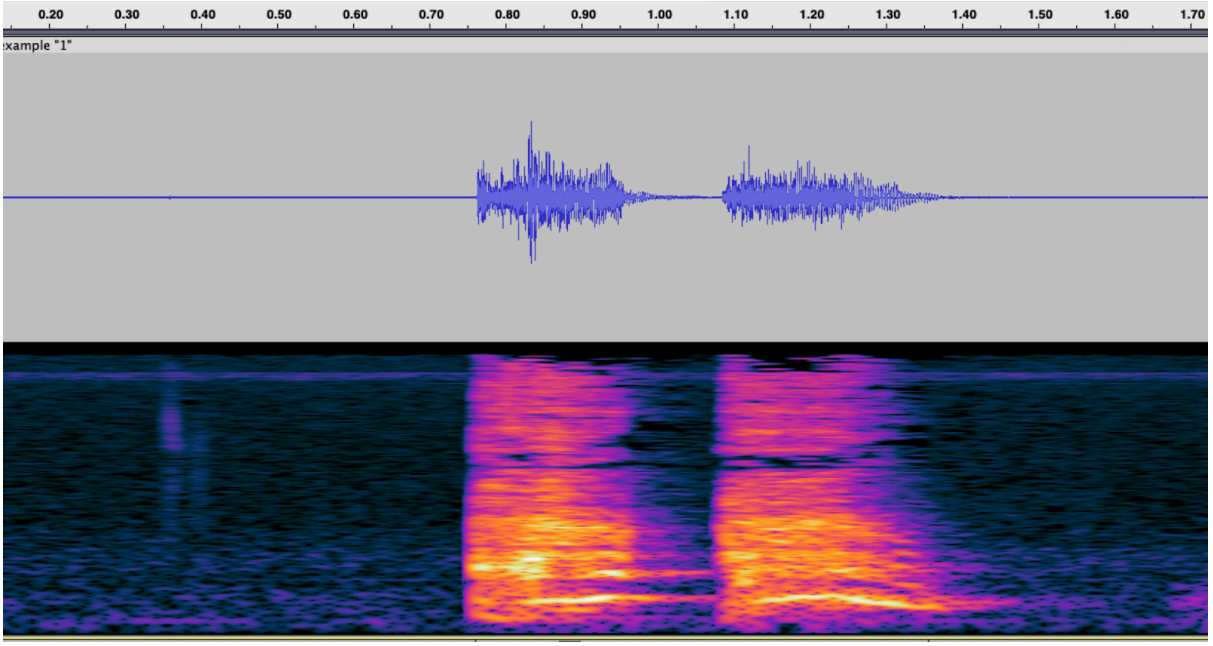
A video example of using the web labeling app to annotate an obvious cough sound with zooming-in and also using the spectrogram feature to assist in determining the duration of the target sound. See here.

- **Audio example of "COUGH" that is "FAR"**, therefore requiring the label "COUGH" and a "FAR" tag: sound example (link) - you can hear two sounds, which are 100% coughs, however, far from the recording microphone, therefore, the tag "FAR" is needed

Examples of "THROAT CLEAR"

- **Obvious "THROAT_CLEAR" sound example 1** (link)

Sound wave and spectrogram image (zoomed-in to ~2s on the screen) - this image is for illustrative purposes.

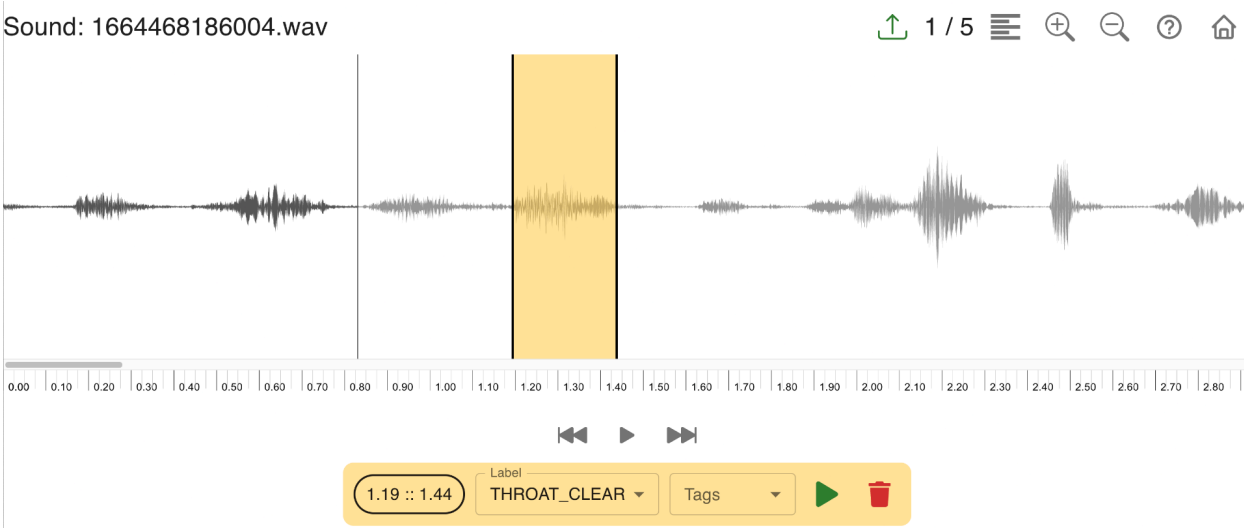


In this segment, we can hear and see two throat clears and they are not separated by 1s, therefore, there should be one label “THROAT_CLEAR” for the whole episode.

- **Obvious “THROAT_CLER” sound example 2** (link)

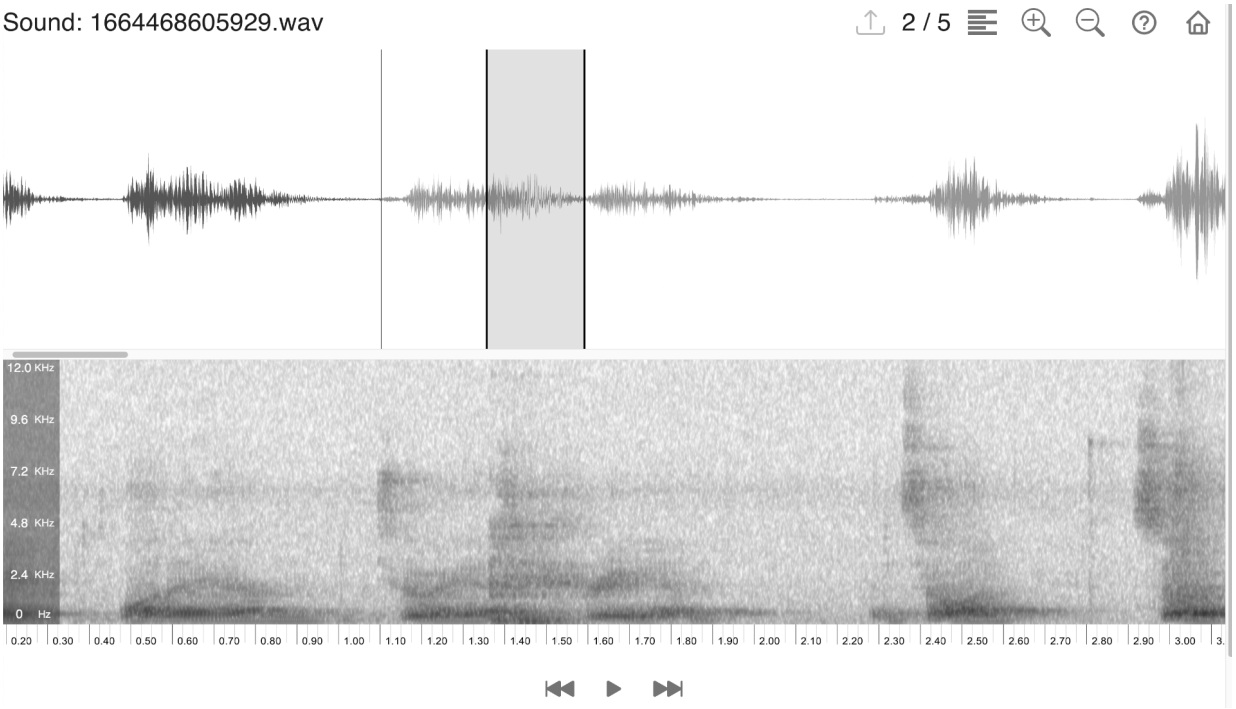
Sound wave image from the Hyfe web labeling app, which will be used for labeling continuous audio (zoomed in ~5s on the screen for general view):

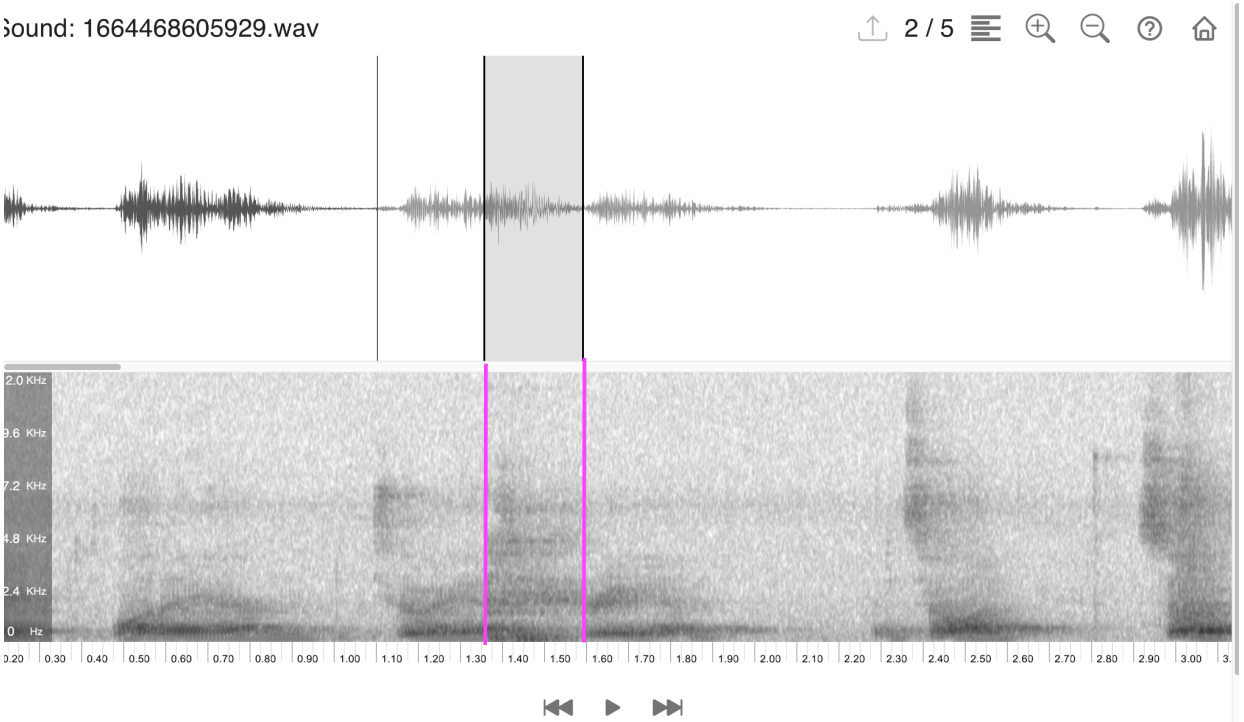
And the label start and end marks should be placed while zoomed-in more (2-3s of audio on the screen):



A video example of using the web labeling app to annotate the above obvious throat clear sound with zooming-in. See here.

There will be cases when target sounds happen in the middle of other sounds - for that reason, the spectrogram feature will be of great assistance. In the image below depicting this sound (here) - the “Thorat_clear” is audible but not visibly distinguishable, and with the help of the spectrogram - it becomes clear where throat clearing happened.

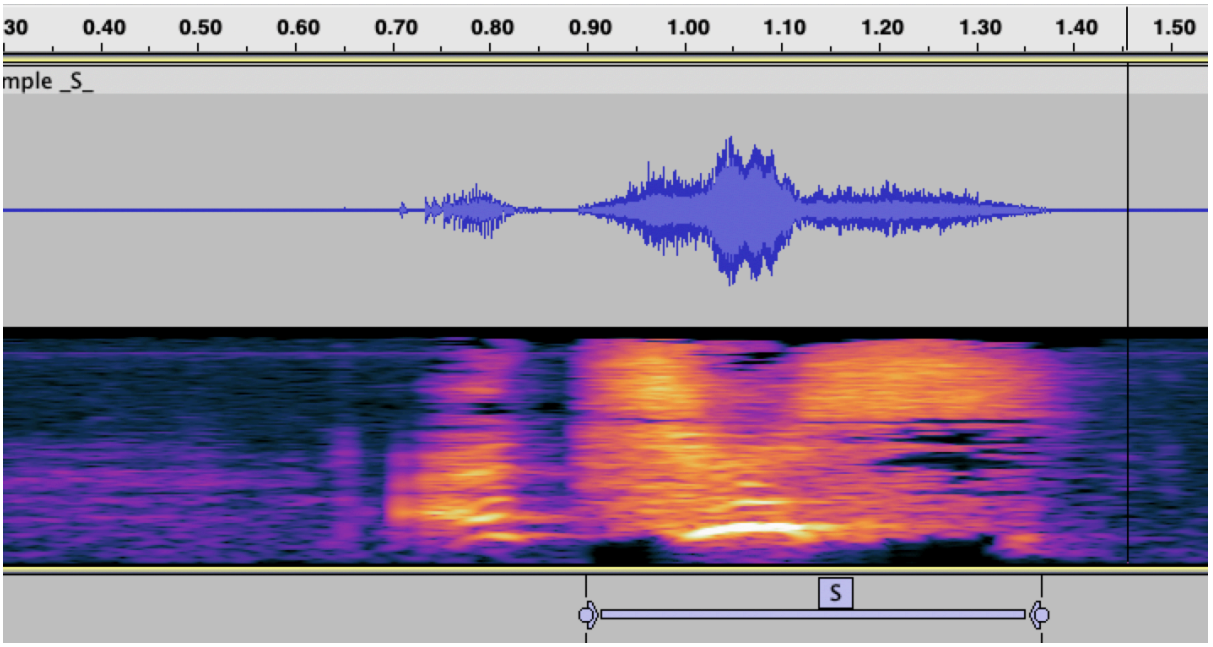




Examples of “SNEEZE”

- Obvious “SNEEZE” sound example (link)

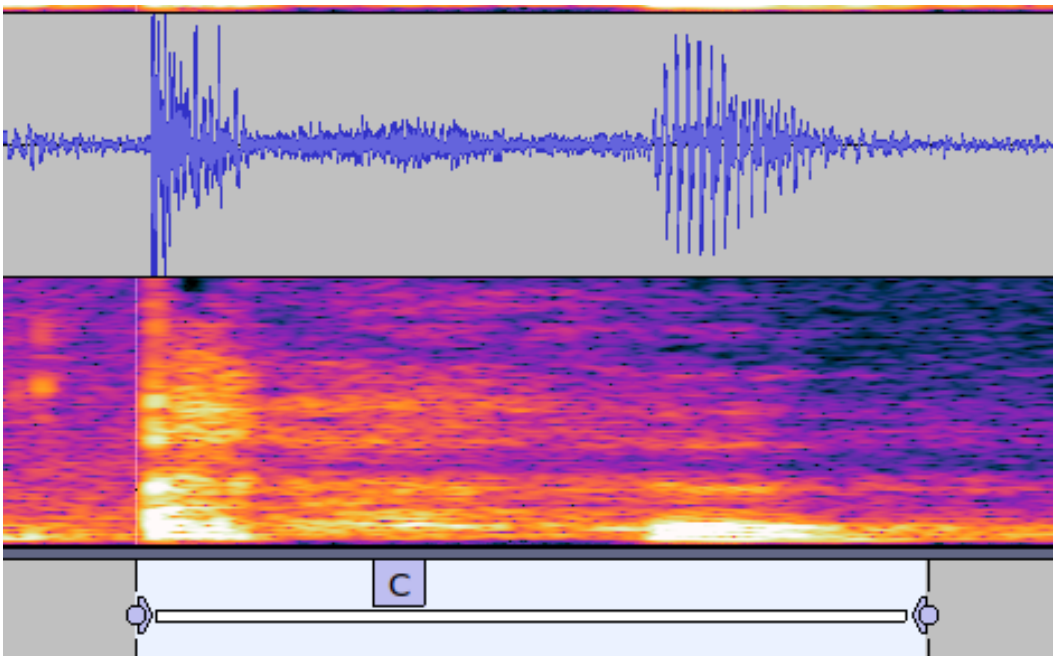
Sound wave and spectrogram image (zoomed-in to ~2s on the screen)



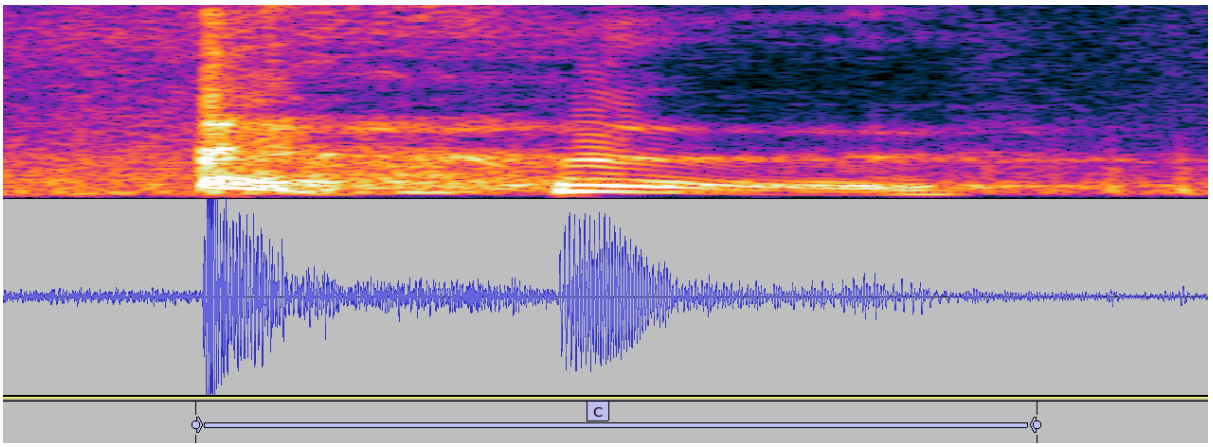
In general, sneezes are easily identifiable from their sound (as in this example) and should be labeled with “SNEEZE” from the beginning to the end (illustrated with “S” in the image above).

VI. Additional examples

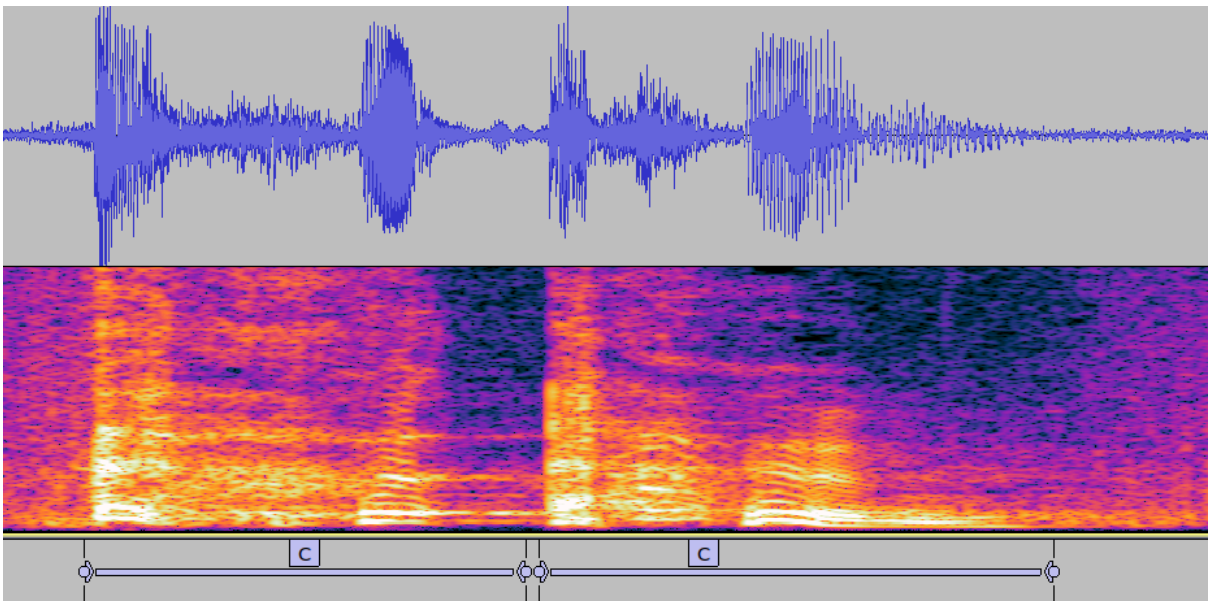
Example sound 001 (link) - a very obvious cough - should be labeled “COUGH” (duration as illustrated with “C” below) - this image is for illustrative purposes.



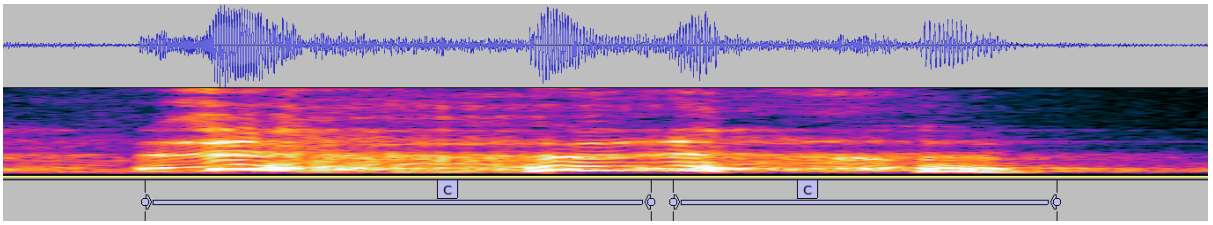
Example sound 002 (link) - a more vocal (vocal phase and its wave on the right), should be labeled “COUGH” (duration as illustrated with “C” below) - this image is for illustrative purposes.



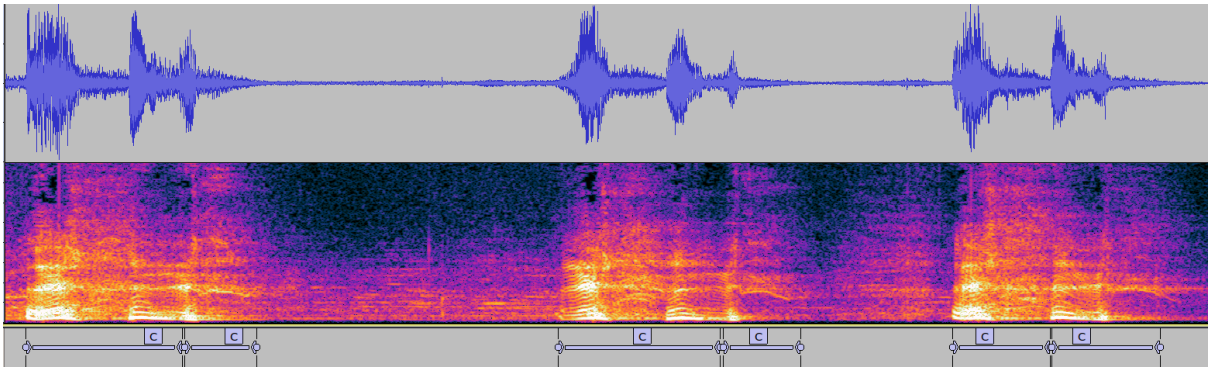
Example sound 003 (link) - two separate expulsive cough phases, thus labeled as two separate labels “COUGH” (duration as illustrated with “C” and “C” below) - this image is for illustrative purposes.



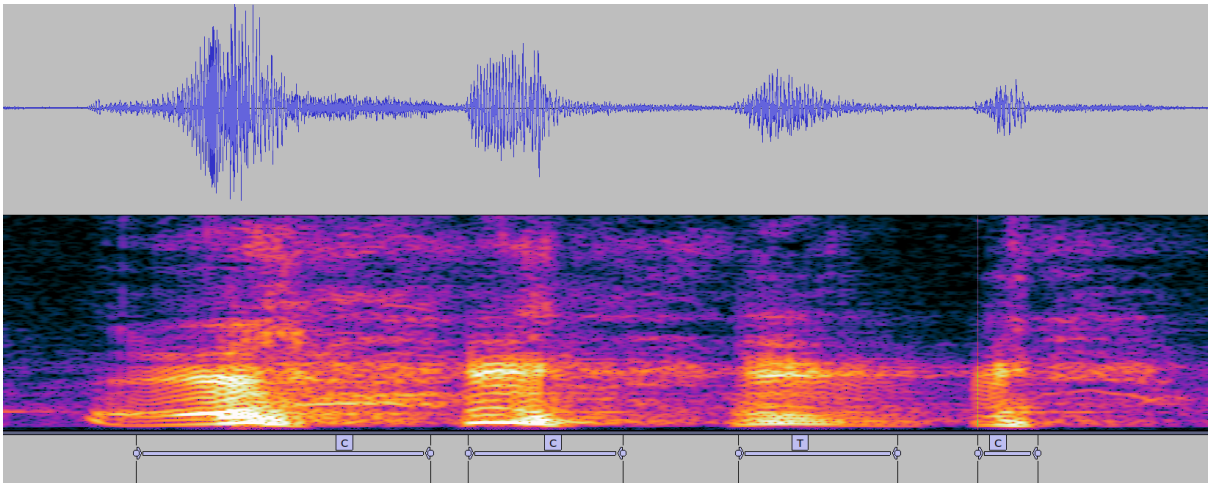
Example sound 004 (link) - two separate expulsive cough phases, thus labeled as two separate labels “COUGH” (duration as illustrated with “C” and “C” below) - this image is for illustrative purposes.



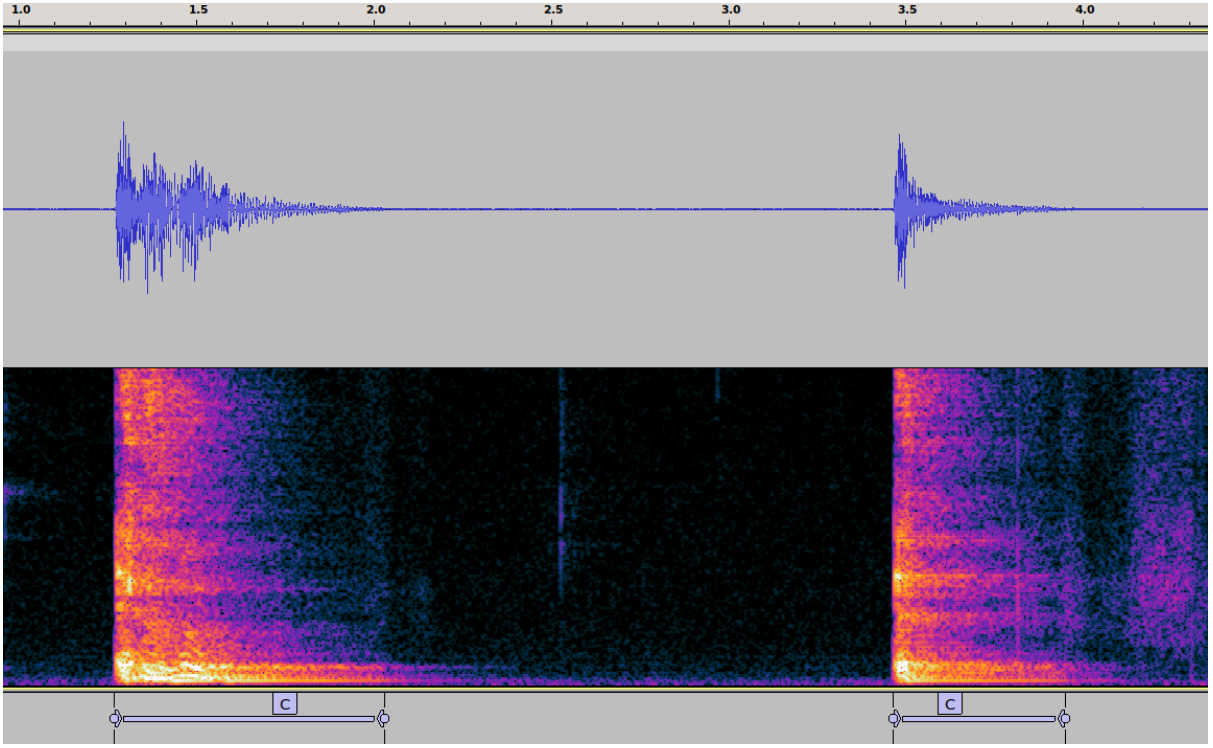
Example sound 005 (link) - 3 episodes of 2 coughs with separate labels “COUGH”, as every episode has two separate expulsive cough phases. (illustrated with “C” for the durations of each label) - this image is for illustrative purposes.



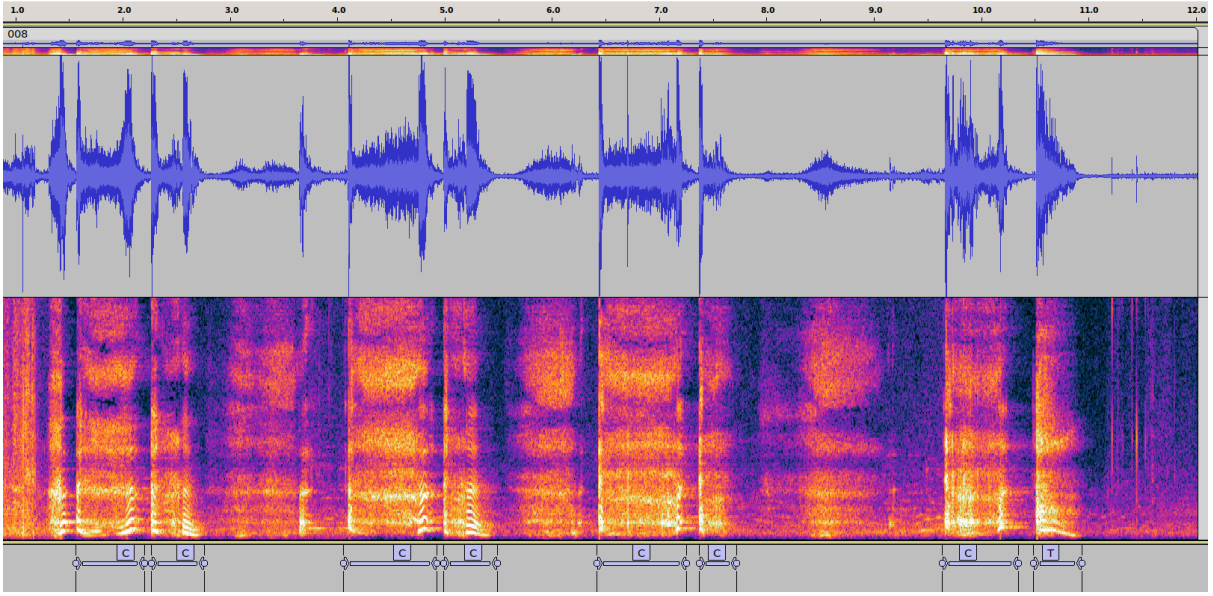
Example sound 006 (link) - An episode with 4 explosive sounds, of which 3 are obvious coughs with labels “COUGH”, and 1 sounds like a “COUGH” or a “THROAT_CLEAR” - therefore requiring a “NOT SURE” tag.. Upon close inspection, the first two are obvious “COUGH”, then a “THROAT_CLEAR” (or a “COUGH”) that needs to have a “NOT SURE” tag, and the last is an obvious “COUGH”. (below illustrated with “C” and “T” letters for the duration of target labels) - this image is for illustrative purposes.



Example sound 007 (link) - coughs can be voiced and non-voiced - listen to this recording (elicited coughs) to learn the difference. For labeling - it has less importance, both expulsive phases have to be labeled separately as “COUGH” (illustrated as “C” below) - this image is for illustrative purposes.



Example sound 008 (link) - an episode of multiple explosive sounds, which are to be labeled as “COUGH”, with the last explosive sound being not an obvious cough (probably - a throat clear). The last sound in this case might be labeled either as a “COUGH” or a “THROAT_CLEAR” with the tag “NOT SURE”. (“C” and “T” letters illustrate the duration of each label) - this image is for illustrative purposes.



VII. General instructions for the use of the Hyfe Continuous Labeling Web App

What follows are instructions for the labeling of continuous audio files, within the context of validation trials of the Hyfe cough detection software. These instructions are meant for use by trained human labelers, i.e. those who listen to continuous audio files and annotate by indicating when coughs / throat clears / sneezes / cries occurred (labeling the total duration from the beginning to the end of the target sound) and indicating when a relevant tag is needed (far / not sure).

All sounds played through the web-app stay in the Hyfe database and will not be stored on your computer. Do not attempt to download or record the audio from the continuous labeling app, unless

These annotations will be used as the “gold standard” by which Hyfe’s algorithms are compared.

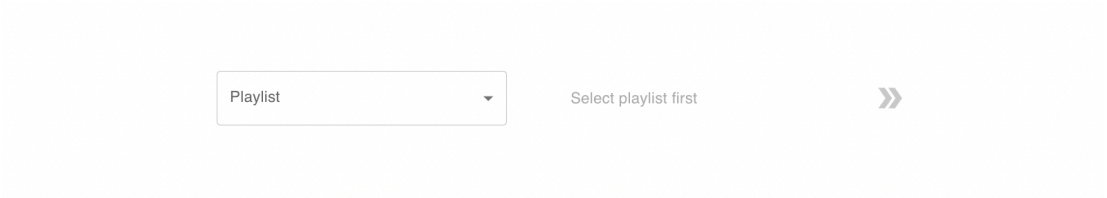
1. Go to Hyfe Continuous Labeling Web App

Hyfe has developed this Continuous Labeling Web App which takes 5 30s-long sound snippets into a single session for continuous labeling. The web app is compatible with Windows, macOS, and Linux browsers, **we recommend using Google Chrome browser** and allow cookies for it to fully function.

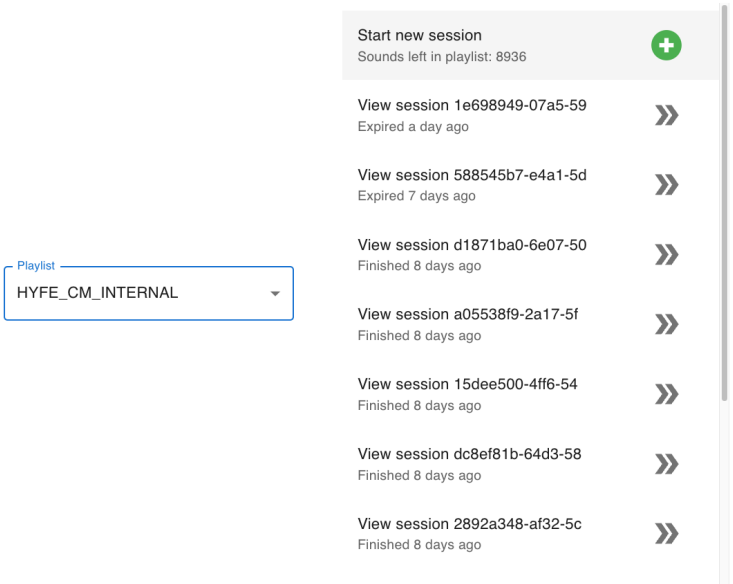
Access the Hyfe Continuous Labeling Web App: https://hyfe-continuous-labeling.web.app/

2. Log In

Use your google account to log-in into the Hyfe Continuous Labeling Web App - share your google credentials with the Hyfe team (mindaugas.g@hyfe.ai) and you will receive a dedicated playlist assigned to these email addresses.



3. Select the assigned playlist and start a new session



After selecting the assigned playlist from the drop-down menu on the left side on the screen, start a new session by clicking the green “+” symbol on the right side of the screen.

4. User controls overview

The Hyfe Continuous Labeling Web App was developed to make labeling easy - therefore, there are a lot of keyboard shortcuts that could be explored by clicking on the “?” icon in the top right corner.

NOTE: icon "Toggle Spectrogram"
The spectrogram is useful in assisting to determine the duration of the sound which had to be labeled - keep in mind that having the spectrogram opened, it might slow the web app. General recommendations are to open the spectrogram when placing a label and marking the beginning and end marks, and close the spectrogram when listening continuously.

The spectrogram feature can be very useful in determining the duration of the sound - take a look at these two examples (here) where spectrogram color intensity guides the duration of two "THROAT_CLEAR" labels for separate episodes in a single 30s audio snippet.
As you can see in the video - some part of the audio is looped in a region (see VII. 7 - selecting a label region in this SOP), also zoom-in and zoom-out is being used with keyboard shortcuts - arrow up and down to navigate the file and ensure the most precise placement of label start and end times.

5. Begin listening

Use headphones for listening. "Spacebar" key on your keyboard starts and stops the track, you can also use your mouse to locate the play marker on the audio file.

To navigate the audio - **zoom-out and/or zoom-in** (either using the magnification glass icons with "+" and "-" or your keyboard keys "arrow up" for zooming-in or "arrow down" for zooming-out.

To select a desired segment for placing a label - left-click with the mouse and drag the mouse to the right along the audio track. This selection can be played by clicking the "play" button on the label control window that appears for every selected audio region.

These 3 levels of zoom (or audio duration visible on your screen) should be followed:
- Any comfortable zoom level - for continuous listening of audio recordings - could be 30s of audio on your screen.
- **~2-3s of audio on your screen - for placing a label.**

- ~<1s of audio on your screen - for extreme zoom-in in differentiating expulsive/vocal cough phases.

When labeling, include the time from (a) the moment the cough or other target sound starts until (b) the time the target sound ends. **We ask you to use the zoom level of ~2-3s of audio on the screen for placing a label.**

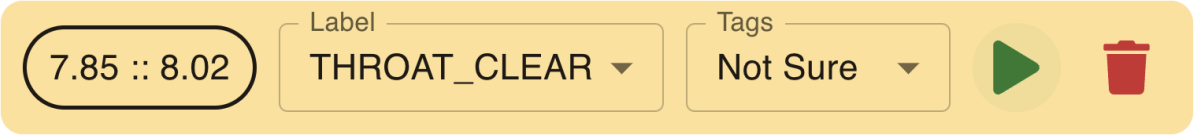
When you have doubts about the cough (whether it was one or two coughs / to differentiate between the expulsive and vocal phases of a cough) in some short period of time, use the "Zoom in" function until you see <1s of audio on the screen).

6. Annotate

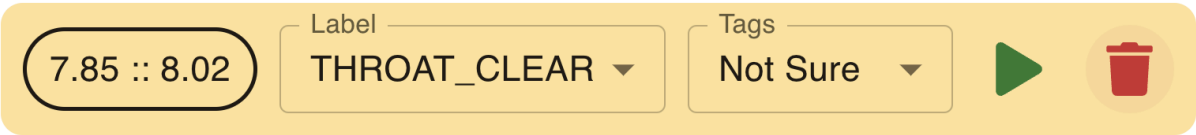
When you encounter a cough / throat clear / sneeze / crying - position the pointer (with the mouse) exactly at the beginning of the target sound, click and drag to the end of it, and then enter the label from the dropdown menu (see the labels table above), also add a relevant tag from the tags menu, if necessary. This saves your input, you do not need to click anywhere else after making a label and can continue with labeling other audio segments through the web app.

Check this video (link) to see a video example identifying a target sound, selecting the region and labeling the sound.

Replay the sound that you are annotating by clicking on the green "play" icon in the label menu.



If you wish to delete the accidentally placed label - click the red "trash bin" icon in the label menu.

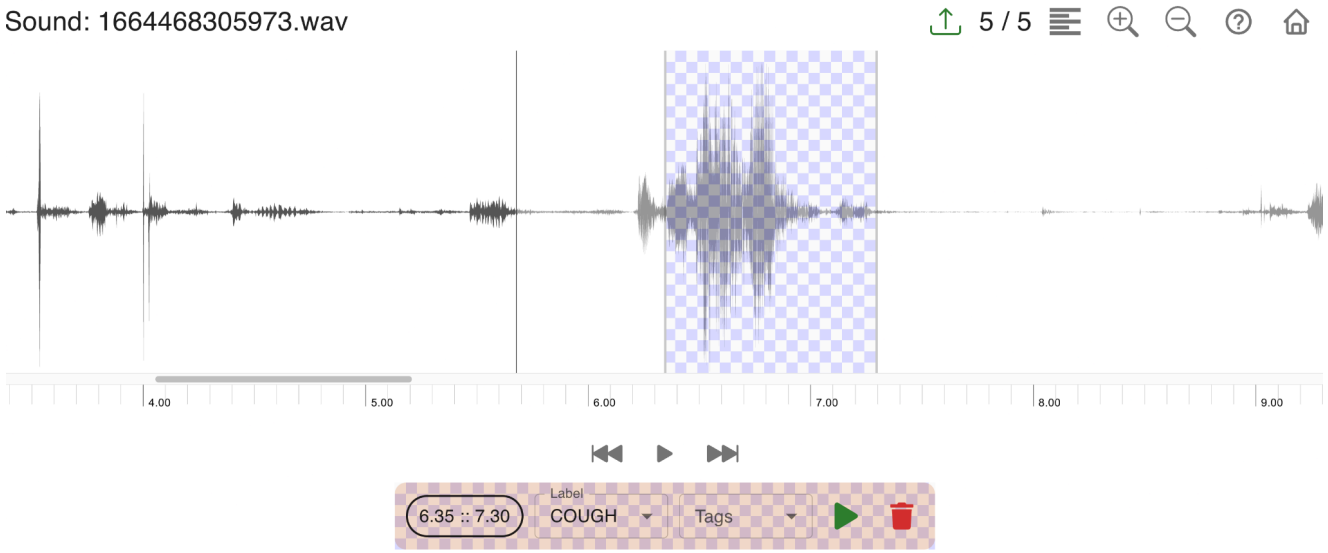


When comparing the accuracy of labels done by separate annotators - we will be looking into the time differences at the beginning of the label, and at the end of it - therefore, place these marks as precisely as possible (zoom level ~2-3s of audio on the screen for label placement).

7. Selecting a label region

If you double-click with the mouse (or use a keyboard shortcut "n") on the selected label - you will select the label region and enter a view that shows the label in checks. This allows

you to loop the selected time by clicking the “spacebar” on your keyboard, you will also be able to move the label with your mouse. To exit this view - click “esc” on your keyboard.



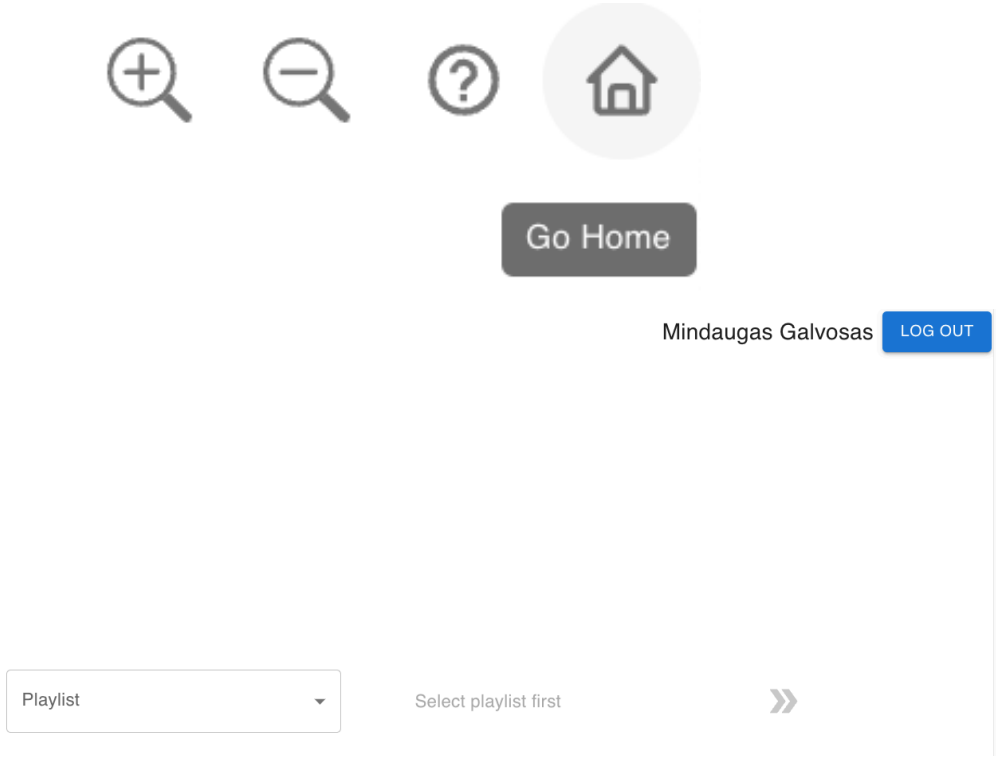
8. Submit labels

Once finished listening and annotating a sound snippet of 30s, click “Submit Labels” - the most left icon on the top right and your labels will be saved. You will see a new snippet from the assigned playlist. After all snippets in a session have been submitted (5 30s snippets) - you will have to start a new session from the assigned playlist.

There might be many 30s audio snippets and even full sessions (of 5 snippets in each) that contain no labels - and that is OK, submit such “empty” sessions with confidence.

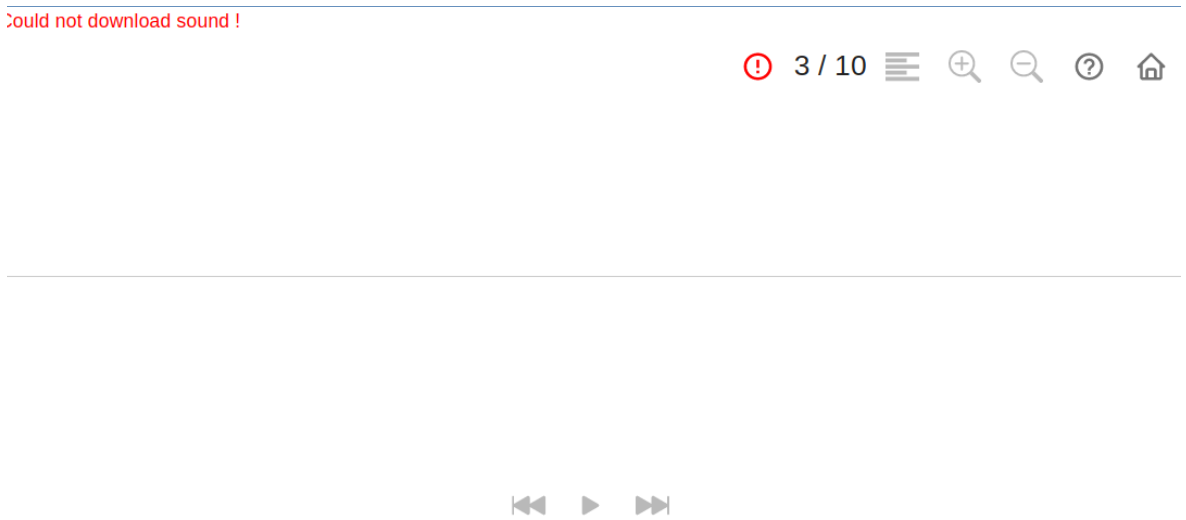
9. Log out

If a labeler is using multiple devices or if a device is being used by multiple labelers - a labeler is requested to log out every time after finishing work. To do that - click on the ‘Home’ icon and then ‘Log Out’ on the main screen.



10. Troubleshooting

If a sound fails to load in a selected playlist and session, and you see the following message ‘Could not download sound!’ as in the screen below - click on the red exclamation mark icon and the page should reload. If this does not fix the issue - please contact mindaugas.g@hyfe.ai.



If you experience some issues with a specific audio snippet and wish to report it - contact mindaugas.g@hyfe.ai with the 'Snippet ID' copied from the sound that needs to be reviewed.

VIII. Summary for a labeler

Cough and its sound wave usually consists of:

- Expulsive phase wave: irregular in shape, jagged when zoomed-in;
- Vocal phase wave: regular in shape, smooth when zoomed-in.

We are labeling the full duration of a cough: expulsive + vocal cough phase!

Based on the number of these phases - we determine the number of coughs in each coughing episode (e.g., a double cough, three coughs in a row, or more), and each target sound should be labeled separately (from their beginning to the end).

Label	Meaning
COUGH	Obvious cough
SNEEZE	Obvious sneeze
THROAT_CLEAR	Obvious throat clear
CRY	Obvious crying

There are also 2 tags that could be assigned to each of the 4 label categories above: a distance tag and a confidence tag. Tags are complementary and there is no need to add a

tag, unless the sound is considered to be far from the microphone that recorded the sound or the sound is not that obvious to be labeled as “cough”, “sneeze”, “throat_clear” or “cry”.

DISTANCE TAG	Explanation
Far	Definite but **distant (far) or muffled (obstructed)** target sound.

CONFIDENCE TAG	Explanation
Not Sure	**Use if in doubt** that a sound is a cough, a throat clear, a sneeze or crying.

Labeling tips:

1. If you consider the sound as certainly a cough - use the label “COUGH”.
2. For placing a label - always include the entirety of the cough sound, from the beginning of the expulsive phase to the fade out of the voiced component.
3. For labels “THROAT_CLEAR” and “CRY” - mark <u>from the beginning of the throat clearing or crying until the end of the episode of throat clearing or crying.</u> Only in cases where two separate throat clearing or crying sounds are separated by more than one (1s) second, mark such throat clearing or crying episodes separately.
4. For all distant target sounds (coughs, throat clears, sneezes and cries) (not taking into consideration if the sound was produced by the subject or not) - add tag “Far” to a respective label.
5. If you are unsure if the sound is 100% a cough, a sneeze, a throat clear or crying, and you have doubts that someone could label the sound differently - choose the label that fits your opinion the best and add a tag “Not Sure”.

Tips for the Hyfe Continuous Labeling Web App:

- Use the space bar on your keyboard to “start” and “stop” the audio file.
- Use the spectrogram option only when adjusting the duration of the label, close it when listening for the audio continuously as this speeds up the app.
- Use three levels of zoom:
    - 1) any comfortable zoom level for listening to the audio recording,
    - 2) a 2-3s timebar on the screen when placing a label and
    - 3) a very high level zoom of “<1s timebar on the screen” zoom level to decide in complicated cases so that you can look at the zoomed-in wave shape, find and label the target sound.

IX. Self-assessment

QUESTIONNAIRE

Read through and assess yourself if you can answer the questions below.

1. What does an expulsive cough sound wave look like?
    a. Regular sine shape
    b. Irregular sine shape
2. What moment on the sound wave do we label?
    a. The beginning of the target sound
    b. The highest peak (maximum amplitude) of the target sound
    c. The entire cough sound
3. Which statement is **incorrect**?
    a. There can be cases when an expulsive phase starts at the time of the vocal phase (or right after the vocal phase).
    b. We have to label coughs, throat clears, sneezes, and crying with their respective labels and add the label “Far” if we think that the target sound is ambiguous and we are not certain about a 100% accurate label for this sound.
    c. If we hear an explosive sound, which is, for example, a dog barking - we don’t have to label it.
4. What should be done when a snippet does not have any sound to label?
    a. It should be submitted with no unnecessary labels
    b. We should add any label in the audio file just to mark it
5. Which zoom level is recommended for continuous listening of audio recordings on the web app?
    a. 0.5s increments
    b. 1s increments
    c. 5s increments
    d. Any comfortable level
6. Which zoom level is recommended for label placement in the audio on the web app?
    a. 2-3s of audio on the screen
    b. 5s of audio on the screen
    c. Any comfortable level
7. Which statement is **correct**?
    a. We are labeling every throat clearing sound individually
    b. We are labeling throat clearing episodes with one label, except in cases when two such episodes are separated by >1s in between them

Check your answers with the correct answers, which are provided in Annex 1, further below.

LABELING ASSESSMENT

After completing the questionnaire, inform mindaugas.g@hyfe.ai and you will receive access to the final test playlist on the web app. You will have to score 95% accuracy in detecting and labeling the correct durations of obvious sounds to pass the practical task.

X. Contact information

For SOP, confidentiality and labeling questions, contact:	Mindaugas Galvosas, MD Hyfe, Inc. Email: mindaugas.g@hyfe.ai
For medical questions or additional labeling questions, contact:	Carlos Chaccour, MD PhD Hyfe, Inc. Email: carlos@hyfe.ai
For Hyfe product (app / dashboard / other) questions, contact:	Lola Jover Hyfe, Inc. Email: lola.j@hyfe.ai

XI. List of references

1. Korpás J, Sadlonová J, Vrabec M. Analysis of the cough sound: an overview. Pulmonary pharmacology. 1996 Oct-Dec;9(5-6):261-8. PubMed PMID: 9232662. Epub 1996/10/01. eng.
2. Widdicombe, John. (2008). A Brief Overview of the Mechanisms of Cough. 10.1002/9780470755846.ch3.
3. Lee KK, Matos S, Ward K, Rafferty GF, Moxham J, Evans DH, et al. Sound: a non-invasive measure of cough intensity. BMJ Open Respiratory Research. 2017;4(1):e000178.

Annex 1

Correct answers to the self-assessment questionnaire:

1. B
2. C
3. B
4. A
5. D
6. A
7. A

For labeling assessment - you will receive an email with your performance score and a link to schedule a review call (if needed).