Behayve User Guide

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NOTE: This User Guide may be viewed and downloaded at behayve.com/guide and may also be found on the app's *Help* page.

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About Behayve

The Behayve app for iPhone and Android aims to support animal behavior researchers working in the field, indoors or in enclosed spaces.

The development team – who use the app in their own research projects – made sure it was highly configurable to support a wide range of studies of different species.

While the possibilities for configuration of a study are many and varied, once you have configured the app to your exact requirements it's going to be simple to use the app for data recording.

Behayve remains under active development and we'd love to hear your ideas for future product directions. Contact us for free support.

Here in a nutshell is what Behayve offers:

- Record quickly and easily with ultimate data safety
- Get citizen scientists up to speed rapidly
- Work even without Internet, syncing to the cloud or email once back in range (or to laptop any time)
- Record precise 2D or 3D animal tracks based on compass bearing and range, with automatic observer tracking – differential GPS may be used where extreme positional accuracy is required – aerial or theodolite observations are supported as well
- Record behavior, off your own ethogram, and optionally the exact locations where selected behaviors occur – normally a calculated latitude and longitude
- Periodically record the environmental conditions under which the behaviors occur
- Develop an integrated view of movement, behavior and environment
- Use focal, scan, behavior and ad-libitum sampling, simultaneously, as per Martin and Bateson's classic 'Measuring Behavior'
- Configure each behavior as event or state, optionally with multiple modifiers, roles and mutual exclusions
- Configure custom data items for optional capture and validation at each observation
- Record notes at any stage via text entry, dictation or voice clip – or record animal vocalizations
- Capture compass bearing and elevation simply by putting a target in the crosshairs, or manually
- Capture range automatically from a wireless laser rangefinder, or manually
- Define groups and individual subjects in advance and as encountered; record tracks and behaviors at group or individual level, or both
- Record individual participation in rapidly-evolving communal dynamics like social play
- Easily review and correct data at any time
- Record positions as latitude/longitude (automatic), easting/northing (mostly automatic) or as being within one of a set of adjacent polygonal or simply notional areas, or as (east, north, height) coordinates relative to the observer
- Gain real-time insights by viewing tracks, behavior locations and associated data during an observation session
- Provide users with images, videos or audio clips typifying each behavior and species

- With practically no effort, transport any amount of data into ArcGIS, QGIS, Google Earth, Google MyMaps, spreadsheets and others, in structured form
- Automatically position clickable photo and video icons on maps of tracks and behaviors – even for external cameras without GPS capability
- Distribute a locked configuration to prevent modification by colleagues or students
- Collate and distribute a collection of study configurations
- Merge data from different team members working apart or in proximity
- Speed up recording, by filtering individual subjects, behaviors, roles and modifiers
- Work in challenging environments with one-hand operation, no laptop required at any stage
- Avoid losing animals that are moving in a general direction, using a predictive function
- Where GPS is unavailable, use relative positioning or semi-automatic grid map positioning
- Automatically record periods of actual observation and sampling
- Automatically stamp every observation with observer name, observer position and time
- Flag items of special interest
- Data safely preserved with immunity from power failures and other interruptions
- See a subject's speed and course between successive observations, and heading if recorded, as it happens or later
- Configure and record control variables varying from session to session
- View current bearing and range to defined landmarks
- Triangulate the position of an inaccessible landmark
- Work with multiple independent studies
- If on the water, automatically record water temperature and depth at intervals and for each observation, via wireless NMEA feed from almost any chartplotter or fishfinder – see Appendix D – Wireless connection to aircraft's or ship's Instruments

iPhone and Android versions are fully interoperable.

Behayve is a free app, with in-app subscriptions or purchase for some of the above features, priced at educational levels. For details, see Appendix V – In-app subscriptions and purchase.
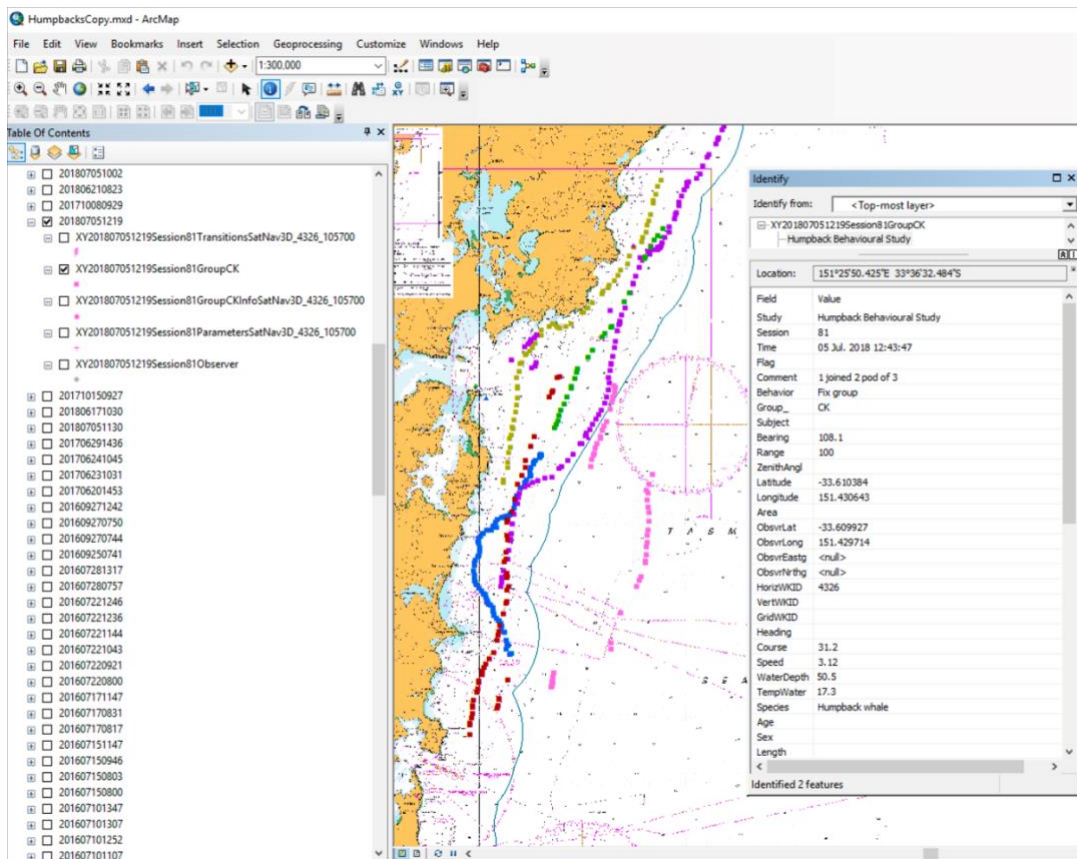
Figure 1 Tracks of migrating humpback whales in ArcMap. Clicking on an observation pops up its associated data.

Overview

This section provides an overview of Behayve: concepts, terminology and functions. A following section walks you through the sample Elephant Study provided with the app.

Study

A <u>Study</u> is like a project. Behayve comes with a sample Study you can reconfigure to your own needs, or you can configure your own Studies from scratch. Studies are independent of each other.

Session

A <u>Session</u> is a period of time during which observations are made, typically a day's work. Along with any observation or action you take in a Session, Behayve can also record the observer's position and a timestamp, periodically and when an observation is recorded. As well, Behayve records the session start time, finish time and pause/resume times.

Once you have selected your Study on the home screen, you can review and amend observations in earlier Sessions, or start a new Session by entering your name and other information. A Session can be paused and resumed, for a rest break for example.

Group and subject

A <u>Group</u> is a collection of one or more Subjects of study, a <u>Subject</u> being an individual animal. Every Subject belongs to a Group. You can record positions and behaviors of a Group as a whole or of individual Subjects, or both. Groups and subjects have properties, such as Species, that you can update during a Session.

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Aggregate counts of animals in different states may be recorded. See [Appendix Q: Recording aggregate counts](#).

You can define Groups and Subjects in advance and during a Session as you encounter them. When you create a Group or Subject, it's automatically given a name such as Group C, Group AQ or Subject 3 and you can add your preferred name if you wish.

Fix

A <u>Fix</u> places a Group or Subject at a geographic location at a time. To get a Fix, you enter a compass bearing and range (and optionally a zenith angle). From this, Behayve calculates and records the location, normally as latitude, longitude and elevation. A series of Fixes forms a track on a map.

For each Fix, Behayve also calculates the target's position relative to the observer, in (x, y) or (x, y, z) coordinates; this can be useful where GPS is unsuitable, for example indoors or at close range. See [Appendix T – Positioning when GPS is unavailable or unsuitable](#).

Alternatively, fixes can be used to specify geographic areas, rather than point positions.

Behavior and behavior class

Before running any Sessions, while configuring your Study, you may supply a simple list of named <u>Behaviors</u>, your 'ethogram', classifying each as either an instantaneous <u>Event</u>, such as 'Peck', or a continuous <u>State</u>, such as 'Sleeping'. In the case of a State, Behayve will automatically record the start and end times of the Behavior and its duration; for an Event, the time of the event is recorded.

NOTE: If you will just be recording tracks, no Behaviors need be defined.

For organisational purposes and to speed up recording, you can optionally define named <u>Behavior Classes</u>, placing individual Behaviors and Groups in one or more Behavior Classes. Or you can just use the built-in Behavior Classes named 'Events' and 'States'.

The Behaviors that a Group and its Subjects may have are restricted to those Behaviors that belong to Behavior Classes that the Group belongs to. A restricted set of Behaviors has the advantage of limiting the choice of Behaviors to those that are relevant in context, which means you can record faster and more accurately. A Behavior Class might represent a constellation of Behaviors.

Modifiers, roles and mutual exclusions

Often a Behavior can simply be a named event or state, as described above. In more complex cases, you have the option of assigning Modifiers and Roles to particular Behavior Classes or individual Behaviors, and to define mutually-exclusive behavior states.

NOTE: A complete description may be found in [Appendix G: How behavior classes work.](#)

Let's say we have a Behavior where orangutan Alice strikes orangutan Bertie 'hard' while companion Charlie is present. Here we can say the Behavior is Strikes, Alice has the <u>Role</u> of <u>Actor</u>, Bertie has the Role of <u>Receiver</u>, the <u>Modifier</u> is Hard and Charlie has the Role of Companion. With Behayve you can configure any Behavior to have multiple Modifiers and Roles. When that Behavior is recorded, the user will be prompted to select the appropriate Modifiers and Role players.

Many times, roles will simply be associated with a behavior and a subject. However, in situations where several subjects in a group rapidly take up a role or leave it, a so-called 'communal' role may

be used. An example would be social play where different primates quickly join or leave the play. Another example would be a group of whales individually surfacing and quickly submerging at different times.

Now suppose we have 'state' Behaviors *Awake* and *Asleep*. We can configure these two Behaviors to be <u>Mutually Exclusive</u>. Then, when we record a Subject as being Awake when previously it had been recorded as Asleep, Behayve will automatically record the termination of the Asleep state (as well as the start of the Awake state).

NOTE: A state may also be used to represent a context rather than a behavior, for example Raining. You might want to put contexts in all-caps to make them stand out.

Sampling

Once a Session has been started, the user is offered four kinds of sampling:

- <u>Focal sampling</u> – Select a Group or Subject and all observations will be for that Group or Subject until another is selected
- <u>Scan sampling</u> – Select a Group and the app will prompt you periodically to select the current Behavior of each Subject in the Group
- <u>Behavior sampling</u> – Select a Behavior Class and you will be offered only the Behaviors in that Class – used for constellations of Behaviors or for convenient recording of rare Behaviors
- <u>Ad libitum sampling</u> – Select a Group or Subject each time a Behavior is to be recorded – used in initial exploratory observations or for the avoidance of confusion when recording more than one Group or Subject for a period of time.

For each, the user can nominate the length of time sampling will last, or an indefinite duration. During this sampling interval, both Fixes and Behaviors can be recorded. There is also the facility to Fix selected Behaviors, in other words to record the Behavior and the position of the target together.

All four sampling modes can be active at once if desired.

Environment

Preconfigured environmental parameters can be recorded at any time while sampling. Additionally, environmental parameters may be tied to a particular occurrence of a Behavior.

Custom data items

When configuring a Study, you optionally may define <u>custom data items,</u> of various kinds, to be captured during a Session:

CUSTOM DATA ITEMS	WHEN USER IS PROMPTED FOR ITEMS	APPLIED TO
PerSession	When starting a session (control variables, differing per session)	Current Session
PerBehavior	When a behavior belonging to a nominated behavior class is recorded	Current Behavior
PerRole	When a role is recorded for a behavior belonging to a nominated behavior class	Role of current Behavior
PerModifier	When a modifier is recorded for a behavior belonging to a nominated behavior class	Modifier of current Behavior
PerGroup	When a group is created or updated	Current Group
PerSubject	When a subject is created or updated	Current Subject
PerFix	When a fix is taken	Current Fix
PerScan	Each time a nominated group is scanned	Current Group
PerEndSampling	When *END* is tapped, and confirmed with *OK*, following sampling	Current Subject or Group
PerEnvironment Snapshot	When an environment snapshot is taken	Current Environment snapshot

When prompted, the user may enter some or all of the requested data, or skip.

Each custom data item may be configured as:

- Text
- Integer number
- Decimal number
- Multiple choice (configured with several <u>Choices</u> items)
- Date and Time

Throughout the app, and here as well, Behayve validates user input to ensure it is of the right type.

Place

A <u>Place</u> or landmark is a named geographic location with a specified position, defined during configuration or in a session.

Places may be used:

- To define the extent of an Area
- As a 'home' position relative to which positions can be recorded as easting/northing in locations where GPS is unavailable
- For triangulation of inaccessible landmarks
- To inform the user of the distance and compass bearing to distant landmarks
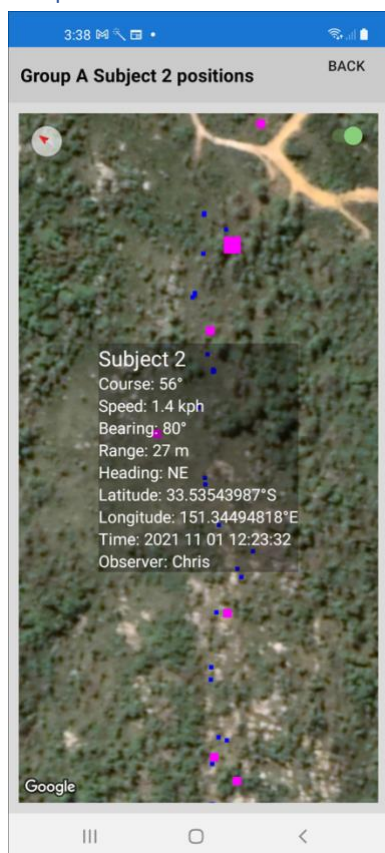
Area

During Configuration, the territory of Groups and Subjects may be split into polygons known as Areas, defined by the Places forming their vertices. Optionally, when performing a Fix, Behayve can automatically use the calculated position of the target to place it in one of a set of contiguous Areas. Alternatively, the user can manually select the Area the target is in. This is controlled by the *AreaRecording* setting.

An Area may be simply a name, with no defined polygon (relying on the researcher's mental definition), or a named polygon.

NOTE: If you wish to record Areas manually without entering bearing and range, set *Area Recording* to *Manual* and *PositionType* to *None,* in Settings.

Map

During a Session, a real-time map can be displayed showing the track of a Group or Subject together with the track of the observer and locations where particular Behaviors occurred. Clicking on map icons will display associated data. Maps from earlier Sessions can also be displayed. The canvas can be Google Maps™ online or a user-created custom map, useful when Internet is unavailable.

NOTE: Exports from Behavye may be passed directly into GIS systems or Google Earth, for detailed post-processing.

Review and correction

At any time during or after a Session, the user can view a listing of the observations in a session in reverse chronological order and, by tapping on an observation, open a window for amendment of the data.

NOTE: When amending *after* a session, several of the settings must be the same as they were during the session. (Should you need to verify settings, they can be found in the *Transitions* export.)

Notes

The user may enter timestamped Notes in the form of text, dictation or voice clip, with author attribution, at almost any time. A facility for later corrections and transcription of voice clips is provided. Where Notes are in context, for example in conjunction with a particular Behavior, Fix, Group or Subject, Behayve will associate the note with the item in question.

Sample behaviors and species

For each Behavior and Species, an illustrative image, video clip or sound clip can be downloaded from Dropbox, the web or a laptop to your Android, during configuration.

During a Session:

- when prompted to select a Behavior, the user can review the Behavior's media item by long-pressing, instead of tapping, the relevant Behavior button
- when adding or editing a Group or Subject, the user can choose to:

  o select a Species by scanning an image gallery, or

  o review a selected Species' media item.

This may be particularly useful for citizen science studies.

Data synchronization and backup

For speed and reliability, Behayve initially stores all data in an onboard relational database. A flat battery or various glitches will not result in data loss.

When no Session is in progress, the user can perform a backup of all Studies on the database to the user's personal and private Dropbox cloud account, from any location where Internet is available. The backup then is accessible from the user's Android, Mac or Windows PC. Alternatively, the backup can be performed to a local computer or to email. A restore facility is also provided. Backups may be distributed to other Behayve users.

Preserved across database backup and restore are:

- all user data, including audio Notes
- any behavior and species examples (images, videos, sounds)
- any user-supplied maps.

Additionally, Behayve users can export selected data of various types, or all data in a Study, to the safety of Dropbox or to a computer or email. This can be in spreadsheet form or formats compatible with a variety of Geographic Information Systems (GIS), such as ArcGIS™ and QGIS™, and mapping systems like Google Earth™ and Google MyMaps™, for visualisation. Tools are provided for effortless transfer of large amounts of data to these systems in structured form. In detail, the export data formats are CSV, KMZ, ESRI JSON and GEOJSON.

Resulting visual displays in GIS and mapping systems are clickable: a click on icons of various kinds (Fix, Behavior, Group and Subject) pops up a display of associated data.

One export type worth noting is Transitions. A Transition entry is recorded each time a significant change occurs, such as start and end of sampling or a switch to record a different Subject. This way, you can see exactly when different Groups and Subjects were and were not under actual observation.

Photos and videos

Even for photos and videos recorded without a GPS location, Behayve is able to semi-automatically position them on a Google Earth map (or other KML-based mapping system) as icons that display the relevant media when clicked. Here the proviso is that on cameras lacking built-in GPS, the time of day has been synchronised to the second with the Android before observations begin, and *Position recording* is enabled in Settings. Because Behayve records the observer's position twice a minute, it is able to interpolate the camera's position, knowing the time of exposure.

This post-processing is done as follows:

1. Import any number of photos and videos from a Session into Adobe Lightroom or the lower cost ACDSee photo manager on a laptop. In the case of Lightroom, you'll need to install the free LR/Transporter plugin for the next step.

2. In the photo manager, export the photo/video metadata (containing, notably, the time of exposure) to a file on Dropbox or the laptop.
3. Import the file into Behayve using the 'MediaInfo' option.
4. Export from Behayve a 'MediaInfo' KMZ file as well as the normal track and behavior KMZ files.
5. Import the KMZ files into Google Earth, for example by double-clicking on them.

Water temperature and depth

If you are working on the water, it may be useful to have Behayve record <u>water temperature and depth</u> automatically every 30 seconds, and when observations are made. This easily can be achieved by linking the vessel's chartplotter or fishfinder to the phone via a wireless connection.

To do this, you attach an inexpensive serial-to-wireless adapter to the [NMEA-0183](#) serial output of your chartplotter/fishfinder, and Behayve automatically accepts the incoming wireless data stream, which contains the temperature and depth information. A little wiring may be required to connect the NMEA signal to the adapter.

Although wireless technology has its vagaries, Behayve ensures that a robust and reliable connection is maintained.

For details see [Appendix D – Wireless connection to aircraft's or ship's instruments](#).

Working in a team

When events are unfolding rapidly a team approach may be invaluable, with different team members at a single location assigned to record different event types. Or, a team may be geographically dispersed. In either case, Behayve is able to <u>merge</u> the data recorded on different devices into a single on-board database, given that all the studies involved are based on a common configuration.

In team scenarios, it is possible to configure a Study, <u>lock</u> it down, and distribute it to colleagues and citizen science volunteers. Your colleagues and assistants are then unable to alter the configuration and settings.

Merging works as follows:

1. You distribute a configured Study to the team, for example via email.
2. Team members import your Study into Behayve and use it to record tracks, behavior and environment.
3. Team members export their Behayve onboard databases and send them to you.
4. You use Behayve's *Merge* function to merge received databases into your own onboard database on a per-session basis. In doing so you indicate whether the team (including yourself) was in a single location (and thus in agreement as to the names of the Groups and Subjects) or dispersed. Based on this, Behayve knows how to handle the naming.
5. Redistribute the merged database to team members before they perform further observations – this avoids data duplication.

For more details, see [Appendix M – Distributing studies to other Behayve users](#).

NOTE: On the *Merge configuration* screen, turn on the switch *Common groups and subjects* if the team agreed on the naming.

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NOTE: We recommend saving and setting aside a copy of your database before each merge.

Expanding the configuration while sampling

During sampling you may find a need to record a group, subject, behavior, modifier, mode or species that was not preconfigured. A plus button + on the sampling screen allows you to rapidly add these on-the fly, at the time they are needed.

Finishing a session

Finishing your Session is important. It allows astronomical data like sunset time to be automatically recorded, and observer tracking to be terminated. You don't want your observer tracks to end at the pub or worse! Backtrack repeatedly until you see the red *Finish session* button.

Limitations

To minimize crashes, it's recommended to:

- Restart Behayve before using it
- If you need to use another app while using Behayve, restart Behayve afterwards

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Elephant Study walkthrough

In this section we'll be walking through the sample *Elephant study* supplied with the app, to record some data. You may like to step through with the app as you go, and experiment further. In a later section we'll see how to configure a new Study, using *Elephant study* as an example.

A key point to remember is that navigation of screens in Behayve is like climbing the branches of a tree. To reach a particular branch (i.e. screen) you may need to descend to a lower fork of the tree then ascend again on another branch. Returning to the previous screen is like descending to a lower fork.

NOTE: Before any observations, if you will be recording positions, you should enter the local magnetic declination in Settings. You can get your local magnetic declination at www.magnetic-declination.com. It may be positive or negative. Enter a decimal number, for example -8.47.

Starting a Session
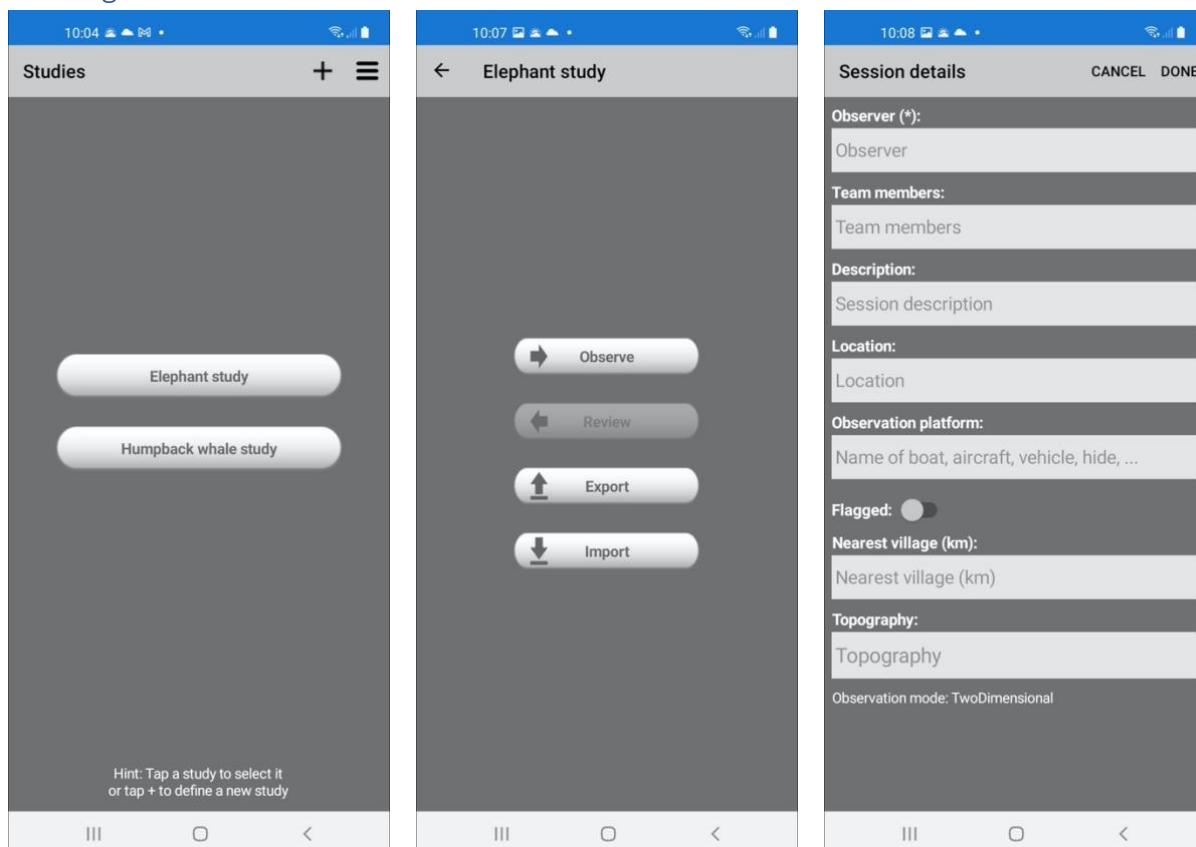
The *Studies* screen is the home screen. Tap *Elephant study* to select this study. The *Elephant study* screen appears. Tap *Observe* to set up a new observing session.

This brings you to the *Session details* screen, where you enter your name as the observer and optionally record further details about this session. *Flagged* would indicate a Session of special interest.

The upper items are standard, but *Nearest village* and *Topography* are custom data fields specific to this Study, specified when the study was configured. You may need to scroll, or hide the keyboard, to see them. Tap *Done* to continue to the *New session* screen, where you can tap *Start session* to begin recording. (If prompted to allow the app to access your location, select *While using the app*.)

NOTE: If you see "For a better experience, turn on device location", tap *OK* to enable access to location then re-start the app.

Behayve begins recording the phone's position twice a minute and whenever you record an observation (as well as data from external instruments, if wirelessly connected).

NOTE: Double-taps are never needed in Behayve – single taps are fine.
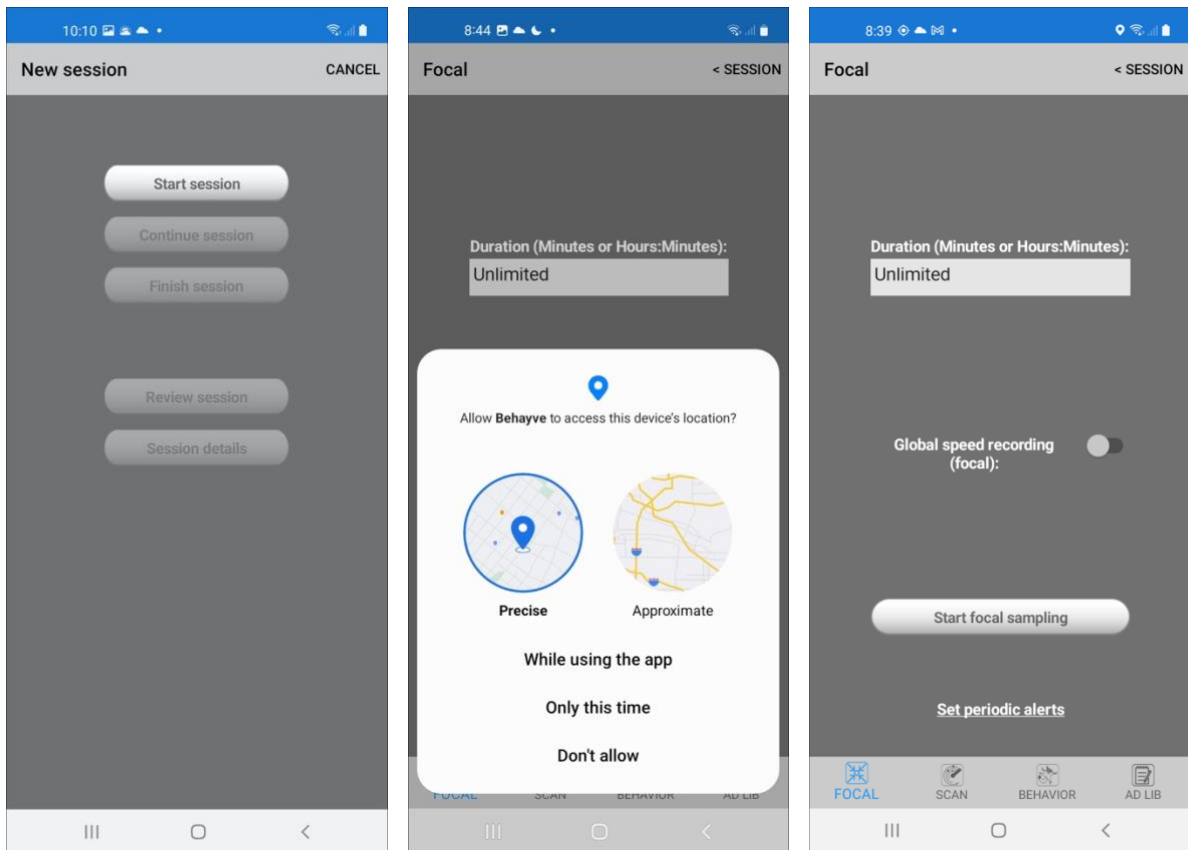
Tabs at the bottom of the screen now allow you to choose *Focal*, *Scan*, *Behavior* or *Ad lib* sampling (rightmost image above). Choose the *FOCAL* tab and tap *Start focal sampling* to focus on one elephant for the time being.

NOTE: The *Global speed recording* option will ignore any roles you have configured, allowing very fast recording of behaviors. Actor and Receiver roles, and any modifiers, remain functional. You can also select *Speed Recording* for each Behavior separately (see below).

NOTE: The optional *Set periodic alerts* function allows you to be alerted at regular intervals in focal mode.

Sampling
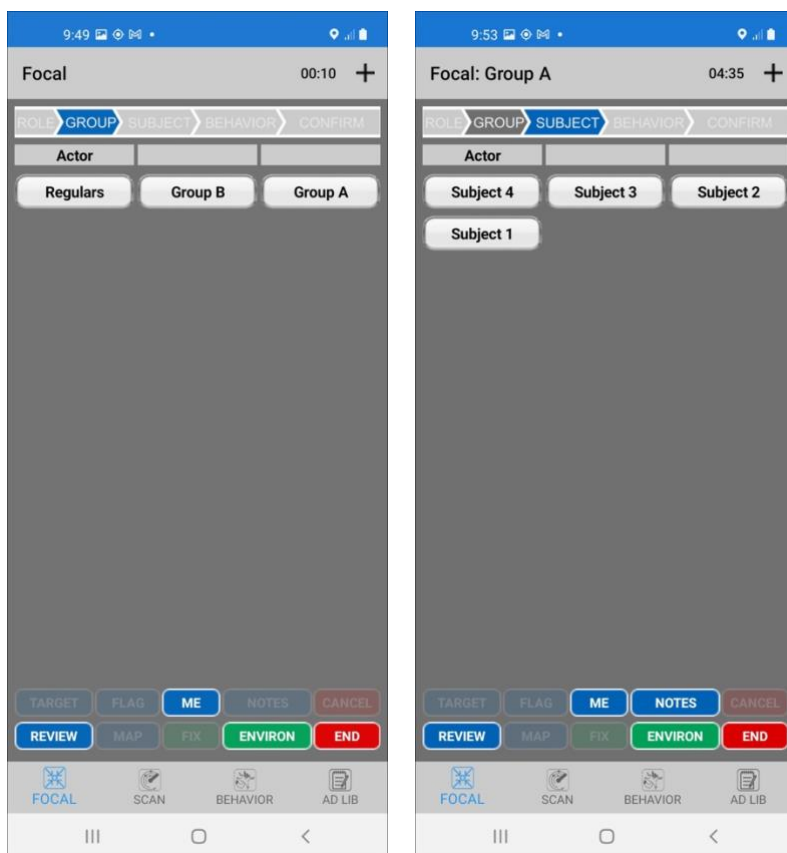
In the row of five chevrons across the top, we see *GROUP* highlighted in blue, indicating that we may select a group. The Role below that has been automatically set to *Actor*. Our study has been configured with three groups (and further groups can be added as encountered, using the + button at top right of this screen). Tap *Group A* to select it. The *Focal: Group A* screen appears.

Now the *SUBJECT* chevron is highlighted, indicating that we may select a subject, and the four subjects of Group A are displayed. (We could tap the gray *GROUP* chevron to go back and select a different group.) These four subjects were pre-configured when the study was set up, and further subjects could be added as we encounter them, using the + button of this screen.

We see Subject 2 in front of us at 100 meters, and tap the *Subject 2* button. The Focal: Subject 2 (A) screen appears. Checking the title at the top is key to knowing where you are in Behayve.

This is the screen we'll mainly be working on.

NOTE: If you wish to record at group level as well as subject level, a setting is provided at configuration time to allow this. The flow will be slightly different, but the same principles apply.

Since a list of behaviors was created when this study was configured, behavior buttons appear in the middle panel of the screen. Again, you may add a new behavior any time using the + button on this screen.

NOTE: The behavior buttons for different groups might not all be the same, since the study was configured this way.
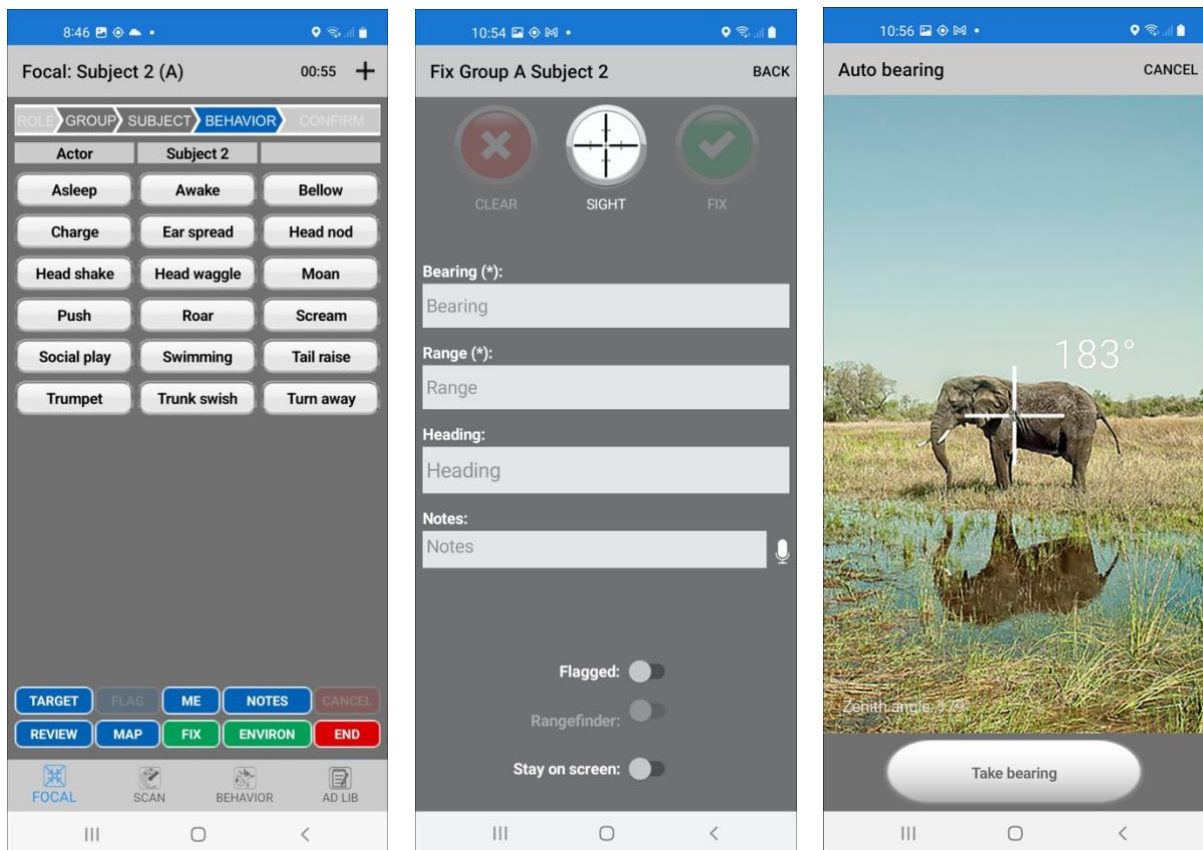
Fixes

We'd like to record the elephant's position so we tap *FIX*. The Fix Group A Subject 2 screen appears. We could enter the compass bearing, but instead tap the *SIGHT* button. When the elephant is in the cross-hairs we tap *Take bearing* and we are returned to the Fix screen with the compass bearing filled in automatically. To complete the fix, we enter the range (distance from phone to elephant, meters by default) and tap the green *FIX* button at top right. We are then are returned to the Focal: Subject 2 (A) screen.

HINT: For best accuracy, face the phone towards the animal before tapping *SIGHT*.

Behayve automatically records the observer's position and the time of the fix, in addition to the computed position of the animal (latitude and longitude by default). The time is the time of your initial action (tapping the *Take bearing* button or entering data), allowing you to complete the fix without rushing.

A sequence of these fixes will define a track. Once you have recorded three or more fixes, you can tap *MAP* to display a map with the tracks superimposed. Tapping on a fix displays its associated data. Between fixes you may wish to record behaviors and, from time to time, the current environment.

Should you wish, for a time, to record a sequence of fixes without any behaviors, you can select *Stay on screen*, for convenience.

Optional use of a wireless laser rangefinder, to record ranges automatically, is described in Appendix C – Wireless Laser Rangefinder.

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NOTE: Because compass north is not the same as true north, Behayve needs to know the amount of the difference when calculating positions. During configuration, this is done in Settings by providing the local 'magnetic declination'. Otherwise Behayve will try to use a GPS-provided magnetic declination, but in general this may be less accurate.

NOTE: Compasses might not work well in buildings or near power lines. If prompted to calibrate the phone's compass, wave the phone around in a figure 8 pattern at arm's length a few times.

NOTE: If the elephants had been in hilly country, we might have enabled 3D fixes beforehand in *Settings*, in which case the zenith angle as well as the compass bearing would be captured when we record animal positions. Here 2D is fine for our purposes.
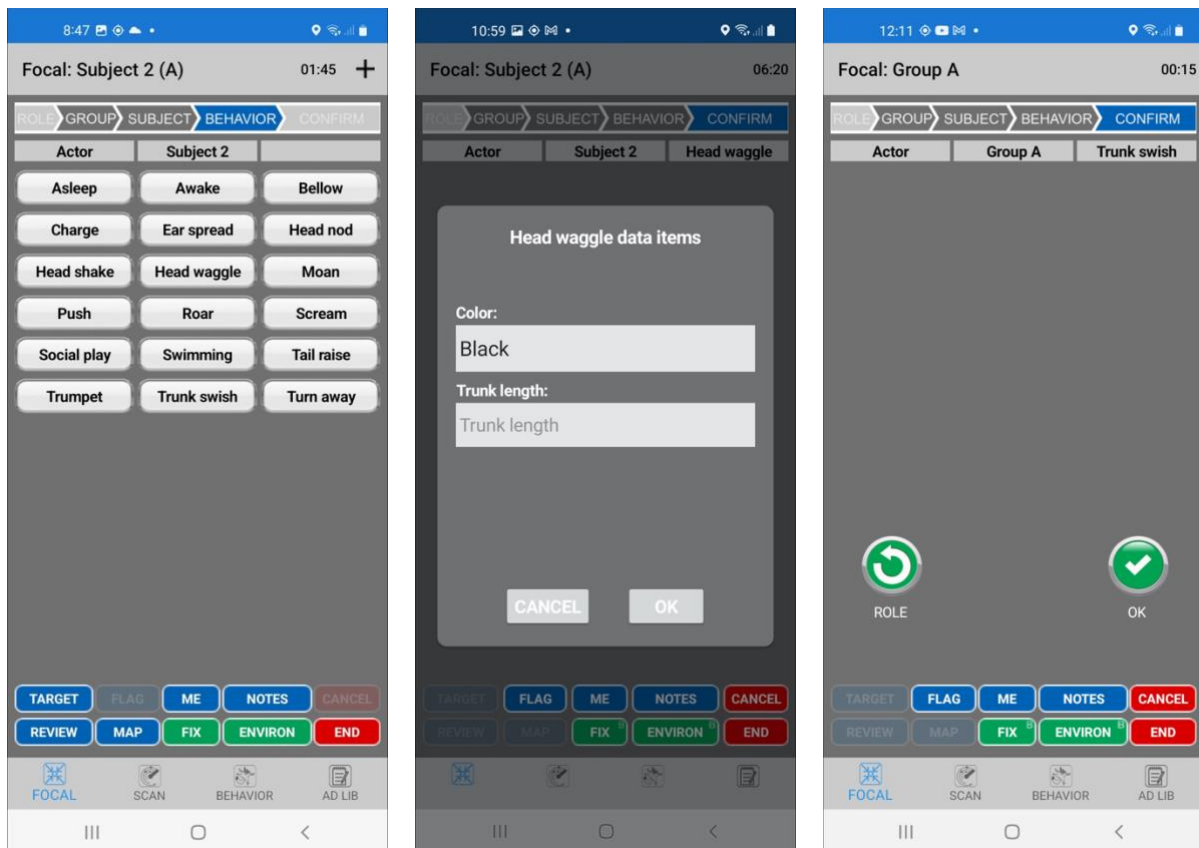
Behaviors

The elephant shakes its head. We tap *Head shake.* The elephant roars. We tap *Roar*.

After a while the elephant waggles its head and we tap *Head waggle*. This time, before we are returned to the previous screen, we are prompted to enter data (middle screen above). This is because, when the study was configured, the *Head waggle* behavior was configured to prompt for this data. Apparently when the elephant wants to play, its color is important to know 😊. We can enter the data or just cancel.

As with a fix, Behayve automatically records the observer's position and the time the behavior was recorded. The time is the time the behavior button was tapped.

Subject 2 swishes its trunk and we tap *Trunk swish*. For this behavior, a screen appears with *Role* and *OK* buttons (rightmost image above). The study was configured such that for particular behaviors, including this one, an opportunity would be given to record associated roles. More on this later: for now, we won't tap the Role button.

Let's say we want to record exactly where the elephant was, when it swished its trunk. The trick here is to tap *FIX* <u>after</u> *Trunk swish* and <u>before</u> *OK*.

NOTE: When you tapped *Trunk swish*, a small *B* appeared in a corner of the *Fix* button to give you a hint that the fix will be tied to the *Trunk swish* behavior. At most one Fix is accepted for the Trunk swish.

You'll notice the <u>status line</u> just beneath the row of chevrons, with the current role (Actor), group/subject (Subject 2) and behavior (Trunk swish). This updates at every step so you can check where you are up to.

NOTE: When you record a behavior or a fix, an automatic timestamp is taken when you first begin to record it. This allows you to take as long as you like recording further information such as notes. Timestamps are *Local Time* by default, but can be *UTC* (*Timestamps* setting). See <u>Appendix L – When exactly are timestamps taken?</u>

Long-pressing a behavior button will show any example image, video or sound clip that was provided when the behavior was configured. You can try this with the *Roar* and *Trumpet* buttons, to compare the sounds[1].

NOTE: Example media are preserved during database export/import, for example when distributing a study to citizen scientists.

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[1] Sample sound clips are from the amazing https://www.elephantvoices.org/elephant-ethogram.html

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Subject 4 appears on the scene and you decide to focus on her from now on, in your focal sampling. Tap the *SUBJECT* chevron and tap *Subject 4*.

Events and states

Until now the behaviors have been events. Let's try some behaviors that have been configured as states. Tap *Awake*. Notice that the *Awake* button has acquired a circular decoration to indicate the state is now in progress (rightmost image above). If you tap *Awake* again, the decoration vanishes, indicating the Awake state has ended.

Behayve records the start time, end time and duration of state behaviors.

NOTE: Where some state behaviors were still in-progress when sampling was ended, their duration is recorded along with an annotation indicating they were in-progress. This is based on the time the *End* button is tapped and confirmed with OK (in some cases, the OK is automatic).

NOTE: As a separate issue, the *Awake* and *Asleep* buttons in this study have been configured to be 'mutually exclusive'. For that reason, clicking on *Asleep* would have the effect of ending the Awake state and beginning the Asleep state (the *Asleep* button would acquire a decoration and the *Awake* button would lose its decoration).

NOTE: The decoration does not appear in Scan sampling, as it would not make sense there.

Editing and adding groups and subjects

Editing groups and subjects

To update information about a group or subject from time to time, tap the TARGET button whenever the group or subject is selected. For example, you may wish to update your estimate of a group's size from time to time, along with a confidence level such as Approximate or Exact.

In the case of a subject (rightmost screen above), you can update properties including age, sex, length, breadth, height, weight, personality, mother and father.

Additional species may be added at any time, using the + button.

For each update, a timestamp and the observer's position are automatically recorded. Behayve maintains a running log of changes (accessible via the *Group info* and *Subject info* exports).

NOTE: Use of the optional *Selector* dropdown is described in Appendix U – Filtering subjects using selectors.

Adding additional groups and subjects

To add a new group at any time, tap the *Group* chevron then the **+** at top right of the screen. The leftmost screen above will appear.

To add a new subject, tap the *Group* chevron and select a group, then tap the *Subject* chevron and tap the **+** at top right. The rightmost screen above will appear.

Here, *Group D* and *Subject 5* are automatically generated codes. Optionally you can give groups and subjects a name, in addition to the code, to aid memory.

When adding a group, you may set the group size, together with the confidence of the size estimate (all these can be updated later from time to time). The group will by default have the behavior classes selected by the previous group added, and therefore the behaviors in those classes, unless you tap *Behavior classes* to make a selection. (If there was no previous group, Events and States will be selected.)

When adding a group or subject, you can select a species from a dropdown list.

NOTE: Because images of elephant species were supplied during configuration, the species dropdown list includes an option to select a species by scanning an image gallery (*View gallery …*). Once a species is selected, you can review its media item (*View example …*). The media item may be configured as an image, video or sound clip.

Optionally, you can set the color that the corresponding subject button will have during sampling.

Switching between groups and subjects
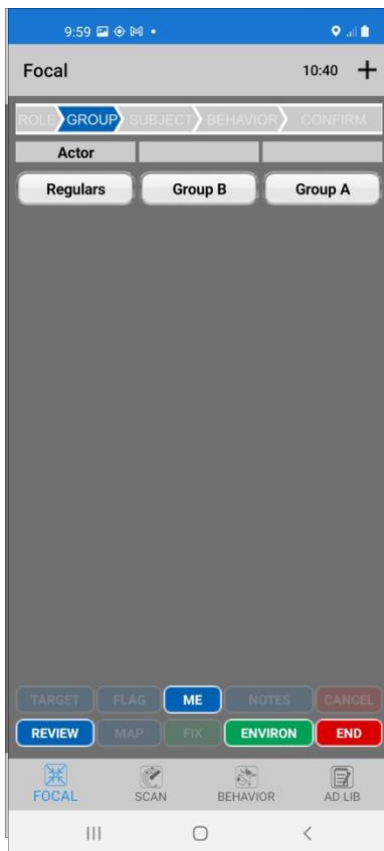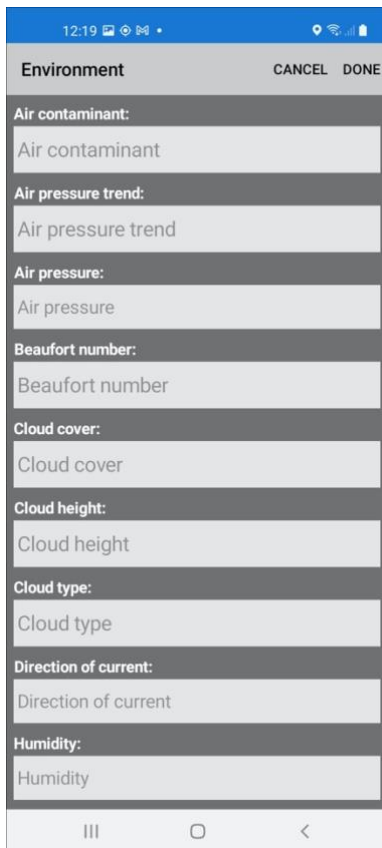
To switch observations from one group or subject to another, you use the chevrons at the top of the sampling screen.

Tapping the *GROUP* chevron allows you to select an existing group (or add a new group to the configuration).

Similarly, once a group has been selected, tapping the *SUBJECT* chevron allows you to select an existing subject (or add a subject).

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Environment

From time to time while sampling, you may take a snapshot of the environment by tapping the ENVIRON button on the sampling screen and supplying requested environmental data (determined when the study was configured).

Notes
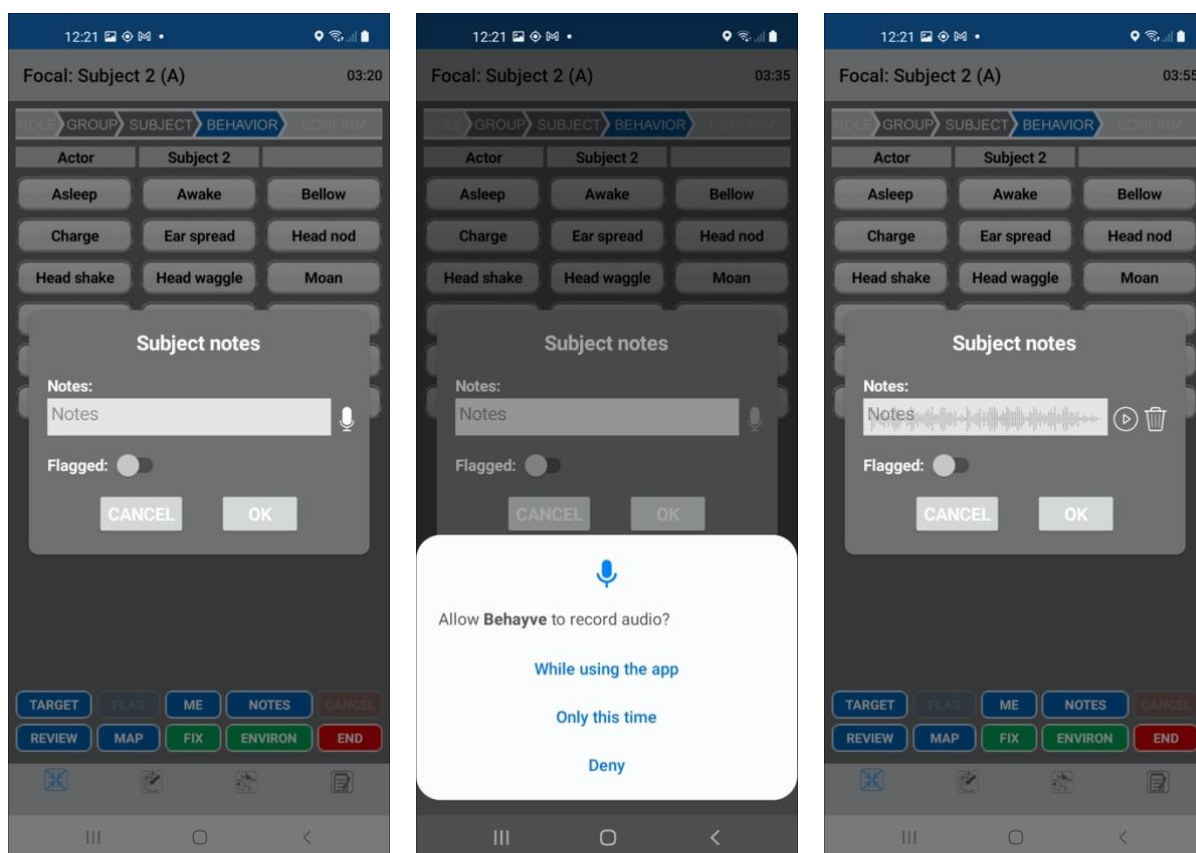
To enter notes, tap *NOTES* at any time. You can:

- Type in your notes, and/or:
- Record your notes or an animal vocalization (tap the microphone icon next to the Notes box)
- Dictate your notes (tap the microphone icon on the keypad) for automatic speech-to-text conversion
- Flag a note as important

While recording, the microphone icon will turn red. To stop recording, tap the microphone icon again. To play back the recording, tap the play button (rightmost image above). To delete a recording, tap the trash icon.

Behayve automatically records the time, observer position and observer name of all notes.

NOTE: To play back a recording at a later time (and possibly transcribe it) use the *Review* function.

Review and correction
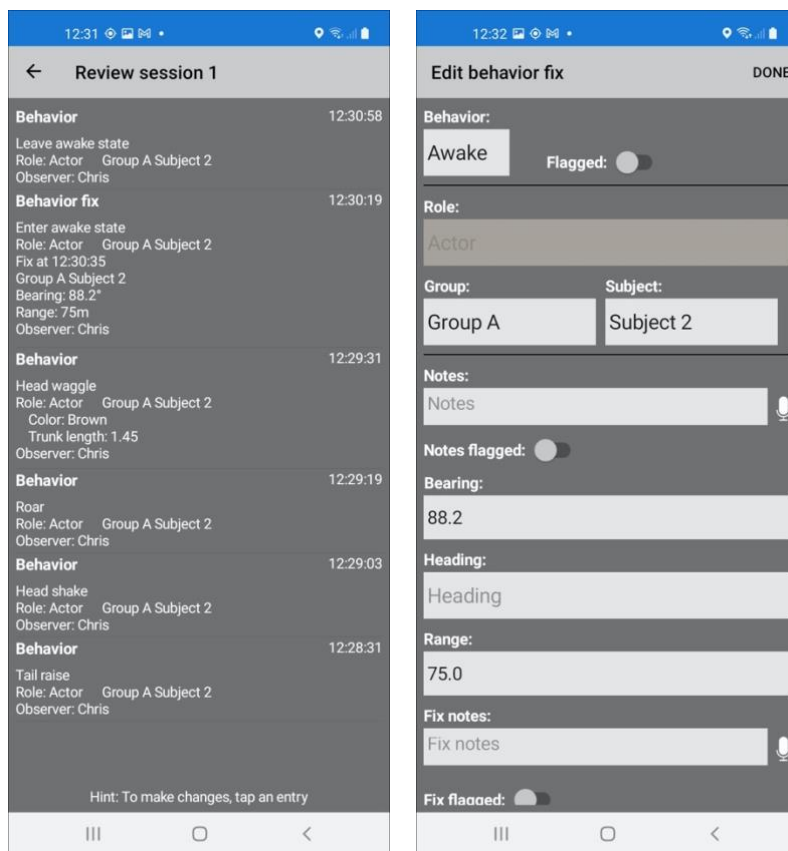
The *REVIEW* button on the sampling screen allows you to view data you've recorded in the current session while sampling, and make corrections if necessary. To change an entry, tap on it to bring up the edit screen. Tapping *Behavior fix* in the leftmost image above brings up the screen at right, where values can be replaced.

NOTE: When not in a session, you can tap *Review* on the *Sessions* page and review or correct data from any previous session.

Modifiers and roles

In many cases, nothing further is required for recording. Sometimes, however, a study will be configured with modifiers and/or roles for particular behaviors, in which case you will have the option of entering these when you select such a behavior.

Modifiers
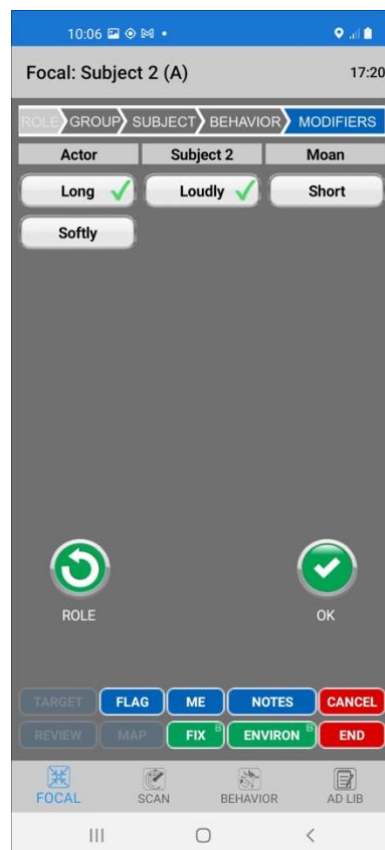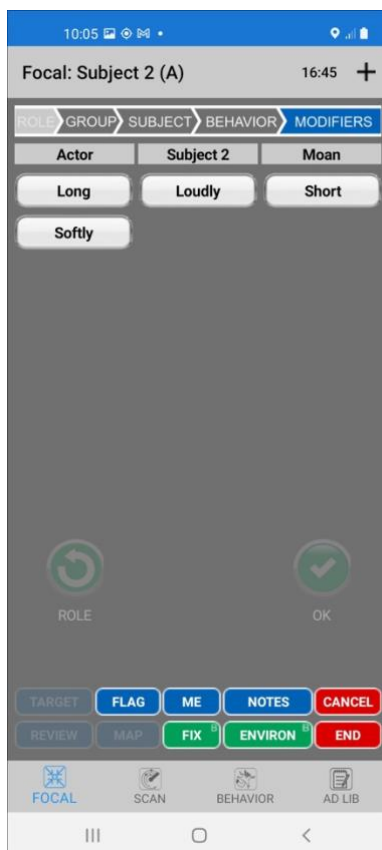
When the study was configured, some behaviors may have been configured with modifiers. As an example, tap the *Moan* behavior. In place of a highlighted *CONFIRM* chevron, there is a *MODIFIERS* chevron and you must select one or more modifiers, for example *Long* and *Loudly*. Then tap *OK* or *ROLE* as usual.

Roles

There are two built-in roles, *Actor* and *Receiver*. For many behaviors there may be simply an Actor. Other behaviors may be configured to have a Receiver as well. And when the study was configured, additional custom roles may have been defined and assigned to various behaviors. When you record a behavior, you can assign animals to these roles.

When you tap a behavior that has a Receiver, you are immediately taken to a screen where you select the receiver. With Subject 2 of Group A selected, tap *Charge*. The following screen appears:
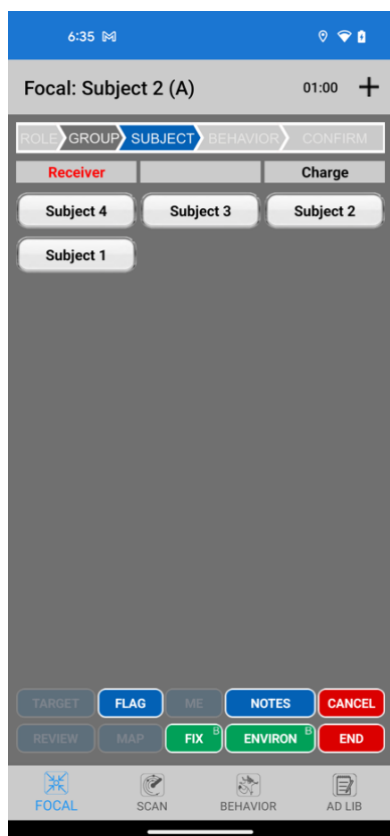
In the status line just below the chevrons the role is shown as *Receiver*, in red. Subject 2 is charging towards Subject 4, so select *Subject 4* as the Receiver. Keep out of the way if you can.

Earlier, we mentioned the *ROLE* button. When you've tapped a behavior and the *ROLE* and *OK* buttons appear, you can tap *ROLE* and record custom roles that have been configured for this behavior. Or just tap *OK* immediately to skip the custom roles. (If no roles have been associated with this behavior during configuration, the *ROLE* button will be disabled.)

Let's take an example. Tap *Ear spread,* then tap *ROLE*.
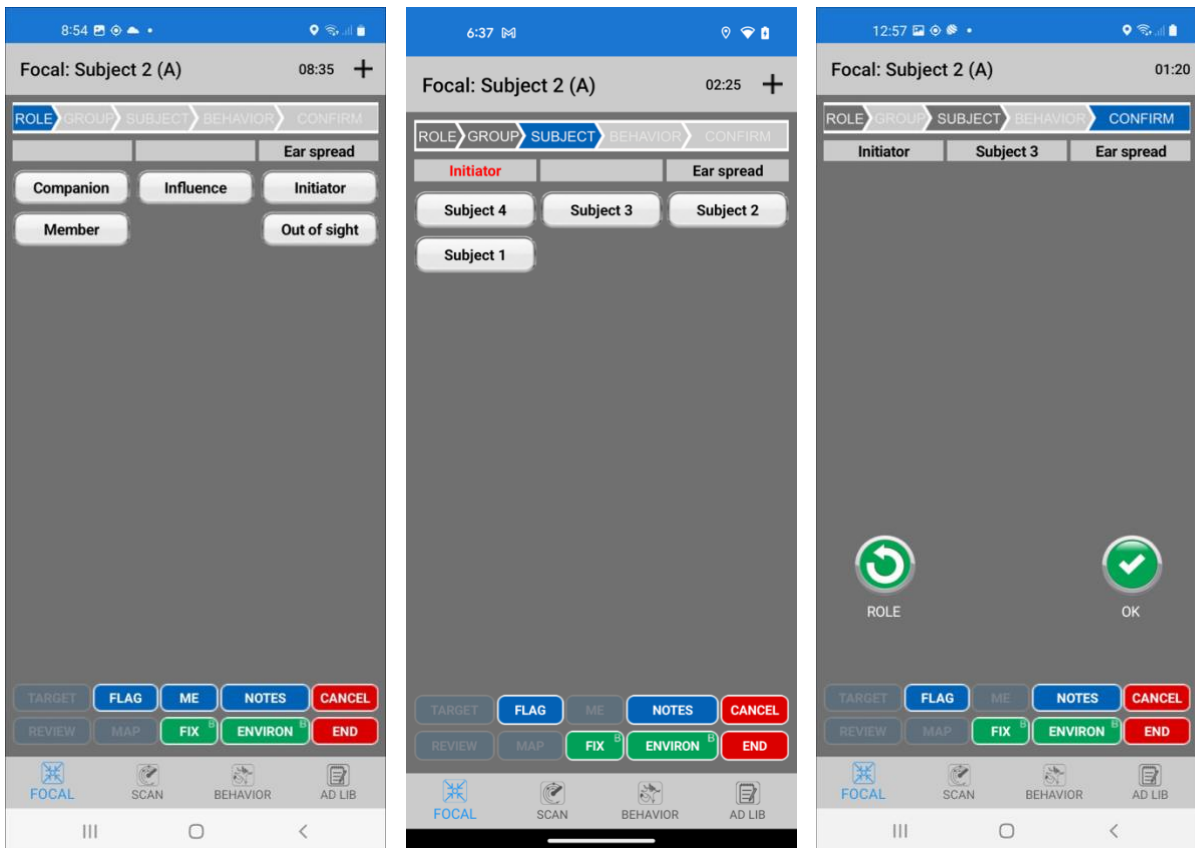
We see the *ROLE* chevron highlighted and a choice of five roles. Tap the *Initiator* role. Now the *SUBJECT* chevron is highlighted (middle image above) and we have a choice of subject. Select *Subject 3* as the Initiator. Once more we have a choice between the *OK* and *ROLE* buttons (rightmost image). We can tap *ROLE* again to add another role, or tap *OK* to finish this behavior.

Here the status line below the chevrons is especially useful to keep track of where we are up to.

NOTE: When assigning a subject to a role, there is the possibility to assign a subject belonging to another group (by tapping the dark grey *Group* chevron), In this way, interaction between members of different groups may be recorded.

Communal roles

Communal roles are designed for situations where several subjects in a group rapidly take up a role or leave it. Examples would be:

- Social play, where different subjects quickly join or leave the play
- A group of whales individually surfacing then quickly submerging at different times.

Any role of a State behavior can function as a communal role: no configuration is required. (Speed recording must of course be turned off for the behavior, so that the *Role* button will be enabled.)
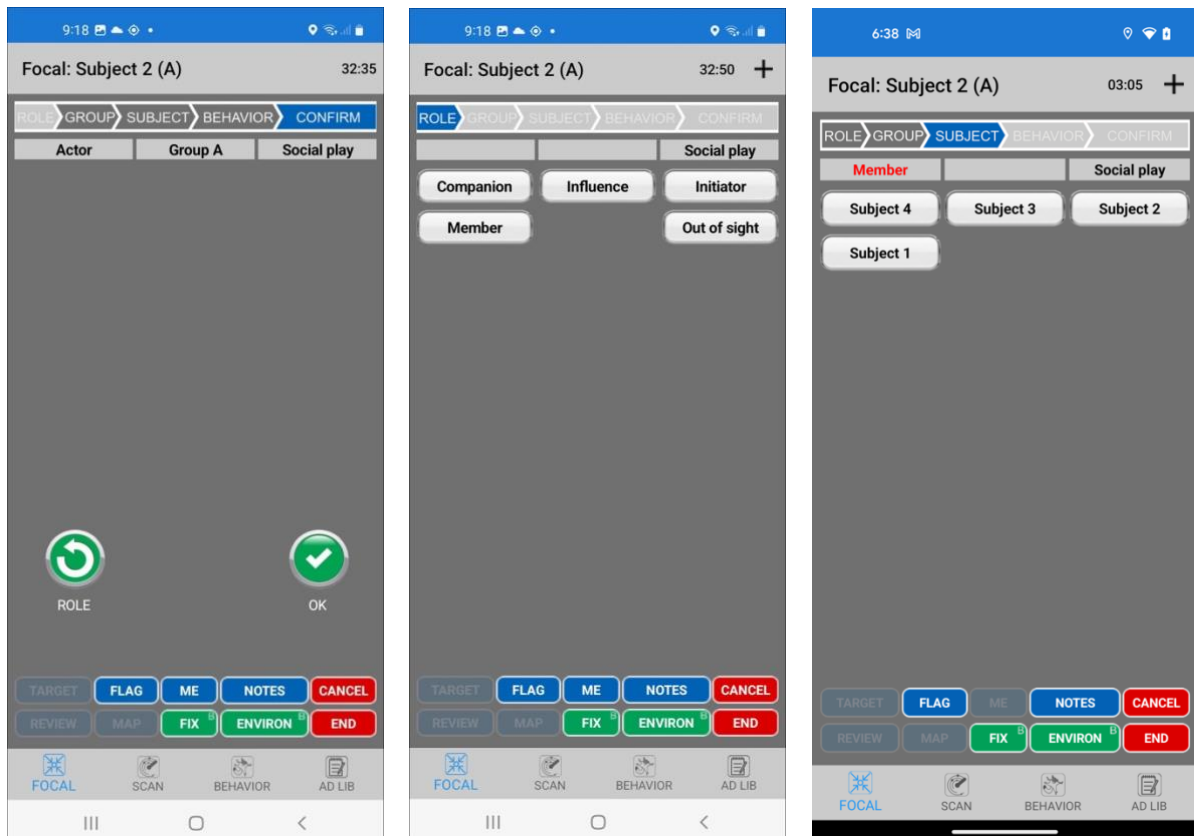
Begin in the usual way by selecting the *Social play* behavior and the *Member* role, as in the three images above.
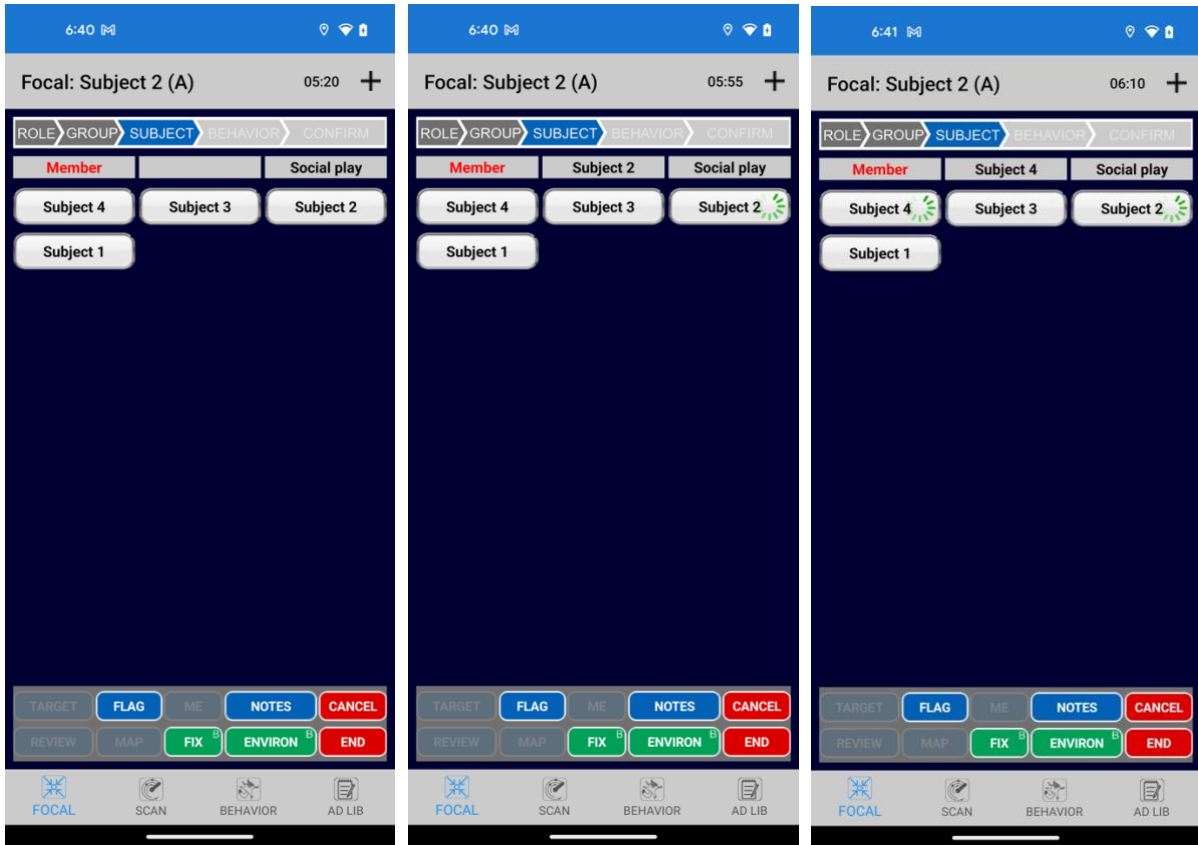
Communal mode is then entered by long-pressing any subject button; which subject button is immaterial. The screen turns dark blue, as in the leftmost image above, to indicate that we are now in communal mode for the *Member* role.

NOTE: The title bar at the top of the screen shows *Subject 2*, however that is ignored for communal roles.

Coincidentally, Subject 2 is playing, so we tap the *Subject 2* button. The button acquires a decoration (middle image above), indicating that Subject 2 is a currently a player.

Subject 4 is playing with Subject2, so we tap the *Subject 4* button. Subject 4 likewise gets a decoration (right image above).

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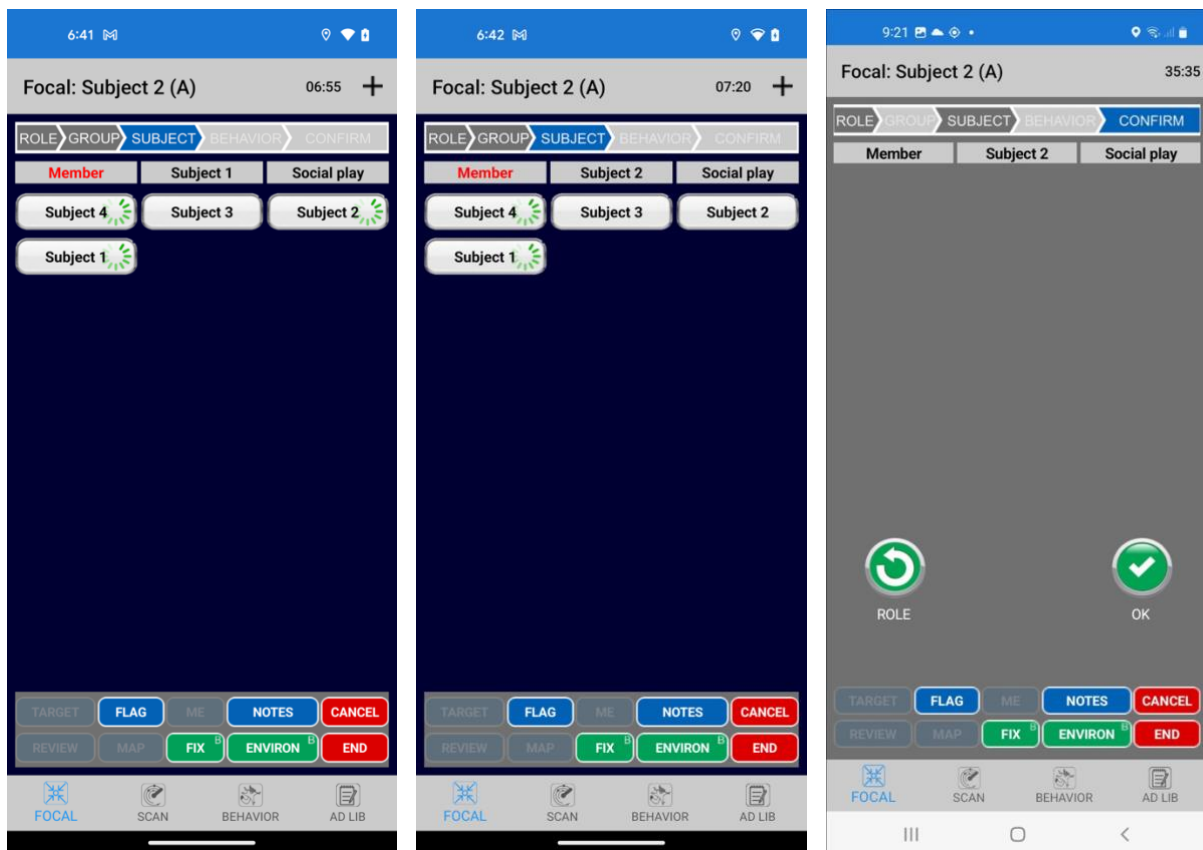
Soon after, Subject 1 joins the play and we tap *Subject 1*. Now there are three subjects playing together (leftmost image above).

After a short time, Subject 2 leaves the play and we tap *Subject 2*. Its decoration disappears (middle image above), indicating that Subject 2 is no longer in the play. (Subject 2 may re-join the play later.)

Suddenly the remaining subjects scatter and the play is over. We could tap *Subjects 1* and *4*, but when we terminate communal mode, any remaining subjects are automatically terminated. So, we will just terminate communal mode by long-pressing any *Subject* button; which button is immaterial. The screen now has reverted to gray, and we have re-joined the normal flow (rightmost image above). Tap *OK* to save the data, or select another role.

In the *Observations > Roles* export, you will find each subject's start time, end time, duration and other details. Results can also be found in *Review*.

Observer name and position

The *ME* button displays the observer's latitude and longitude and, for nearby Places that have been configured, the current compass bearing and range to that Place. It also allows the observer name to be changed at the end of a shift. The geoidal separation is also shown.

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Exporting and importing data

Observational and configuration data, as well as studies or entire databases, may be exported and imported via your own private Dropbox storage, cloud drive links shared by others, web, email or a local computer.

Cloud storage

When a session is not in progress, recorded data can be exported from Behayve's onboard database to cloud file storage (Dropbox), and data can be imported from cloud storage. Dropbox is safe, secure, private and convenient to use. You'll need a free Dropbox account (dropbox.com).

Any Mac or Windows computer, or any Android, can be used to retrieve data from Dropbox later for analysis, or to place data in Dropbox for import.

eMail

Recorded data may alternatively be exported to email. In *Settings*, you can specify a default email address to be used (*ExportedEmailAddress*), or you can enter a desired email address each time.

NOTE: Any missing emails might be found in your email Junk folder. Not all email clients support the email attachments.

Web

Data may be imported via links, shared by others, to files on a personal Google Drive, iCloud Drive, OneDrive or Dropbox, or via links to files on public websites.

Local computer

A local Mac or Windows computer can be used instead of Dropbox, email or web for export and import functions. You will need a connecting cable. This is most useful if Internet is unavailable.

Accessing exported files

When Behayve is first run, a folder named App/*Behayve* is created on your private Dropbox account (if set up). It has subfolders named *Exports* (for receiving exported files) and *Imports* (for staging files to be imported).

In Dropbox, exports can be accessed conveniently at dropbox.com.

Exports sent to *Local*, meaning the local file system within the Android, may be transferred to a laptop or desktop computer using Android File Transfer (Mac) or File Explorer (Windows).For details, see Appendix A – Accessing Local Files. (In fact, when Dropbox or eMail is the destination, exports are first placed in *Local* automatically, then copied from there to Dropbox or eMail.)

NOTE: It may sometimes appear that the app is frozen part-way through an export. Actually, we are waiting for Dropbox to digest the exported files that are all already stored within the phone. For large groups of files, this can take some time. If you don't want to wait, drag the Behayve folder from the phone to the desktop using Android File Transfer (Mac) or File Explorer (Windows). Or, you may prefer to export in smaller batches.

On the *Exports* screen, a common choice for Type is *Observations*, with Items set to *Behaviors, Positions, Transitions, Data Items, Group Info* or *Subject Info.* Exported files in *CSV*, *JSON* and *KMZ*

format all carry the same information. *JSON* is used for transfers to GIS (e.g. via an automated script) and *KMZ* for transfers to Google Earth.

Importing files

This works in reverse fashion. Files placed in the *Imports* subfolder in Dropbox, or at a specified web address (URL), may be imported directly into Behayve.

Where a local computer is used instead, Android File Transfer or File Explorer as appropriate is used to transfer the files to the Android 's local file system, then the files may be imported from *Local*. Details are provided in Appendix A.

Performing an export
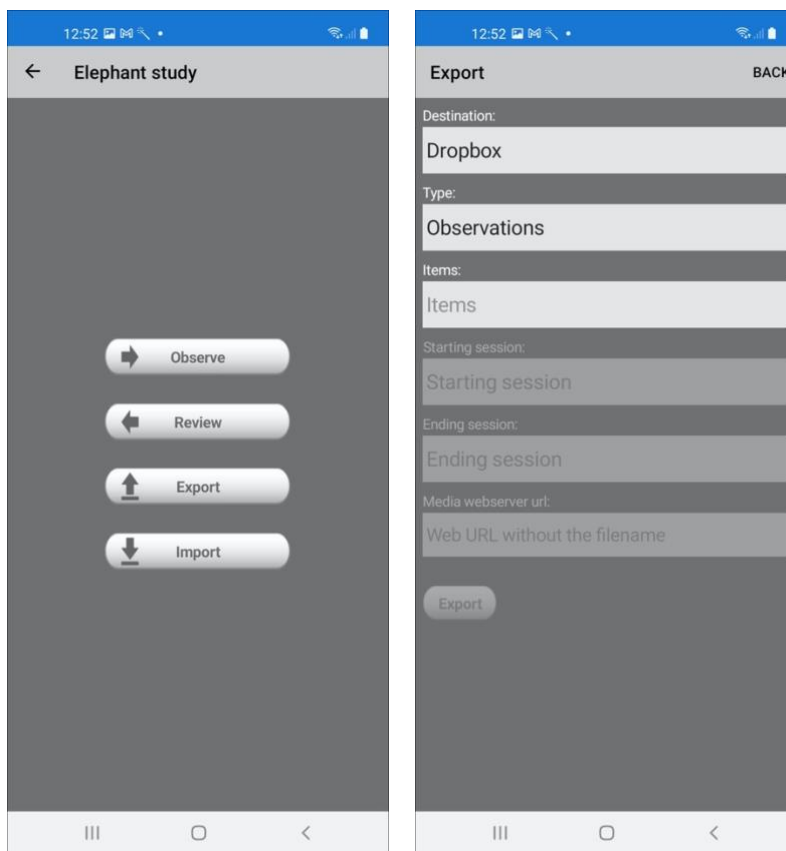
On the home page, tap on your study then, on the next page, tap *Export*. The *Export* screen appears (rightmost image).

For *Destination*, choose *Dropbox*, *eMail* or *Local*.

You'll normally want to leave *Type* with its default setting of *Observations* – the other choices are occasionally used when configuring a study.
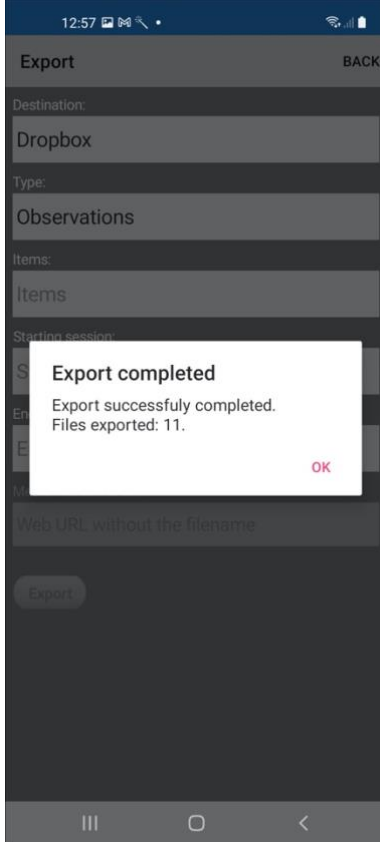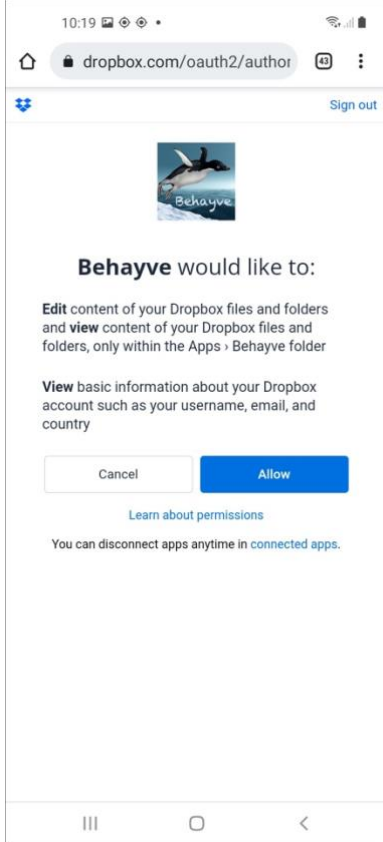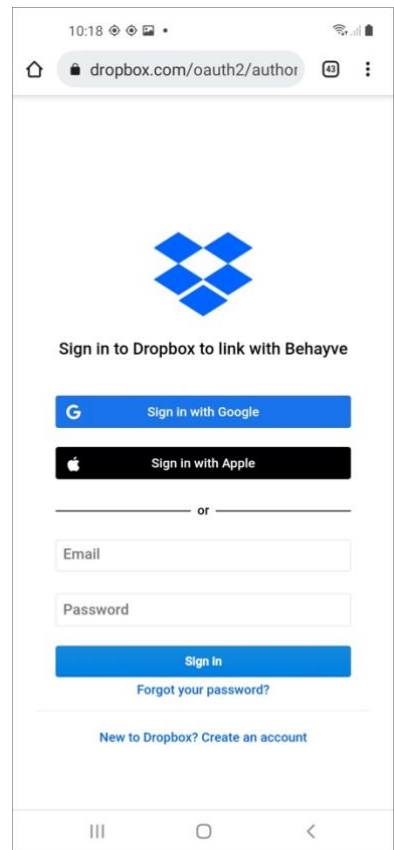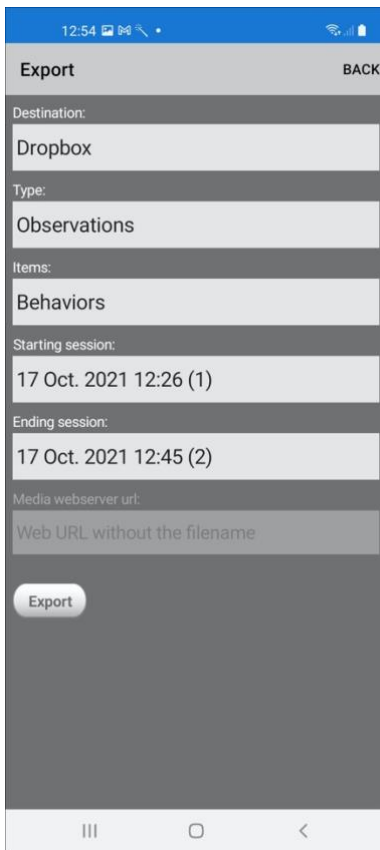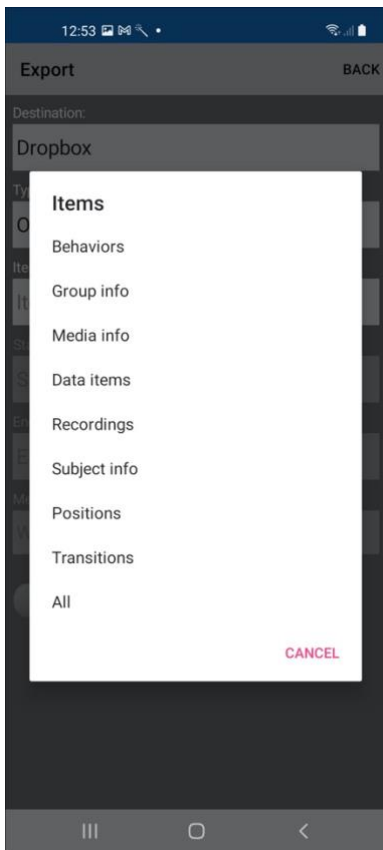
Tap on *Items* and select the kind of observation data to be exported (leftmost image).

ITEMS	DATA EXPORTED
Behaviors	Behaviors with their positions (where recorded)
Positions	Position fixes (tracks)
Roles	Occurrences of roles, including communal roles – roles are aligned in their own spreadsheet columns
Data items	Custom data items (Session details, Environment, PerBehavior, PerFix, …)
Group info	Log of changes to group information
Subject info	Log of changes to subject information
Transitions	Log of changes such as start and end time of sampling, subject switching
Media info	Positions of photos and videos
Recordings	Presently unused
All	All of the above

Select a range of sessions then tap *Export*. If you chose Dropbox, the exported data will shortly arrive in the *Apps/Behayve/Exports* subfolder in your personal Dropbox. If you chose eMail, an email with attachments will appear, ready to send.

If you chose the *Local* destination, your exported data will be found in your phone's local file system.

The first time Dropbox is accessed, you'll see screens asking you to connect. For this, you'll need a free Dropbox cloud account (dropbox.com).

NOTE: For security reasons, Dropbox allows Behayve access only to files that are in its *Apps/Behayve* folder.

NOTE: To export the entire database, see Maintenance and Backup/Restore.

Data export formats
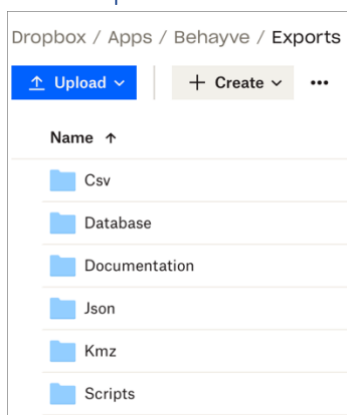
Data exported to Dropbox can be found in the *Apps/Behayve/Exports* folder as shown in the browser screen above. Exports to Local follow the same structure.

SUBFOLDER	CONTENTS
Csv	Files to open in a spreadsheet program
Database	Encrypted file containing both a copy of the onboard database and associated files
Documentation	Welcome
Json	Files to import into a GIS system such as ArcGIS or QGIS

Kmz	Files to import into KML-based systems like Google Earth and Google MyMaps
Scripts	Script allowing one-step import of multiple Json files into ArcGIS See Appendix B – One-step Import into ArcGIS

NOTE: Kmz files may be dragged into Google Earth and Google MyMaps. (Kmz files are zipped KML files.) Json files may be dragged into QGIS provided the *JsonStandard* setting is set to *GeoJson* prior to data export.

NOTE: In ArcMap and Google Earth/MyMaps, clicking on an observation pops up a window with details of the observation.

Performing an import

You can import the following into Behayve:

- Media info – metadata from a session's photos and videos pre-processed in Adobe Lightroom or ACDSee, containing the times that photos and videos were recorded – for use in track/behavior maps
- Spreadsheet data for bulk configuration of the current study – intended only for exceptionally large volumes of configuration data.

NOTE: To import a study or an entire database, see Maintenance and Backup/Restore.
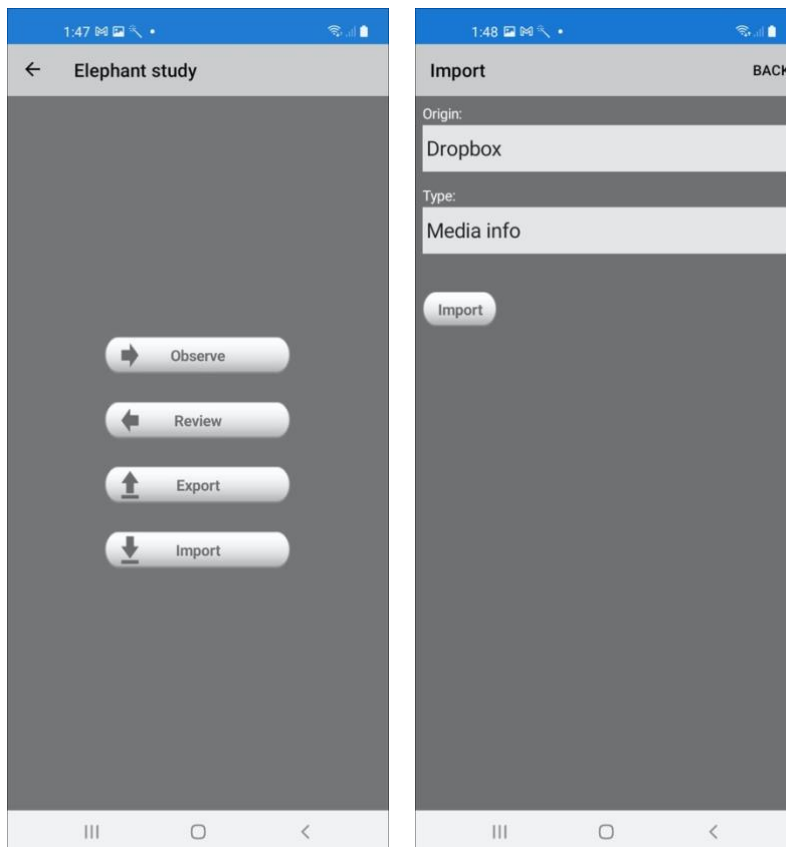
1. Place the file(s) to be imported in the Apps/*Behayve/Imports* subfolder in Dropbox or, if importing from a computer, stage the files on the Android's local filesystem as described in Appendix A -Accessing Local Files

2. On the *[Your study]* screen, tap *Import* then on the *Import* screen select an import *Type* (Dropbox, Web or Local) and tap *Import*.

Home screen menu
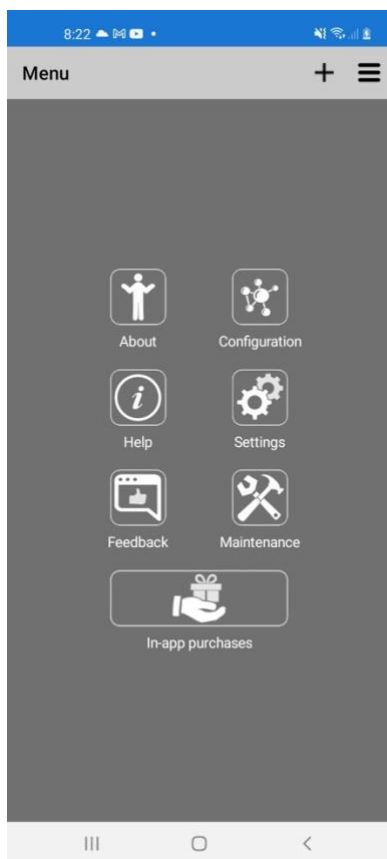
Tapping the menu at top left of the home screen brings up seven choices:

About – View information about this version of Behayve.

Configuration – Configure or re-configure a study.

Help – View the Behayve User Guide – support can be contacted at behayve.com/support.

Settings – A list of app settings is presented; when you tap on a setting its meaning is displayed. Common settings are:

-   PositionRecording (set to off if not recording positions, to save battery)

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- ExportToDefault
- ExportEmailAddress (if exporting to email)
- ImportFromDefault
- LocalMagneticDeclination (recommended to set this if recording positions)
- ObservationMode: see Appendix J – Observation mode setting
- JsonStandard：*EsriJson* for ArcGIS, *GeoJson* for QGIS

Feedback – A chance to have your say and make suggestions for new features.

Maintenance and Backup/Restore

- Export database – This copies your entire onboard database to a file *ExportedDatabase.dbf* in the *Apps/Behayve/Exports/Database* folder on your Dropbox, to email, or to a local computer. The exported file contains all details of all your studies, all data recorded including voice notes, and any files you have downloaded to the app such as photo, video or audio examples of various behaviors and species as well as any onboard maps. An exported database therefore makes an ideal backup of your work. It's recommended to back up your database daily or weekly. Bear in mind that when Behayve is removed completely from your device, all onboard data is permanently lost and you'll need that backup. (Swiping the app out of memory is fine, however.) After exporting to the cloud or to Local, you should move the export to a safe place before it is overwritten by the next database export.

- Import database – This imports a file *ReplacementDatabase.dbf* originating from a previous database export from your device or somebody else's, for example a backup database. If you are restoring a backup database, you'll need to rename it to *ReplacementDatabase.dbf*. Before importing, place the file in the *Imports* subfolder of the *Apps/Behayve* folder (Dropbox) or in the *Android/data/au.com.technologyinsights.behayve/files/directorydocuments* folder (Local import). Or import from an existing web link. You will see a warning that importing will obliterate all studies and data from your Android – so backing up your existing database beforehand is recommended. Behavior and species example files, onboard maps and voice notes are included in the import.

- Merge databases – This allows you to merge, into the existing database on your Android, sessions from a database that was exported from Behayve on any device. An option lets you specify whether the merged data was from observers at your location, agreeing with you on the naming of each animal, or from distant observers. Behavior and species example files, onboard maps and voice notes are included in the merge, except where they already exist on your device. For details, see Appendix M – Distributing studies to other Behayve users.

- Compact database – This function reduces the physical size of the onboard database and is useful after mass deletions of data. It also provides options to delete all voice notes, behavior and species examples (images, videos, sound clips) and onboard maps, should they exist.

- Import study – This imports an entire study from a file *ImportStudyDatabase.dbf,* originating from a previous database export from your device or somebody else's (for example, a backup database) adding the study to the collection of studies on your device.

  Sessions (observations) are not imported, just the study's configuration. An option allows

subjects to be included.

The file must have been placed in the *Imports* subfolder of the *Apps/Behayve* folder (Dropbox) in the *Android/data/au.com.technologyinsights.behayve/files/directorydocuments* folder, or in the *Behayve* folder of a connected computer (Local import), or be accessible via a shared web link.

In-app purchases

Subscription and purchase offers, for restricted features of Behayve. See [Appendix V – In-app subscriptions and purchase](#).

Configuring a study

Configuring a study, ready for use, is straightforward. Once you are clear on the concepts, you'll typically complete the task in a short time. Afterwards, you can make changes between sessions.

To define your study, you can create a new study from scratch or modify the sample Elephant Study. We'll describe how the sample Elephant Study was configured. You could follow along by creating a study with a different name if you wish.

NOTE: As an alternative to this interactive method, it is also possible to perform bulk imports of configuration data from spreadsheets, using options provided by the *Import* button on the *Study* screen. This should be used only for very voluminous configurations. See [Appendix O – Bulk configuration](#).
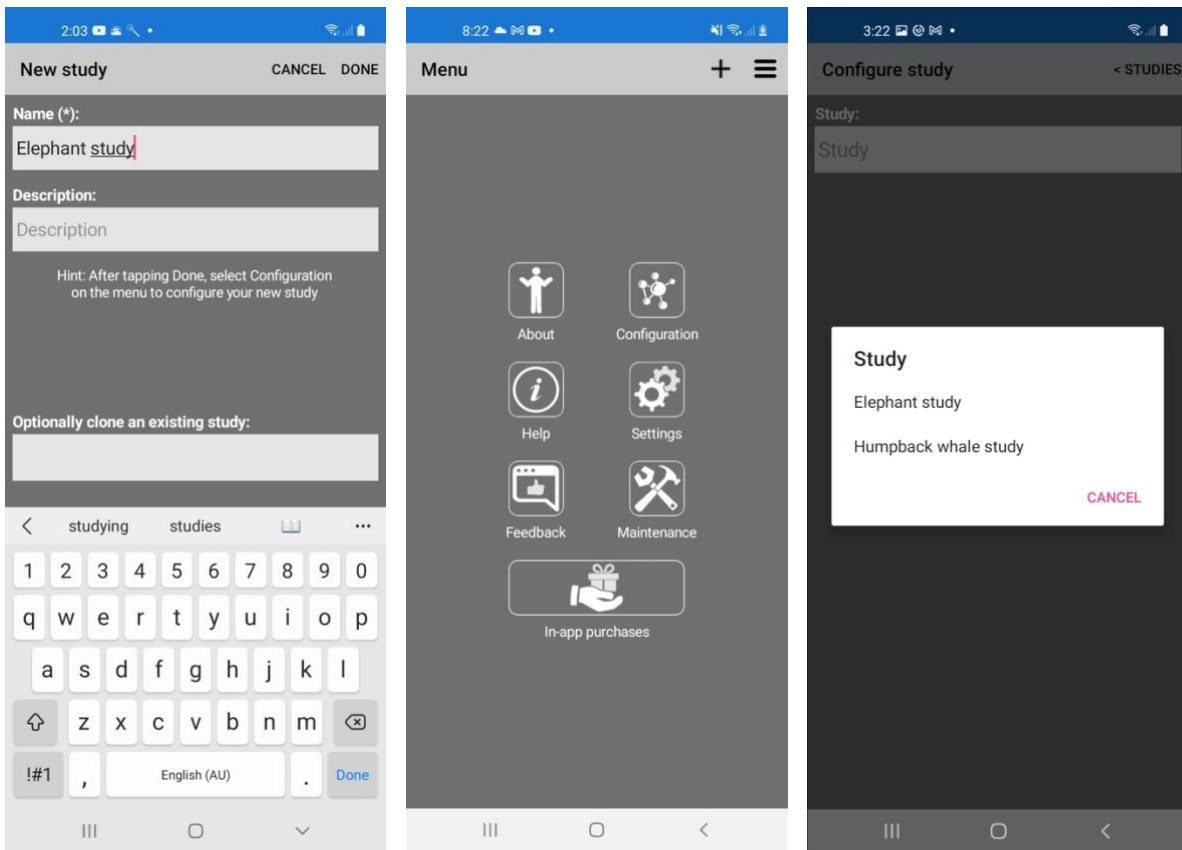
To begin, click the plus sign on the home page to create a new study. Enter a name for the study and optionally a description. Press *Done* to return to the home page.

Tap the menu icon at top right and select *Configuration*. On the *Configure study* page select your new study, if there is more than one.

NOTE: Alternatively, you may select an existing study to clone. The clone will have the same configuration as the existing study, but no recorded sessions. It can be useful to have one study for testing and another clean one, free of the test sessions, for field observations.

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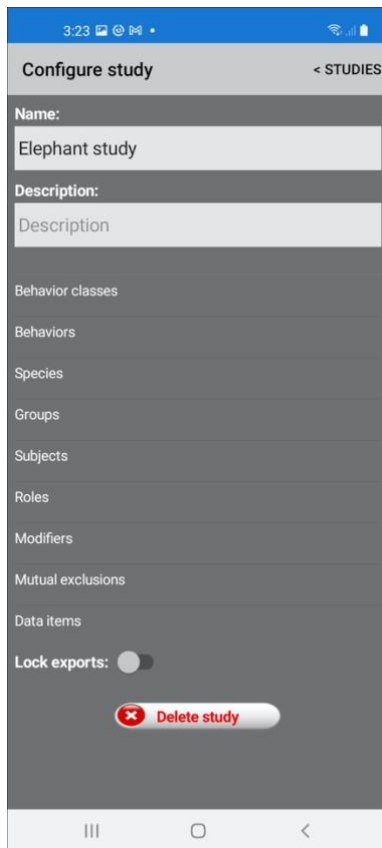
Here, there are a number of items that could be configured, and there is no set order in which to do them. To avoid unnecessary back-and-forth, we suggest configuring in the order they appear on the screen. You configure only the items you need.

NOTE: If you will be recording tracks but not behaviors, little or no configuration is needed. Certainly, you will not have to configure behavior classes or behaviors.

Behavior classes

Behavior classes are central to configuration, and it's worth taking a few moments to understand them.

Every behavior is going to be in one or more behavior classes. There are two built-in behavior classes, *Events* and *States*. Often that's all you'll need. Behaviors that are events will be put in the *Events* class, and those that are states will be put in the *States* class.

For greater control, you might decide to add some of your own behavior classes. You might want to be able to restrict the choices offered in various situations to speed up recording. You can use behavior classes to limit the choice of behaviors, roles and modifiers depending on context.

Firstly, each group will have one or more behavior classes assigned (*Events* and *States* by default). That means when observing a group or its subjects, the only behaviors that will be offered are those in a behavior class associated with the group.

If you wanted different behaviors to be offered for different groups, you would add some new behavior classes and add them to different groups.

Just as for groups, each role and each modifier will have one or more behavior classes assigned. As an example, a role or modifier assigned to a particular behavior class will be offered if recording a behavior in that behavior class.

NOTE: A given behavior class might be assigned to a number of groups, roles and modifiers.

In the Elephant Study, we have added the behavior classes *Agonistic*, *Play* and *Vocalization*.
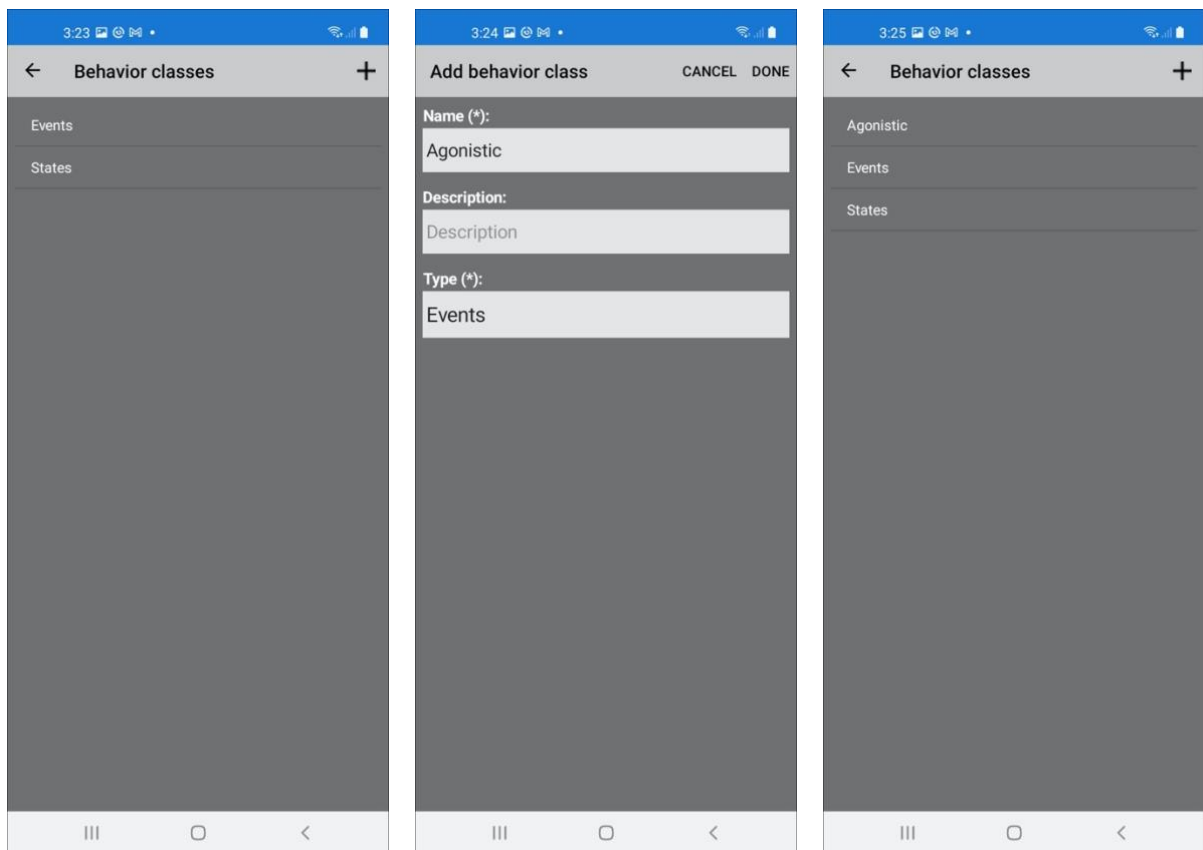
To add the *Agonistic* behavior class, tap *Behavior classes*. On the *Behavior classes* screen that appears (leftmost image), you'll see the two predefined behavior classes, *Events* and *States*. Tap the plus sign and we see the *Add behavior class* screen.

All that's needed here is to enter *Agonistic* as the name and select *Events* as the Type (the other possible selection is *States*).

Since we selected *Events* as the Type, all behaviors placed in the *Agonistic* class will be events, not states.

Tap *Done* to save the class. In the same way, add further behavior classes of type 'Events' called *Play and Vocalization.* Tapping *Back* returns you to the previous screen (*Configure study*).

NOTE: Behavior classes are more fully described in Appendix G - How behavior classes work.

NOTE: You can edit an existing behavior class by tapping on it; in fact, all configuration items can be edited in this way.

Behaviors

Behaviors (3:25)	**Add behavior** CANCEL DONE (5:27)	**Classes** ALL NONE DONE (3:31)
	Name (*): Head waggle	Agonistic ⚪
	Description: Description	Events 🟢
	Type (*): Event	Play 🟢
	Receiver: None	Vocalization ⚪
	Speed recording (*): Speed recording	
	Button color: White	
	Example file: Lowercase filename	
	Restriction: None	
Organize	Classes View	
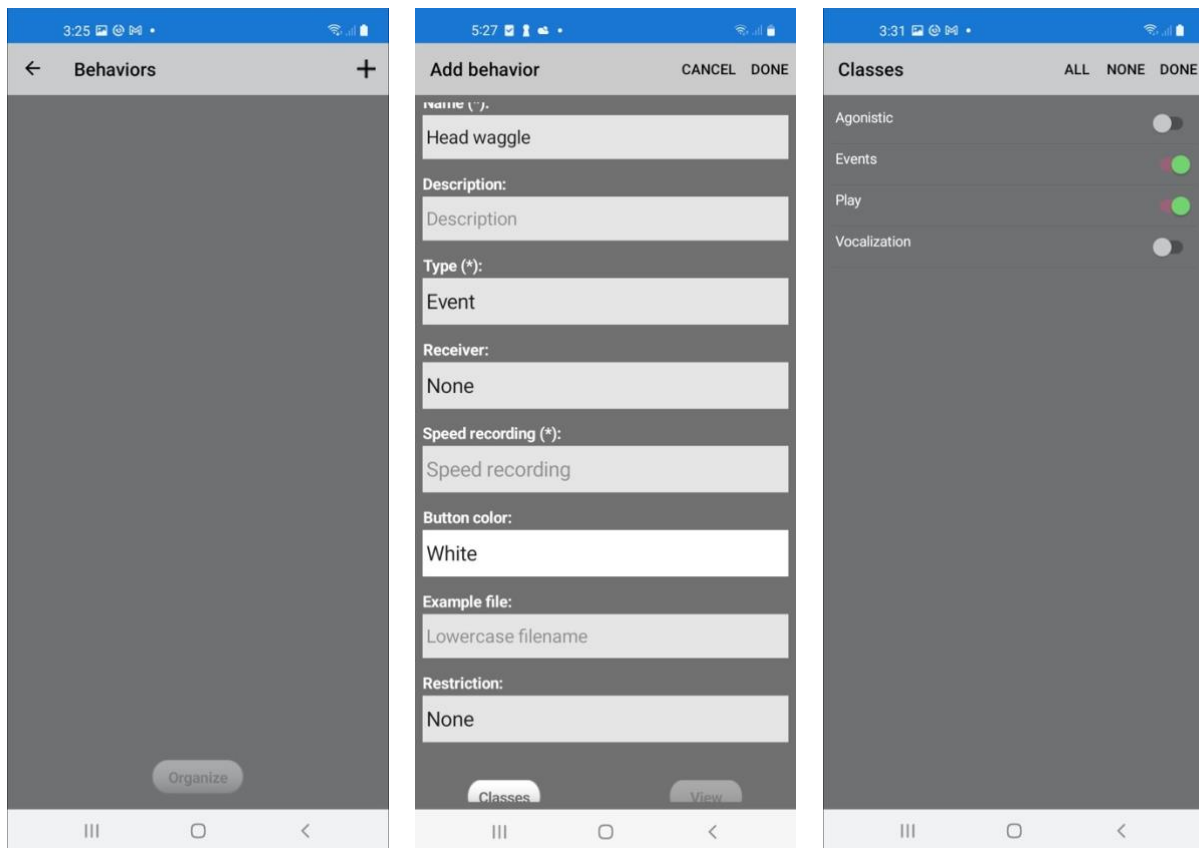
Our ethogram, a list of behaviors, can now be added by tapping *Behaviors* on the *Configure study* screen. The leftmost screen above appears. (The *Organize* button is useful later if you want to control the order in which behavior buttons appear onscreen during sampling. Role, modifier and data item buttons can be ordered similarly.)

For Elephant Study, two of our 21 behaviors are *Head waggle* and *Asleep*. Tap the plus sign and on the *Add behavior* screen enter *Head waggle* as the Name. For *Speed recording*, select *YES*: this means we won't be prompted for *ROLE* when *Head waggle* is tapped during sampling.

Optionally, you can change the color that the corresponding behavior button will have during sampling.

To change the default behavior class(es) for *Head waggle*, scroll down and tap the *Classes* button (obscured by the keyboard) to bring up the screen at right above, where you can select the behavior class(es) for *Head waggle*. Deselect *Events* (which means all events), select *Play* and tap *Done*.

NOTE: Because this behavior is an event, the *States* behavior class was not offered on the *Classes* screen. Here the default behavior class is *Events*, or the behavior classes most recently chosen.

NOTE: We had the option to specify that there is always a Receiver of this behavior. The selection choices are *None*, *Self* or *Other*. When this behavior is recorded, in the case of *Other*, the observer will be required to select not only the Actor but the Receiver as well.

NOTE: There is also the option to enter the filename of a photo, video or audio clip that would serve as an example of this behavior. We would need to have placed the file beforehand in the *Imports*

subfolder in Dropbox (or on the local filesystem, or have it available at a web link). We can always return and do that later.

NOTE: Another option is to restrict the appearance of the behavior to a specified group and its subjects.

Repeating this procedure for the *Asleep* behavior, we select *State* for the Type on the *Add behavior* screen. On the *Classes* screen, we find that this time the only class on offer is *States*, which is as it should be.

Behavior classes and behaviors may be all you need for your study – but there are more possibilities, described below.

Species

To create a list of the species involved, tap *Species* on the *Configure study* screen and enter the species one by one, simply entering a species name each time.

NOTE: There is also the option to enter the filename of a photo, video or audio clip that would serve as an example of this species. We would need to have placed the file beforehand in the *Imports* subfolder in Dropbox (or on the local filesystem, or have it available at a web link). Again, we can always return and do that later.

NOTE: Another option is to restrict the appearance of the species to a specified group and its subjects.

Elephant study has been configured with the species *African elephant* and *Indian elephant*.
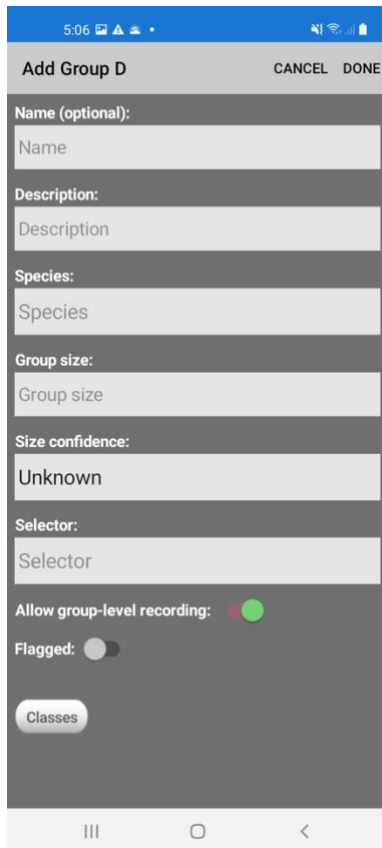
Groups and subjects

Every subject is in a group, even if it's a group of one.

While sampling, you can add groups and subjects as you encounter them.

Should you wish to pre-define some groups and subjects, you can do so by tapping *Groups* or *Subjects* on the *Configure study* screen. For further details, see Editing and Adding groups and subjects during sampling.

In Elephant Study, we have pre-defined *Group A, Group B* and *Group C* (*Group C* has the name *Regulars*). *Group A* has classes *Agonistic*, *Play* and *States*. *Group B* has *Play* and *Vocalization*. Group C has the default of *Events* and *States*. Each of these groups has several subjects configured via the *Subjects* option on the *Configure study* screen.

HINT: If you will be recording not just at subject level but also at group level for a particular group, you should set the 'Allow group-level recording' option in Configuration, when adding or editing the group.Roles

If you wish to configure roles, tap *Roles* on the *Configure study* screen. Tapping the plus sign, you'll enter a name for the role and select individual behavior classes and/or behaviors for the role. More roles are added in the same way.

As well as the built-in roles *Actor* and *Receiver*, Elephant Study has added the custom roles *Companion*, *Influence*, *Initiator*, *Member* and *Out of sight*. Each has all behavior classes selected. When any behavior is recorded, the observer can select one or more custom roles. You may like to experiment, selecting different combinations of behavior classes to see the effect.

Modifiers

Tap *Modifiers* on the *Configure study* screen. As with *Roles*, you are asked for a name and to select behavior classes and/or behaviors for the modifier.

Elephant Study has added four modifiers, *Loudly*, *Softly*, *Long* and *Short*, each of which has the sole behavior *Moan*. When a *Moan* behavior is recorded, the observer will be able to select, for example, *Long* and *Softly*.

Mutual exclusions

Some behaviors of type *State*, such as *Awake* and *Asleep*, will be mutually-exclusive. When you observe a behavior of *Awake* and later observe a behavior of *Asleep* for the same animal, you might like Behayve to record that the *Awake* state ended when the *Asleep* state began, without having to tell it explicitly. For this, you can configure a mutual exclusion whose behaviors are *Awake* and *Asleep*. Mutually exclusive behaviors are always to be thought of as states, not events.

On the *Configure study* screen, tap *Mutual exclusions* and tap the plus sign on the *Mutual exclusions* screen that appears. On the *Add mutual exclusion* screen, give the mutual exclusion a name and then select the mutually-exclusive behaviors one after the other. Tap *Done*.

Data items
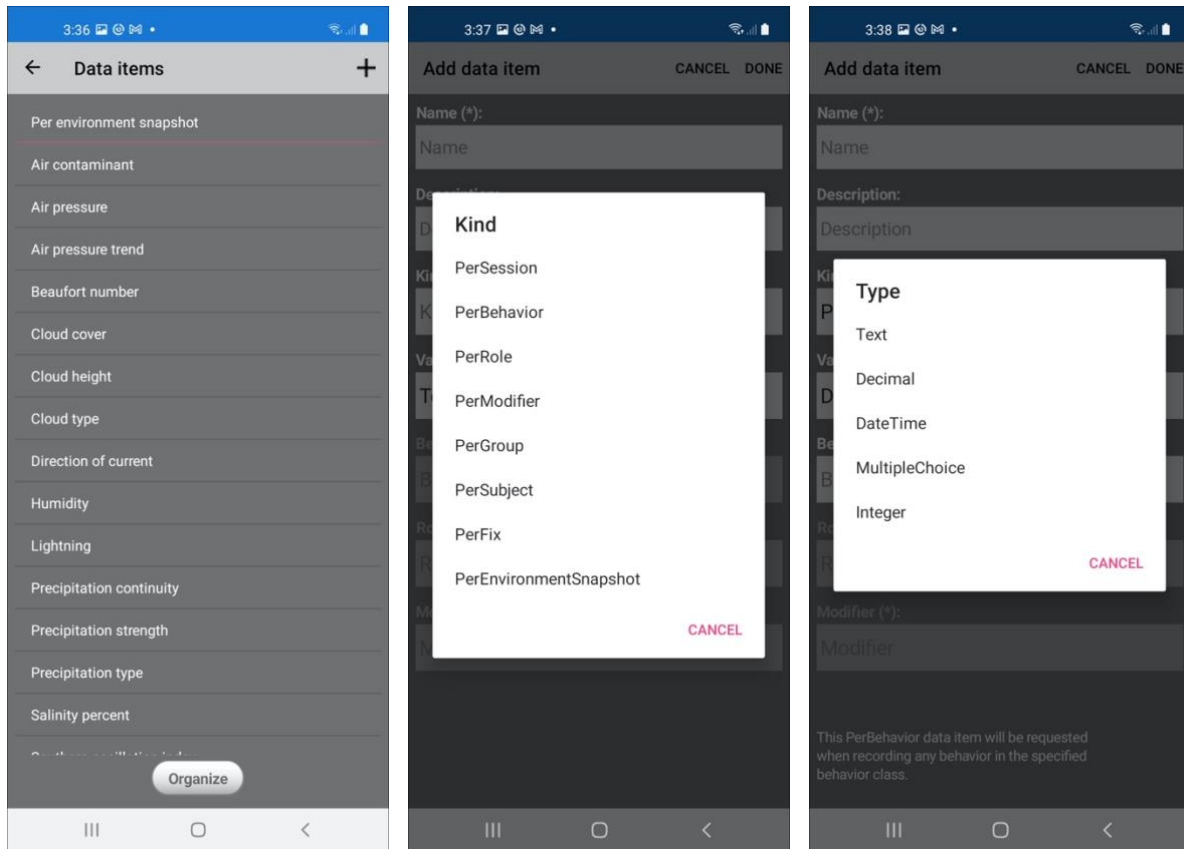
You can optionally configure custom data items by tapping *Data items* on the *Configure study* screen.

You may see a list of data items already defined, mainly environmental. Any of these can be deleted if you wish (tap on a data item then tap *Delete*). To delete multiple data items, or to control the order in which data items appear when sampling, use the *Organize* button.

Tap the plus sign to reach the *Add data item* screen and give the data item a name. Next, select the *Kind* and the *Type* as described in Custom data items. If the *Kind* was *PerBehavior*, *PerRole* or *PerModifier,* you will be prompted to select a behavior class – only behaviors in that class will prompt for this data item. Tap *Done*.

If *Value* was chosen to be *Multiple choice*, a further step is needed, to specify what the choices will be: on the *Configure study* screen, tap *Choices.* On the *Choices* screen, select the data item just named. Repeatedly tap the plus sign, naming a choice each time. When done, tap *Configure study* to return there.

NOTE: The numerous built-in environment data items can be deleted only if no environment data has yet been recorded.

Places

You'll want to define some *Places* if you intend to break up your subjects' range into adjacent polygonal Areas – the vertices of the polygons will be Places. A Place has a name and a position, for example latitude/longitude/altitude or easting/northing/altitude.

Another reason would be in areas where GPS/GNSS is unreliable, for example near buildings or under a heavy canopy. In that case you could use Grid mode instead of SatNav and configure a base Place: recorded easting/northing positions will be relative to the base (which can be moved from time to time). On import into a GIS system such as ArcGIS, GPS/GNSS and grid-map recordings will be seamlessly combined. See Appendix N – Grid Mode.

Other reasons to use Places would be to use Behayve's facility to report the current bearing and range to nearby Places (*ME* button on the sampling screen), or to triangulate the position of a distant inaccessible landmark.

Places are defined in the usual way – on the *Configure study* screen, tap *Places*.

Areas

An *Area* has a name and optionally a set of *Places* forming the vertices of a polygon. Areas can be adjacent but should not overlap. Behayve can automatically or manually assign a subject's position to an *Area* (controlled by *AreaRecording* in *Settings*).

To define an *Area*, tap *Areas* on the *Configure study* screen. On the *Add area* screen, give the *Area* a name then repeatedly tap the plus sign, selecting a *Place* each time in clockwise or anticlockwise order. Tap *Done* when finished.

Areas without Places are notional: fixes may be assigned to such areas entirely at the user's discretion.

Onboard maps

Maps that Behayve displays are normally online Google maps. When the Internet is unavailable, Behayve automatically reverts to an onboard custom map, if available. Where there are several onboard maps, Behayve will choose the most appropriate for your present location.

If there is no Internet and no custom map, tracks will still be displayed, without the underlying map. Once you regain Internet connection, you will be able to see the underlying map at *Configuration > Groups > Group X > Map* or *Configuration > Subjects > Subject N > Map.*

Creating an onboard map is not difficult. Map images can be created in Google Earth™ for example. For details, see Appendix P – Preparing a custom onboard map.

Tap *Onboard maps* on the *Configure study* screen and tap the plus sign on the *Onboard maps* screen. On the *Add onboard map* screen, supply a name for the map, a map image filename (the map image file having been placed previously in the *Imports* subfolder in Dropbox), and the latitude and longitude of the top-right and bottom-left corners of the image. Tap *Done*.

To force the use of an onboard map when Internet *is* available, turn off WiFi and cellular/mobile data, for example by setting Airplane mode.

Deleting or hiding configuration items

To maintain the consistency and integrity of its internal database, Behayve allows the following items to be deleted in Configuration only if they have not yet been referenced:

- Behavior classes
- Behaviors
- Roles
- Modifiers
- Areas
- Places

Groups may not ever be deleted.

All of the above, however, can be hidden so that they do not appear during recording sessions or in exports. For example, to hide a role, edit the role in Configuration and turn on *Hide*. *Hide* can be turned on and off as desired.

Scrubbing test runs

When you have configured a study, test runs are a must. Once you are satisfied with your study, the question may arise, how to get rid of your test runs. The procedure is as follows:

1. On the home page, press '+' to add a new study, and clone your study. Your configuration will be copied over to the clone, but your test sessions won't be.
2. Optionally, you can rename your old and new studies, one being for testing and one for actual field use. Your old study may be deleted if desired.
3. In your new study, unwanted subjects, roles, modifiers and so on may be deleted (or hidden), as described in the section above.

Further information

For further information, contact us or visit behayve.com.

Appendix A –Accessing Local Files

The Local option for import or export copies files between Behayve's onboard database and the Android's own filesystem. You may need to use this option when Internet is unavailable, and then you'll need a way to move files between the Android's filesystem and your local laptop.

YOUR PLATFORM	TOOL NEEDED
MacOS 10.15 (Catalina) or later	Android File Transfer (free download)
Windows	File Explorer

Accessing local files (Mac)Ensure Android File Transfer is installed (android.com/filetransfer).

2. Procedures vary by Android manufacturer, but basically you need to enable file transfer mode on the Android. This might be in Settings, for example in USB Settings there may be a setting 'Use USB for Transferring Files'. On some models you are prompted to allow access to phone data once you unlock your Android and connect it to the Mac with a USB cable. To get the prompt, you may need to start Android File Transfer (it may ask you to plug in your phone even if it is already plugged in), then unplug the phone and then re-plug it. If that fails, restart your Android. If still not working, try another USB port.
3. After connection, Android File Transfer will display a list of files on the Android. Please note, as you progress, Android File Transfer does not refresh its screen as files are added or deleted, which can cause confusion. You will need to restart Android File Transfer to get a current picture of the Android file system.
4. To see Behayve files on the Android, navigate to: *Android/data/au.com.technologyinsights.behayve/files/directorydocuments*.
5. Files can now be dragged between the Android and Mac.

NOTE: If totally unable to connect, you may have lost the use of your USB port. This is reasonably common. To get the port back, see https://osxdaily.com/2015/08/09/mac-usb-ports-not-working-fix. Or connect to another USB port.

Accessing local files (Windows)Do NOT use Microsoft's Cross Copy and Paste facility: it is too limited in file size and file type.

2. Procedures vary by Android manufacturer, but basically you need to enable file transfer mode on the Android. This might be in Settings, for example in USB Settings there may be a setting 'Use USB for Transferring Files'. On some models you are prompted to allow access to phone data once you unlock your Android and connect it to the Mac with a USB cable (you may have to unplug and re-plug a second time to get the prompt).
3. After connection via USB cable, your Android will appear in File Explorer, under *This PC*.
4. To see Behayve files on the Android, double-click on *Phone* in the right-hand panel and navigate to: *Android/data/au.com.technologyinsights.behayve/files/directorydocuments*.
5. Files can now be dragged between the Android and Windows.

NOTE: If totally unable to connect, you may have lost the use of your USB port. This is reasonably common. To get the port back, see https://au.pcmag.com/components/89906/what-to-do-if-your-usb-port-stops-working . Or connect to another USB port.

Appendix B – One-step import into ArcGIS

Import procedure

A quick once-only setup needs to be performed before you import data into ArcGIS for the first time, described in the next section.

It is then simple to import any amount of data into ArcGIS in one go:

1. Place exported Json files in your designated folder (described below).
2. In ArcCatalog click on the Python icon in the toolbar.
3. Right-click in the Python window that appears, select *Load*, navigate to the file *ArcGISJsonImportScript.py* and select it.
4. Click *Open* and press the *Enter* key to run the script.

For each Json file supplied, this adds a Feature Class to your geodatabase and optionally adds a corresponding layer to your map file, meaningfully named. Group and Subject layers are set to *Visible* and you can of course adjust the visibility of all layers.

Once-only setup

By going through a quick once-only setup, you will save a great amount of work each time you import data into ArcGIS.

1. In the *Behayve/Exports/Scripts* folder you'll find the file *ArcGISJsonImport.ini* with the following contents:

   [ArcGISJsonImportScript]
   jsonfolder = c:\MyJsonFiles
   geodatabase = c:\Geodatabases\My Geodatabase.gdb
   mapfile = c:\Maps\My MapFile.mxd
   dataframename = MyDataFrame

2. Using Notepad, edit the content to reflect your local environment:
   a. *jsonfolder* specifies a folder where you'll place .json files for import
   b. *geodatabase* specifies the location of your existing geodatabase
   c. *mapfile* specifies the location of your existing mxd mapfile – remove this line if you don't want an updated mapfile
   d. *dataframe* specifies the data frame to receive new layers – needed only if you have multiple data frames and ignored otherwise

3. Copy *ArcGISJsonImportScript.py* from the *Scripts* subfolder to a local folder and add the updated *ArcGISJsonImport.ini* to that same folder.

4. Unzip *Symbols.zip* (from the *Scripts* subfolder), which will create a *Symbols* folder. Copy the *Symbols* folder into the folder that contains your existing *.mxd* map file. (*Symbols* will then be a subfolder of the folder containing your map file.)

You can now run the import script whenever needed.

Appendix C – Wireless laser rangefinder

When taking fixes of positions, the range can be obtained by any means and manually entered. Alternatively, with a wireless laser rangefinder, the range can be automatically entered when the rangefinder obtains a range – speeding recording and eliminating transcription errors.

Behayve supports the ATN LaserBallistics digital rangefinders, communicating via Bluetooth.

If first-time use, install and run the *ATN Ballistics* app to pair the Android with the rangefinder, giving the power button two good presses when prompted. The power button is the one nearer the eyepiece. In Behayve settings, set *ExternalInstruments* to *Enabled*.

NOTE: If you have problems connecting, go to Android Settings. Make sure Bluetooth is on. If unable to pair using the ATN app, you may be able to pair in Bluetooth settings using a PIN of 000000.

Make sure the rangefinder is in the correct mode: in the rangefinder eyepiece you should see an angle icon at top left and *M* at top right. If you don't, press the *M* button on the rangefinder repeatedly until you do. (Try not to touch the M button again.)

To record a range:

1. In Settings, ensure that *ExternalInstruments* is set to *Enabled*.
2. On the *Fix* screen, ensure the *Rangefinder* switch is on.
3. Ensure the rangefinder is powered on (the power button is the one nearer your eye).
4. Get the range to the animal by pressing the button nearer your eye. The range will automatically appear in the *Range* box on the *Fix* screen.

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NOTE: The rangefinder will maintain power for about 90 seconds after last use, allowing further fixes.

Appendix D – Wireless connection to aircraft's or ship's instruments

If your observations will be done on the water, water depth and temperature may be useful. Behayve can connect wirelessly with any chartplotter or fishfinder having NMEA 0183 output, to automatically record water depth and temperature twice a minute and each time an observation is made. For temperature, the vessel will need a suitable transducer.

Connection to a differential GPS, for greater positional accuracy, could be a requirement.

Equally, on board an aircraft it may be useful to connect wirelessly to a cockpit GPS.

An inexpensive serial-to-wireless adapter is required –the AirConsole LE DB9 is supported and other adapters may work as well (check with Behayve support).

Behayve maintains a reliable, robust and persistent Bluetooth connection to the onboard instrument.

Wiring details

The following describes connection of an Airconsole LE DB9 for use with iPhone or Android. You can wire it yourself or enlist an electrician.

NOTE: If you have an Airconsole Mini or Airconsole Pro, you can find instructions for these at behayve.com/older-devices.

You will need:

- AirConsole LE DB9

- Cable from device (e.g. chartplotter/fishfinder/GPS) manufacturer that plugs into their NMEA-0183 output socket
- Pliers / screwdrivers
- Cable ties
- DB9 (aka DE-9) connector, female
- Soldering iron and solder
- Wire-stripping tool
- Electrical insulating tape
- Multimeter - may be useful to verify connections.

Battery life of the Airconsole LE is rated at fully 12 months, so connection to power should normally be unnecessary. However, if power is required, you will also need:

- USB car charger
- Cigarette lighter socket, female.

Connections

NMEA-0183 signal

The objective here is to feed the NMEA-0183 signal from the external device into the AirConsole's male DB9 9-pin connector.

Your device should have an NMEA-0183 serial output socket (often the same socket for power and NMEA), and you should obtain the manufacturer's NMEA cable for it.

- From the manufacturer's manual, find out the colour coding for the *NMEA out* and *ground* wires in the cable. (Typically, *ground* is black.) In conjunction with this, you might need to use a multi-meter to confirm connectivity between pins at the device end of the cable and wires at the other end.
- Cut off and discard the plug on the end of the cable furthest from the external device.
- Solder a female DB9 connector to the NMEA and ground wires – NMEA to pin 2 (RECEIVE DATA) and ground to pin 5 (SIGNAL GROUND). If cabling via a patch panel, shielded twisted pair is suggested, to minimise electrical interference.
- Normally it will be necessary to jumper pin 7 (Request to Send) to pin 8 (Clear to Send). Solder is suggested.
- Screw on the DB9's protective cover, making sure that cable tension won't strain the solder joints.
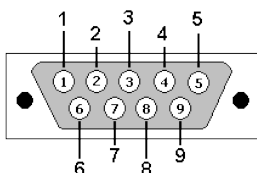
*Looking into **male** DB9 plug*

Finally, connect the components as shown in the photo above, and use cable ties to securely fasten the components and cables.

Power (normally not required)
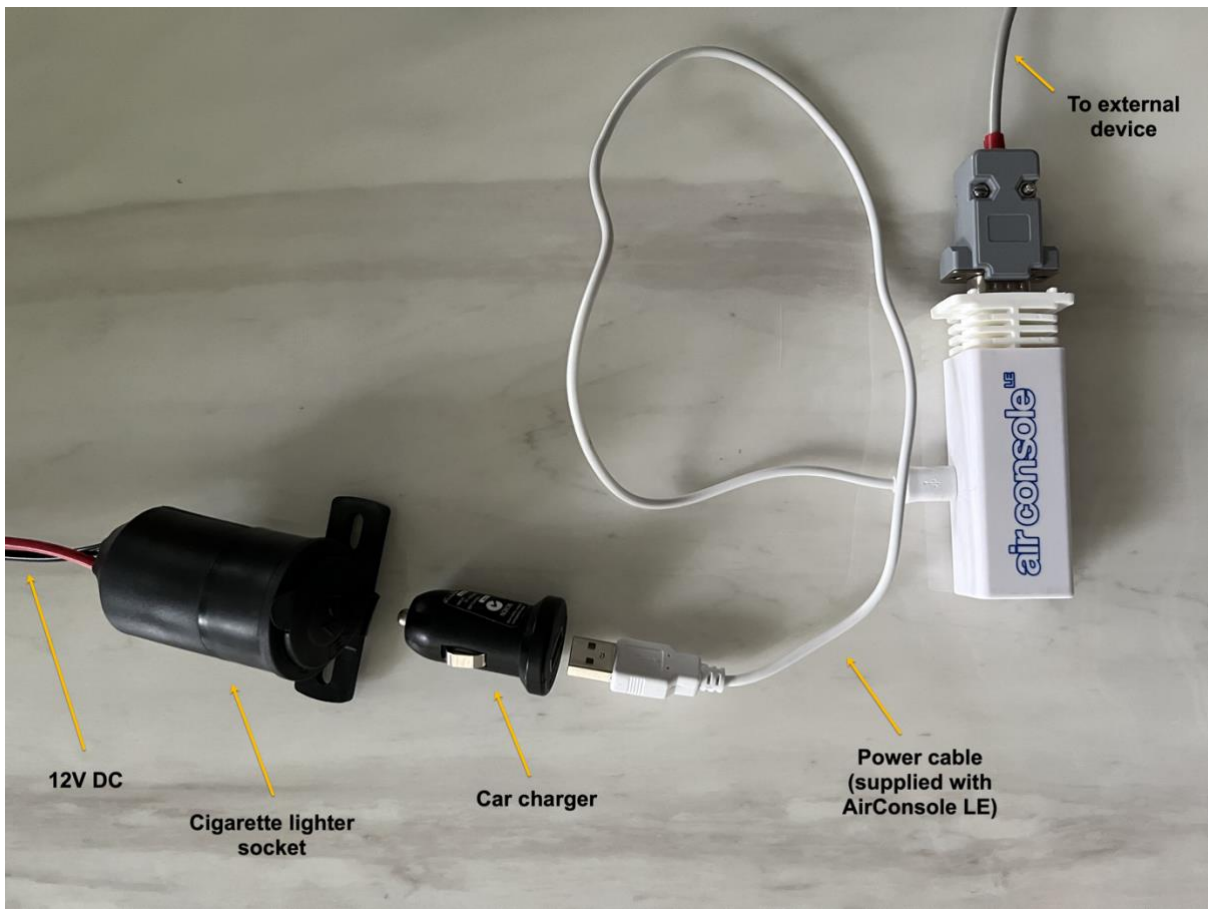
With the 12V DC supply turned off, connect one of the two wires coming out of the back of the cigarette lighter socket to +12V (ideally beyond the external device's fuse) and the other to ground, taking care to avoid any short-circuit and ensure the correct polarity. The center pole at the rear must be positive and the cylindrical metal shell must be negative (ground).

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The following setup is required only once.

1. In Behayve's settings, enable the *ExternalInstruments* setting, and if appropriate the *WaterDepthRecording* and *WaterTemperatureRecording* settings.
2. On the external device's setup menu, look up the current NMEA transmission speed and, if possible, change it to 4800 baud.
3. In Behayve's settings, verify the following settings (assuming 4800 baud):

SETTING	VALUE
SerialAdapterBaudRate0	4800
SerialAdapterBaudRate1	4800
SerialAdapterDataBits0	Databits8
SerialAdapterDataBits1	Databits8
SerialAdapterFlowControl0	None
SerialAdapterFlowControl1	None
SerialAdapterStopBits0	StopBits1
SerialAdapterStopBits1	StopBits1

4. In Android Settings check that *Bluetooth* is *On* .
5. Fully charge the Airconsole LE. To configure it, you will need to download the free *ACLE Updater* app from the App Store, on an iPhone (borrowing one for a few minutes if necessary: the app does not appear to be available on Android). With the Airconsole nearby, enable Bluetooth on the iPhone, start the ACLE Update app and select the AirConsole device. On the next screen, tap *Change Settings*.
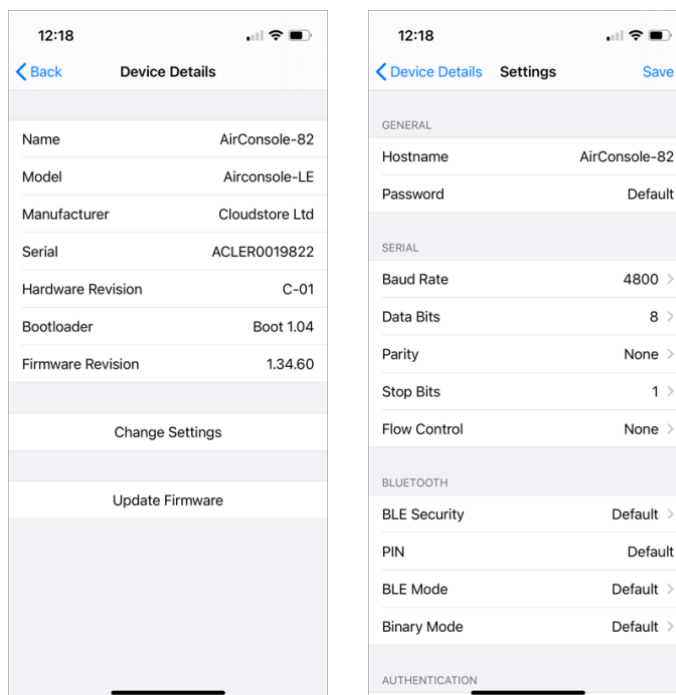
Change the settings to the values shown in the right-hand image above (assuming 4800 baud), and click *Save*. "AirConsole" must appear as part of the Hostname. If there are several

AirConsole devices at your location with the same name, arrange for them to have unique names.

Operation

Turn on the external device to initiate the flow of data. Automatic recording of data, such as water depth/temperature or GPS, will begin when a session starts. To confirm it's working, look for the water depth and temperature or an External GPS status on the *My Position* page (*Me* button). Allow up to 90 seconds for them to first appear.

Power off or disconnect power when not in use.

Please contact Behayve support if any issues.

Wireless connection to your other equipment

If you have other gear, for example a weather station, that you would like to connect wirelessly, let us know and we'll look into what can be done software-wise. The equipment would need to have serial output (but not necessarily NMEA protocol), so as to allow connection of a serial-to-wireless adapter.

NOTE: While Bluetooth traditionally is fairly short-range, be aware that long-range Bluetooth transmitters are commercially available.

Appendix E – Item limits

There is no practical limit for the number of configured items such as Behavior Classes, Behaviors, Species, Groups, Subjects, Roles, Modifiers, Mutual Exclusions, Choices, Data Items, Places, Areas and Onboard Maps. As the number of configured items grows, the number of columns in exported spreadsheets will increase.

However, the following limits apply:

- Each Mutual Exclusion can incorporate up to 25 Behaviors maximum.
- On the Review page, a maximum of 100 lines can be displayed per observation.
- In some cases, the length of item names will be limited, so as to fit in onscreen displays or to conform to the ArcGIS limit of 10 characters for variable names.

Note that, although for any given behavior in *Behavior* and *Position* exports, a maximum of 25 non-communal roles and no communal roles are shown, all the behavior's roles (including communal roles), unlimited in number, are shown in the *Observations>Roles* export.

Should any of these limits not suffice, please let us know.

Appendix F – Hardware and software requirements

Internet

Internet access is not required during configuration or observation. Your data is stored on the phone in a persistent database.

Access to the Internet on at least a daily or weekly basis would however be convenient, as the simplest way to export and back up your data involves a free Dropbox cloud account. Should Internet be completely unavailable, you can always export and back up your data to a Mac or Windows computer instead.

Software

The most recently released version of the Android OS for your device is recommended, and Android 9 or later is required.

A free Dropbox cloud account is recommended. To view interactive maps generated from exported data, you can use:

- Any Geographic Information System (GIS) supporting EsriJSON or GeoJSON imports, for example ArcGIS or QGIS
- Any KML-compliant mapping application, for example Google Earth or Google MyMaps.

To view exported spreadsheets, you can use common spreadsheet programs such as Microsoft Excel and Apple Numbers.

It's recommended to set auto-update for Behayve to keep on the most current version and benefit from the latest new features and reliability improvements.

Hardware

To take advantage of all Behayve functions, an Android phone or tablet with GPS and motion-sensing hardware is recommended. Without GPS hardware, you probably will be unable to accurately record animal or observer positions, unless you use a grid map. Without gyroscope and accelerometer, you can input compass bearings manually rather than using the automatic point-and-shoot function. In all cases, behavior and environment recording will be possible. Note that some devices use WiFi and other technologies to determine location without having GPS hardware; actual GPS hardware is required to accurately fix locations. In this case, a Bluetooth GPS accessory could be considered.

NOTE: In the field, many researchers find a phone more convenient than a tablet.

Wireless rangefinder

If you want Behayve to automatically record range measurements wirelessly from a laser rangefinder, you'll need an ATN LaserBallistics 100/150 digital rangefinder. We welcome discussion on support for other devices.

On the water

Should you wish to automatically record water depth and water temperature wirelessly from ship's instruments, you'll need the equipment described in Appendix D – Wireless connection to aircraft's or ship's instruments.

Differential GPS/GNSS

If you wish to use differential GPS/GNSS to improve positional accuracy, you'll need a differential unit that provides a serial NMEA 0183 output. It can be wirelessly connected using the method described in Appendix D – Wireless connection to aircraft or ship's instruments.

Appendix G – How behavior classes work

As a reference, here is a formal description of how behavior classes work. In most circumstances, you should not need to refer to it.

- Each behavior is an event or a state.

- A behavior class is a named collection of behaviors. A behavior class is also known as a 'class'.

- A class can be created by a user or can be the built-in Events class (containing all behaviors that are events) or States class (containing all behaviors that are states). In a given class, all behaviors are events or all are states.

- Each behavior belongs to one or more classes.

- Each group, together with any subjects it contains, has one or more classes.

- Each modifier has one or more classes and/or individual behaviors.

- Each role has one or more classes and/or individual behaviors.

At any time while recording observations, one group (or one or more of its subjects) is selected for observation. Then:

1. Only behaviors that are in one or more of the group's classes will be displayed for selection.

NOTE: If one of the group's classes is Events, then all behaviors that are events will be displayed; if one of the group's classes is States, all behaviors that are states will be displayed.

2. For a particular group and behavior:

(a) Each modifier will be displayed for selection only if it has a class in common with both the group and the behavior, or if it has a behavior that is the same as the current behavior.

(b) Each role will be displayed for selection only if it has a class in common with both the group and the behavior, or if it has a behavior that is the same as the current behavior.

NOTE: If the classes that a modifier or role has includes Events or States, it is considered that the modifier or role has every class that is an event or state respectively.

Appendix H – Astronomical data

When the red *Finish session* button is pressed, Behayve automatically computes and records the following astronomical data, based on the observer's present position:

ITEM	NOTES
Moon phase	New moon is 0, full moon is .5
Moon phase description	One of eight phases, for example *waning gibbous.*
Beginning of nautical twilight (morning)	Defined to be when the center of the Sun is at a geocentric altitude of -12 degrees. At the beginning or end of nautical twilight, under good atmospheric conditions and in the absence of other illumination, general outlines of ground objects may be distinguishable, but detailed outdoor operations are not possible, and the horizon is indistinct.
End of nautical twilight (evening)	
Moonrise	
Moonset	
Sunrise	
Sunset	

NOTE: Within half a latitude degree of the Arctic or Antarctic Circle, calculated times for sun/moon rise and set might not be accurate.

Appendix I – Differential GPS/GNSS

Where increased positioning accuracy is needed, you can use an external differential GPS/GNSS device having an NMEA-0183 output connector. This may be wirelessly connected to Behayve using the method described in Appendix D - Wireless connection to aircraft's or ship's instruments. The status of the connection may be viewed while sampling, on the *My position* screen, accessed via the *Me* button.

Alternatively, you can use a handheld Bluetooth differential GNSS of the kind that replaces all location information on the iPhone with its own more accurate position. An example of this is the sub-meter Arrow 100 from EOS Positioning Systems, which uses SBAS differential corrections from satellites.

NOTE: Sub-meter devices will improve coverage area under canopy.

NOTE: Differential units might return altitudes as heights above the WGS-84 ellipsoid, rather than heights above Mean Sea Level such as are normally returned. This can amount to tens of meters or more. If you wish altitudes to be recorded relative to Mean Sea Level, you then may have Behayve apply an altitude adjustment, as described in Appendix K – Altitude adjustment setting. In *Fixed* or *Aerial* mode, this adjustment is mandatory for such units.

NOTE: For accurate positioning of target animals, the external GPS/GNSS device should be as close as possible to the Android.

NOTE: Whereas the Android reports Horizontal Accuracy and Vertical Accuracy in length units (e.g. meters), external devices report this as unitless numbers, where smaller is better and 1.0 represents an excellent 3D fix using four satellites.

Appendix J – Observation mode setting

The *ObservationMode* setting determines the method to be used when recording target positions. Reported altitudes will be heights above Mean Sea Level, unless you have requested an 'altitude adjustment' prior to observations (see Appendix K – Altitude adjustment setting).

NOTE: Some phones are unable to provide the 'geoidal separation' required to convert Android's Height Above Ellipsoid to Mean Sea Level. In this case, the ellipsoidal height is reported instead. This may vary from Mean Sea Level by tens of metres.

Four options are provided:

ThreeDimensional mode
This mode is suited to a moving or stationary terrestrial observer. Target positions are determined based on supplied bearing, zenith angle and range.

TwoDimensional mode
This mode is suited to a moving or stationary observer on flat terrain or at sea. Target positions are determined based on supplied bearing and range.

Aerial mode
This mode is suited to aerial surveys. Target positions are determined based on supplied bearing, zenith angle and the altitude where animals are to be found. You may update the animals' altitude above Mean Sea Level (initially zero) whenever a fix is taken.

If you will be flying at a fixed height, you may nominate this height when starting a session. Otherwise Behayve will use a continuously varying observer height based on GPS/GNSS.

NOTE: For targets on water, determined target positions will be accurate. For targets on undulating terrain, target positions determined in aerial mode necessarily will be approximate, to the extent that terrain heights vary from the specified altitude of animals.

NOTE: The high speed of an aircraft is not a concern regarding accuracy of the recorded latitude and longitude. When a target is selected in the crosshairs, the observation time, observer position, bearing and zenith angle are all measured and recorded together at that same instant. Thus, the recorded latitude and longitude will be correct. If instead you will be using external instruments to determine compass bearing and/or zenith angle at a certain instant, select the target in the crosshairs at that instant then replace the automatic values with values from the external instruments – this will ensure that observation time, observer position and angles all match up and the recorded latitude and longitude will again be correct.

NOTE: In aerial mode, if using an external differential GPS/GNSS unit that reports altitudes above the WGS-84 ellipsoid rather than above Mean Sea level (WGS-84 geoid), an altitude adjustment must be used. See Appendix K – Altitude adjustment setting.

Fixed mode
This mode is suitable for theodolite observations, normally over a body of water. Target positions are determined based on supplied bearing and zenith angle from a fixed observer position, together with the altitude of animals, initially zero and updateable whenever a fix is taken.

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NOTE: Automatic wireless transfer of theodolite data to the app is not currently supported. Please contact us if you have an interest in this topic.

NOTE: No correction is made for atmospheric refraction as this is understood to be negligible in practice.

NOTE: In Fixed mode, if using an external differential GPS/GNSS unit that reports altitudes above the WGS-84 ellipsoid rather than above Mean Sea level (WGS-84 geoid), an altitude adjustment must be used. See Appendix K – Altitude adjustment setting.

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Appendix K – Altitude adjustment setting

By default, the altitude of targets is based on observer altitude as obtained from GPS/GNSS, which approximates height above Mean Sea Level and normally is perfectly adequate.In some circumstances a different base level might be desired, where a fixed height adjustment needs to be applied to each GPS/GNSS altitude reading.

For example, heights might need to match up with a national 'geoid model' such as used by surveyors, for example GEOID12B in the USA. Or an external differential GPS/GNSS might be returning altitudes as heights above the WGS-84 ellipsoid rather than heights above Mean Sea Level (Appendix I – Differential GPS/GNSS) – in this case an altitude adjustment will be mandatory if the observation mode is Aerial or Fixed (where height above sea level is required).

For these cases Behayve has an 'altitude adjustment' setting, defaulting to zero, that it will add to each GPS/GNSS altitude reading. The adjustment may be positive or negative.

The model of the earth's surface used by GPS/GNSS, known as WGS84, uses both a mathematically smooth 'ellipsoid' roughly approximating the earth's shape as a slightly flattened sphere, and a somewhat more accurate 'geoid' approximating the surface of the ocean (Mean Sea Level). The geoid has a somewhat irregular shape.
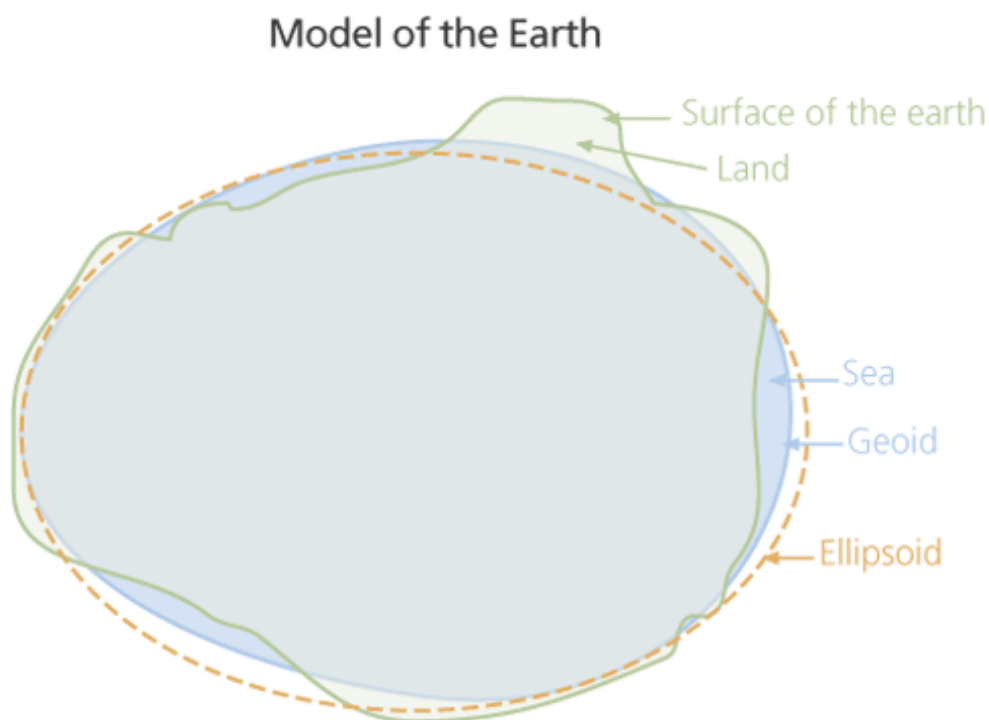
Source: ESRI

Modern GPS and GNSS receivers supply altitudes relative to the WGS84 geoid and typically also provide the ellipsoid height above the geoid.

$$h=H+N$$

Topo surface (earth surface or GPS antenna)

Geoid (MSL)

Ellipsoid

h=ellipsoid height
H=orthometric height
N=geoid height

Mean Sea Level itself is a complicated animal, and land is subject to tectonic plate movement, while positional technology is now at near-centimeter accuracy.

As a result, national 'geoid models' have been created to provide accurate positioning capability. Governments generally provide online tools to convert a GPS/GNSS-supplied height above the ellipsoid to a height in the national datum. There will be a difference between height above the WGS84 datum (altitude as provided by GPS/GNSS) and height above the national datum, requiring an altitude adjustment.

Source: 4Dglobal

Procedure to obtain a local altitude adjustment for conformance to a national model

1. In Settings, ensure *Altitude adjustment* is 0.

2. Determine the GPS/GNSS Height Above Ellipsoid at a particular location within the area of study:
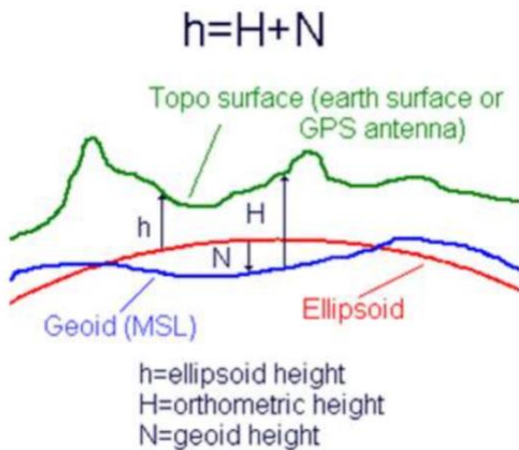   Depending on your device or external GPSS/GPS, Behayve may display it on the My position screen (*Me* button). Alternatively, Geoidal Separation may be displayed, from which Height Above Ellipsoid = (averaged) Altitude + Geoidal Separation.

   Otherwise, a companion app for your positioning device may display it, or you'll need to find or borrow a GPS unit that displays it and take it to that location. Ellipsoidal height may be positive or negative.

3. Note down the latitude, longitude and altitude displayed on the *My position* screen while at the same location.

4. Using the online tools for the national model, determine the height of your location above the national model's geoid. You'll be asked to provide latitude, longitude and the ellipsoidal height.
   NOTE: Latitude and longitude can vary depending on the system used, however here it is sufficient to use GPS-supplied latitude and longitude.

5. Calculate the altitude adjustment:
   A = Location's altitude as displayed in Behayve (with *Altitude adjustment* set to 0)
   N = Height of location above national model, from online tools

Enter N – A as the *Altitude adjustment* setting (positive or negative).

Procedure to convert reported ellipsoidal altitudes to altitudes above Mean Sea Level

Thisprocedure is for the case where an external GPS/GNSS is reporting altitudes above the WGS-84 ellipsoid, but altitudes above Mean Sea Level arerequired.One way, of course, is to stand at the water's edge in the general area where observations will be made, and average a set of altitude readings in 3D observation mode (*Me* button) – that will be the negative of the *Altitude adjustment* you require (apart from any tide height corrections and the height of the antenna above the water).

If that's not a useful method, you'll need to determine the height of the WGS-84 geoid above the height of the WGS-84 ellipsoid ('geoidal separation') in the area where your observations will be made, and set *Altitude adjustment* to its negative. There are several possible ways to get the geoidal separation in the vicinity:

- Your phone may display the geoidal separation (*Me* button)

- A companion app for a GPS/GNSS device may display the geoidal separation

- Another available GPS/GNSS device may display the geoidal separation, or have a companion app that displays it

- You could temporarily connect a GPS/GNSS device having an NMEA-0183 serial output socket (for example Garmin 73) to a serial-to-Bluetooth adapter, along the lines described in Appendix D – Wireless connection to aircraft's or ship's instruments – Behayve should then display the geoidal separation on the *My position* screen (*Me* button). With the manufacturer's serial cable, this may be as simple as plugging a male DB9 to male DB9 adapter between the two.

- A way may be available to view the raw NMEA stream output by some GPS device. Locate a GGA string such as the following:

  `$xxGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47`

  In this example, the geoidal separation is the twelfth comma-separated value (46.9), with the unit being the thirteenth value (M for meters).

Appendix L – When exactly are timestamps taken?

Behayve automatically records timestamps when observations are made (and at intervals, such as every 30 seconds, when the observer's position is automatically recorded). But when exactly in the course of an observation is the timestamp taken? And when is the observer's position recorded?

Behayve always records the timestamp when the observation begins; the observer's position is recorded simultaneously. This allows you to take as long as you like recording further information such as roles and notes.

A behavior's timestamp will be recorded when you tap on the behavior name. The observer's position is also recorded at that time.

When a fix is taken, its timestamp is recorded when:

1. The *Take bearing* button is pressed (for the last time, if repeated), where auto bearings are used, otherwise:

2. When the first of the following happens:
   - You enter the first digit of bearing, range or zenith angle
   - You record a range with a wireless laser rangerfinder
   - You select a heading or area

Timestamps are *Local Time* by default. The Timestamps setting allows you to set this to *UTC* instead. *UTC* is useful when recording and exporting data in different timezones.

NOTE: Timestamps are also recorded automatically for a wide variety of Transition events, such as the start of focal sampling or switching to observe a different animal.

Appendix M – Distributing studies to other Behayve users

Distributing preconfigured studies

Here is how to distribute a study to colleagues or citizen scientists who are using Behayve on iPhone and/or Android. **Recipients should not make changes to the configuration or settings (if you intend to merge their data). Optionally, you can lock a study to prevent this.**

1. Save your database, containing all your studies, by using *Export database* on the *Maintenance* menu. The name of the exported database will be *ExportedDatabase.dbf*. Be sure to copy the exported file away to a safe place and back it up.

2. After verifying you have safely backed up the exported database file, use the *Configuration* menu to delete all studies except the one(s) you will be distributing.

   NOTE: Alternatively, if distributing several studies from different databases, you can begin with an empty database (by removing Behayve from your phone and re-installing) and use *Maintenance > Import study* to gather the different studies into a single database.

3. (Optional) If you want to lock one or more studies, turn on the *Lock exports* switch on the *Configuration* menu, for each study to be locked.

4. Export your database again using *Export database* on the *Maintenance* menu. Rename the exported database (*ExportedDatabase.dbf*) as *ReplacementDatabase.dbf*.

5. Distribute *ReplacementDatabase.dbf* to your colleagues or citizen scientists via email or by sharing a web link (URL) to the file. A web link can be a shared link from a personal iCloud Drive, Google Drive, OneDrive or Dropbox, or a download link on a website. Instruct them to install the latest version of Behayve and then:

   (a) Enable iCloud Drive on their iPhone (if they are using iPhone) or set up a free Dropbox account (if they are using Android)
   (b) Start Behayve,
   (c) Copy the file to the *Imports* subfolder of the *Behayve* folder on their iCloud Drive (if iPhone) or to the *Imports* subfolder of the *Apps/Behayve* folder on Dropbox (if Android)
   (d) Then use *Import database* on the *Maintenance* menu.

   Or, if you are distributing a web link, simply instruct them to start Behayve and use *Import database*, selecting the *Web* option as the source.

   NOTE: Advise your colleagues that they will be unable to use your study if their Behayve apps have a database version lower than yours had when you exported the study. The database version can be seen on the *Menu > About* screen, beneath the app version. If they are on the

latest version, they will have no problem.

6. Finally, restore your project(s) from your backed-up database: Copy the backed up-database to your Dropbox *Apps/Behayve/Imports* folder, or make it available as a web link, renaming it as *ReplacementDatabase.dbf*, and use *Import database* on the *Maintenance* menu.

SEE ALSO: [Working in a team](#).

NOTE: Should you accidentally re-import a locked study (thereby locking yourself out of your own study), contact us for assistance.

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Creating a collection of studies from various sources

You may have several studies (on one or more databases) and wish to create a selection of these studies in a single database, for example for convenient distribution. Here's how:

1. Back up the Behayve database on your device to a safe place, using *Maintenance > Export database* on the home page menu.

2. In *Configuration*, select each study on your device in turn, excepting perhaps the sample *Elephant study*, and delete it. (Alternatively, uninstall and re-install Behayve, to get a fresh *Elephant study*.)

3. Copy to your cloud *Imports* folder a *.dbf* database file containing one or more studies of interest. Rename it to *ImportStudyDatabase.dbf*.

4. On the home page menu, select *Maintenance > Import study* and follow the prompts to copy one or more studies to your device.

5. Repeat steps 3 and 4 for other available databases if desired.

6. Use *Maintenance > Export database* to copy your collection of studies in a single database to the cloud, for distribution, via a shared web link or email, after renaming it to *ReplacementDatabase.dbf.*

7. Copy your backup from step 1 to your cloud *Imports* folder and rename it to *ReplacementDatabase.dbf*.

8. To get back to where you were, restore your backup using *Maintenance > Import database.*

NOTE: *Import study* does not import Sessions (observations), just the configuration of the study. An option allows subjects to be included.

Merging data from colleagues
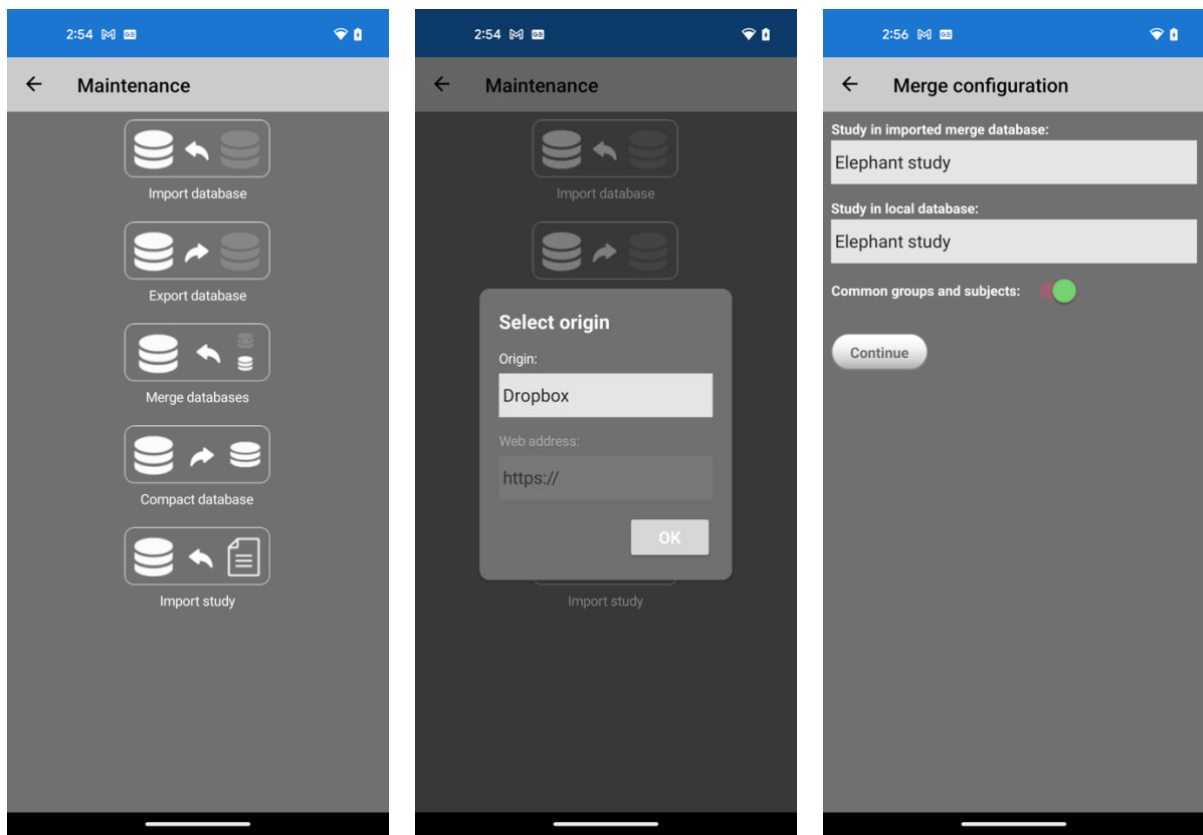
Each colleague may use the *Export database* function to retrieve his or her updated database *ExportedDatabase.dbf* containing recorded observations, and forward this file to you, for example via email. This may be done either periodically or at the end of the study.

Before merging, ensure you have the most recent version of Behayve installed, because your database version must be at least as high as colleagues' database versions. The database version can be seen on the *Menu > About* screen, beneath the app version.

On receipt of the file, you should rename it to *MergeDatabase.dbf*, place it in the *Imports* subfolder of the *Apps/Behayve* folder in Dropbox (or stage it on your laptop), and choose the *Merge Databases* function on the *Maintenance* menu (leftmost image above).

On the *Merge configuration* screen, turn on the *Common groups and subjects* switch if you and your colleague were in close contact during observations and so were able to agree on the group and subject names given to each animal. Turn the switch off if you and your colleague undertook separate observations (meaning that you might have given two animals the same name). Behayve will scan the databases and merge any new groups, subjects and other configurable items into your database (leftmost image below).

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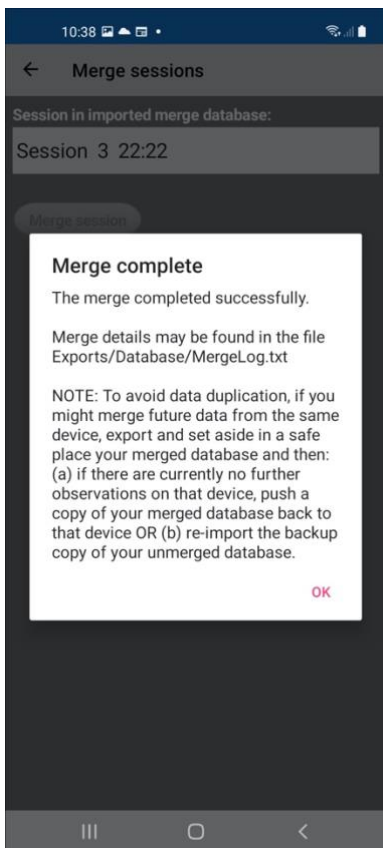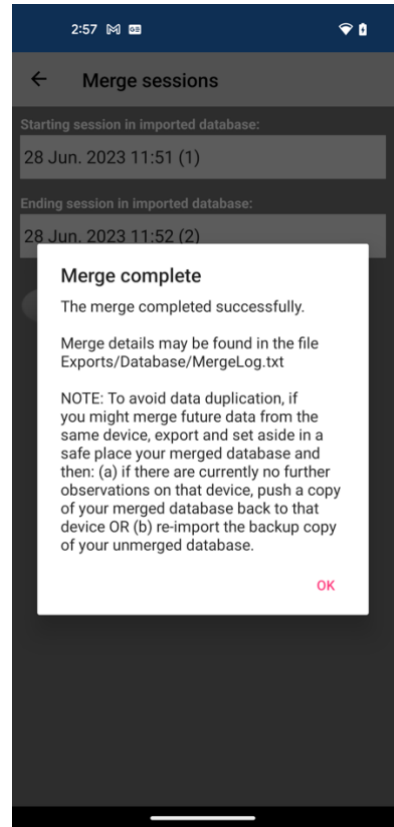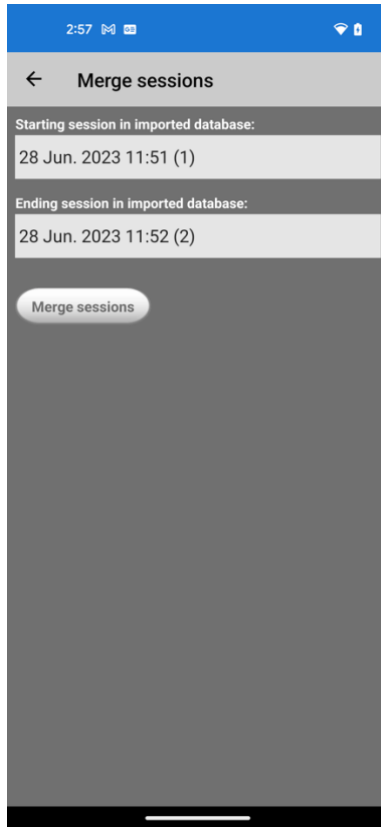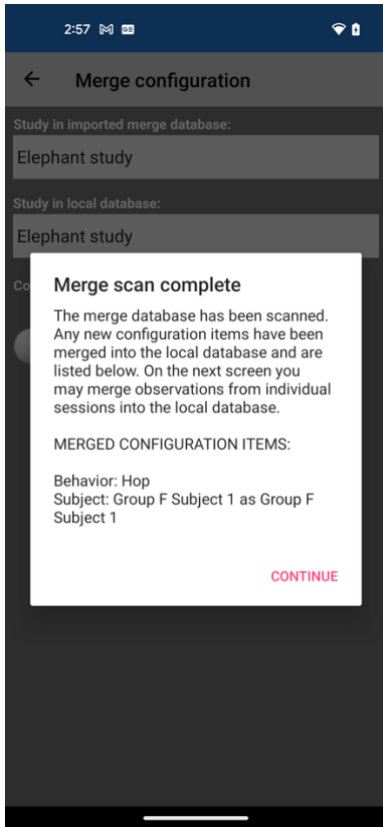
You now can merge a range of your colleague's sessions into your database (images above).When the merge is complete, full details of the merge are provided in a log file, *Exports/Database/MergeLog.txt.*

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Appendix N –Grid Mode

Under forest canopy, GPS might not be reliable in some cases. Then Grid mode will be useful. Grid mode, in conjunction with a grid map, allows you to conveniently record animal tracks as well as behaviors, even with no GPS signal. In a GIS system such as ESRI ArcGIS, SatNav and Grid mode tracks and behaviors may be seamlessly overlaid, if you choose a map projection based on the WGS84 datum (used by GPS).

NOTE: Positioning coverage under canopy can be extended with external GNSS receivers such as the sub-meter Arrow 100, which uses SBAS differential corrections from satellites.

NOTE: In Grid mode, the real-time map display is not available.

Grid mode requires that you use a projected coordinate system having a so-called 'WKID' (well known ID) recognised by your GIS software. For ArcGIS, an example is the Universal Transverse Mercator coordinate system (UTM), covering the entire globe, apart from polar regions (where SatNav is available anyway). As well, your GIS software must be able to process ESRI JSON or GeoJSON files. We'll take UTM with ArcGIS as an example.

Your first step is to determine the WKID for your study area. Here's one way to do it:

1. Enter a representative latitude/longitude into the calculator at www.latlong.net/lat-long-utm.html to find the UTM Zone. For example, Gombe Stream, 4.670009°S, 29.623481°E, will be shown to be in UTM Zone 35 or more precisely Zone 35M (you should ignore the M).

2. Add N if northern hemisphere or S if southern. Thus, 35S for Gombe Stream.

3. At epsg.io, enter *WGS 84 UTM Zone 35S* into the search box (beware the autocorrect). You will see displayed the result EPSG: 32735. Your desired WKID is 32735 in this case.

Start ArcMap and insert a new data frame. To navigate to the map projection for Gombe Stream, right-click on the new data frame in the Table of Contents and select:

> *Properties > Coordinate System > Projected Coordinate Systems > UTM >*
> *WGS 1984 >Southern Hemisphere > WGS 1984 UTM Zone 35S > Apply*

You'll notice the WKID 32735 displayed here, providing confirmation.

NOTE: Navigating in this way is a means of discovering which projected coordinate systems have a supported WKID: while many WKIDs are defined by EPSG, others are defined by ESRI.

In Behayve, in the *Settings* menu for your study, enter your WKID as the value of *GridCoordinateSystem,* and for *Position Type* select *Grid* instead of *SatNav*. You're good to go!

Observational procedure

In Grid mode, rather than roaming freely during observations (as you may in SatNav mode), you must observe from a fixed location or a succession of fixed locations, in order to fix the position of animals.

Your map must use the same projected coordinate system as the ArcMap frame you just created, for example UTM. Preferably it will be a high-resolution map, based ideally on the WGS84 datum.

NOTE: In Grid mode, the real-time map display is unavailable.

When you begin a session, you'll be prompted to select a Place as your first observation position:
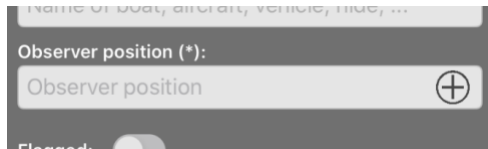
Tap the plus sign to define a new Place. Simply enter a name for the new Place – the easting and northing should NOT be entered during the session.

During the session, when you decide to move to another fixed observation position, navigate backwards through the menus to the *Session* screen and tap *Pause session* then *Session details*. Define the new observer position using the plus button (just giving it a name), and tap *Done* then *Resume session*. Continue your observations.

NOTE: At each successive observation position, it may be useful to leave a physical marker for later recording of its easting and northing. Consider using a Romer scale and be as precise as possible.

After the session terminates, you can enter the easting and northing of each observer position by selecting *Places* on the *Configuration* menu.

After ensuring all your observation Places have map coordinates you can export your observations, creating a collection of *.json* files, before triggering their automatic import into ArcGIS.

Appendix O – Bulk configuration

Normally the *Configuration* screen is the most convenient way to add items like Behavior, Species, Group and so on.

If, however, you have a very large number of items to configure, the *Import* function on the Study screen may be a labor-saving alternative. This function can be used to add a list of items, but not to edit or delete items. With *Import*, you can add lists of the following:

1. Behavior classes
2. Behaviors (behavior definitions)
3. Species
4. Groups
5. Data items
6. Choices
7. Subjects
8. Roles
9. Modifiers
10. Mutual exclusions
11. Places
12. Areas

Procedure: Add items in bulk to the configuration

If you are adding more than one type of item in bulk, for example *Behavior classes* and *Roles*, you can reduce effort by adding them in the order of the numbered list above. (Higher-numbered items may depend on lower-numbered items being present.)

The following procedure uses *Roles* as an example, but it could be any type. We'll also use Dropbox, but it could be a laptop instead.

1. If no user-defined Roles exist yet, add the first one using the *Configuration* button on the home page's menu.

2. On the *Study* page, use the *Export* button to export a list of existing Roles to Dropbox.

3. In Dropbox, navigate to *Apps > Behayve > Exports > Csv* and copy to the clipboard the file *RolesStudy(N). csv*. Here (N) is the study number. Navigate to Apps > *Behayve > Imports* and paste the file into the *Imports* folder.

4. In a spreadsheet program such as Excel or Numbers, go to the *Imports* folder in Dropbox and open the file just pasted. You will see a header row followed by one or more item lines. An example is shown below.

	A	B	C	D	E	F	G	H	
1	NAME	DESCRIF	SEQUEN	HIDDEN	VERSIONAPP	VERSIONDB	BEHAVIOR CLASS 1	BEHAVIOR CLASS 2	BEHAVI
2	Actor			FALSE	2.6	13			
3	Receiver			FALSE	2.6	13			
4	Initiator			FALSE	2.6	13	Events	States	Agonist
5	Companion			FALSE	2.6	13	Events	States	Agonist
6	Influence			FALSE	2.6	13	Events	States	Agonist
7	Out of sight			FALSE	2.6	13	Events	States	Agonist
8	Onlooker			FALSE	2.6	13	Events	States	Agonist

5. Using the existing rows as a guide, add new items, one per row, below the existing items. In this example, at least one Behavior Class will need to be given in each row. Columns like VERSION APP, VERSIONDB, TIME, AUTOGENERATED will be ignored and can be left blank.

6. Delete the rows of pre-existing items, taking care not to delete the header row, and save as CSV. Make sure there are no duplicate names.

7. On Behayve's *Study* page, tap *Import*, and select *Roles*. Tap *Import*. Using the *Export* function, you can verify that all Roles have been imported.

NOTE: The following are ignored on import:

Item	Ignored on import
Group	Auto-generated id, Time
Subject	Auto-generated id, Time, Length unit, Weight unit
Behavior	Example filename
All	Software version, Database version

Appendix P – Preparing a custom onboard map

In regions without Internet coverage, Google Maps is unavailable and you may wish to use a custom onboard map. You can prepare a highly accurate onboard map by scanning or photographing a topographic map or by using Google Earth on a laptop. Because of perspective distortion effects, a corrective procedure will normally be needed in the case of a photograph and sometimes for images captured in Google Earth. Here's how to apply the correction in the case of Google Earth. A similar procedure applies for photographed maps.

1. In Google Earth display an area larger than the expected range of your targets. The area should be reasonably large, to minimize the effect of GPS/GNSS positioning inaccuracies. Press the *n* key to ensure the map points north and press the *u* key to ensure a vertical view. (You may find it convenient to select *Do not automatically tilt while zooming* on the Navigation tab of Google Earth's settings.) It may be instructive to select View -> Grid.

2. Carefully note two easily recognisable points, one toward the southwest corner and one towards the northeast corner, each about 10% of the way in, say. Later you will be measuring their exact position.

3. Add placemarks close to the four corners of the (larger) area in a quadrilateral. To do this, note the latitude/longitude of a point near the bottom left corner, enter those values when creating the placemark, then use its latitude when creating the placemark near the bottom right corner, use the longitude of the bottom right corner when creating the top right corner and use the latitude of the top right corner and longitude of the bottom left corner when creating the top left corner. If the resulting quadrilateral is not perfectly rectangular, you have a perspective distortion effect. Otherwise just take a screenshot with the two 'recognisable' points as corners and continue at step 9.

4. Take a screen shot of the displayed (larger) area and open it in an image editing app. Here we'll use Adobe Photoshop as an example.

5. Using the polygonal lasso tool, zooming in for precision, select the area bounded by the four placemarks, invert the selection and delete that selection, leaving a distorted quadrilateral map. Then precisely crop the image to the smallest possible bounding rectangle (you may need to magnify the image to achieve precision).

6. Select Edit -> Transform -> Perspective and drag corners outward until the selection aligns with the vertical and horizontal axes, taking care not to lose any portion of the map unless necessary. It will be necessary to lose some portion, which is why we chose a larger area in step 1.

7. Crop the result precisely to the rectangle with the two 'recognisable points' (step 2) at its corners and save the result as .jpg or .png.

8. Place the saved map file in Behayve's Imports folder in your Dropbox.

9. In Google Earth, zooming in for precision, place the mouse pointer on each of the two 'recognisable' points in turn and note down their latitude/longitude to six decimal places.

10. On Behayve's *Configure study* screen, select *Onboard maps* and add the map, specifying the filename and latitude/longitude of the two corner points. More than one onboard map may be added.

NOTE: Any inaccuracies of tracks in online maps occur only in real-time viewing: tracks exported to GIS systems like ArcGIS will be exact in every case.

NOTE: Maps may also be viewed after your session ends, in Configuration > Groups and Configuration > Subjects. If at that time you have regained Internet connection, Google Maps will be used.

Appendix Q – Recording aggregate counts

Behayve provides a convenient way of recording aggregate counts of animals in different states, using Data Items. Typically, this would be at defined intervals, but does not have to be. Let's look at an example.

Suppose that once a minute you want to record the number of elephants in Group A that are resting, standing, walking and running.

To configure:

- Add an additional Behavior Class, of type *Events,* called (for example) *Energetics*
- Edit Group A and, under *Classes*, enable the *Energetics* class
- Add Data Items named *Resting, Standing, Walking* and *Running*, each with the following selections:
  - Kind: *PerBehavior*
  - Value: *Integer*
  - Behavior class: *Energetics*
- Add an additional Behavior, of type *Event*, named (say) *Count.* Under *Classes*, select *Energetics* and de-select all other classes (Do not put any other Behaviors in the *Energetics* class)
- If necessary to prevent excessive scrolling during sampling, use the *Organize* button on the *Behaviors* page in *Configuration*, to bring the *Count* button to the top of the screen.

To sample:

- Start a session, select the FOCAL tab and select Group A
- Tap the *Count* button – you will be prompted to enter values for *Resting, Standing, Walking* and *Running* – you may enter some, all or none of these
- To get a periodic prompt to tap the *Count* button, either:
  - Before starting focal sampling, tap *Set periodic alerts*, OR
  - Run FOCAL and SCAN sampling simultaneously – when prompted to scan, switch to the FOCAL tab and tap *Count.*

Appendix R – Plain old data collection, without behaviors or tracks

Want to use Behayve for simple data collection – no behaviors, no tracks, just data? You can! Basically, add a behavior and attach your data items to it. If you wish, take advantage of Behayve's built in selection of data types, data validation and multiple-choice facility.

Select this behavior whenever you want to record data, and you'll be prompted for your data items. In addition to your data, you will automatically get:

- Latitude and longitude
- Date and time
- Name of the recorder
- Possibility to auto-generate a map of data collection points.

Example

You wish to sample washed-up seagrass fragments. The seagrasses, it must be said, are pretty inert. On each of several transects, you need to record the following data items:

- Name of beach
- Number of fragments
- Tide height
- Wind speed
- Wind direction
- Transect latitude and longitude
- Date and time
- Name of recorder

You need to roll up the data in a spreadsheet, and possibly display the transects on a map.

Configuration

1. Add a behavior class named *Transects*, of type *Events*, reserved for the purpose.
2. Add a behavior named *Transect* (of type *Event* by default), tapping *Classes* – enable *Transects* and disable all other classes including *Events.*
3. Add Data Items named *Beach, Fragments, TideHeight, WindSpeed* and *WindDirection*, giving each of them a Kind of *PerBehavior,* a Value as per the table below and a Behavior Class of *Transects:*

Data	Value
Beach	Text
Fragments	Integer
TideHeight	Decimal
WindSpeed	MultipleChoice
WindDirection	Text

4. Under Choices, for 'Multiple-choice data item', select *WindSpeed* and tap the + sign. When prompted for a name, enter *Zephyr* and tap *Done*.

5. Again tap the + sign, entering *Breeze*, and do the same for *StrongWind* and *Gale*.

Data Recording

Start Focal sampling and, for each transect, tap the *Transect* behavior button. You are prompted for the data:
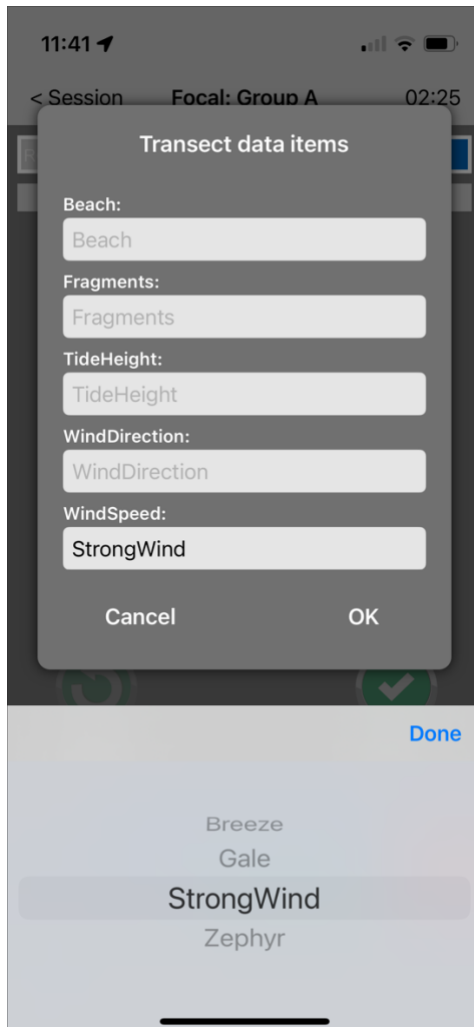
Optionally, so as to be able to automatically generate a map of the transects (in Google Earth for example), you can stand at the transect, tap the *Fix* button and enter 0 for both bearing and range.

Appendix S – Where do I find my notes?

Notes recorded during sampling may be viewed by browsing in *Review,* either during the session or later, when no session is in progress. Notes appear along with the item (group, subject, behavior or fix) to which they apply.

The notation *Notes: (sound clip)* indicates, unsurprisingly, that an item has a sound clip. To hear the sound clip, tap on the item to display a screen where you can play (and optionally transcribe) it.

Notes may also be viewed in exported spreadsheets. The spreadsheet containing a note depends on the item it is associated with, as per the table below.

Item to which the note applies	Exported spreadsheet containing the note
Group	Observations > GroupInfo
Subject	Observations > SubjectInfo
Behavior	Observations > Behaviors
Fix	Observations > Positions
Behavior fix	Observations > Behaviors and Observations > Positions
Environment fix	Observations > Behaviors and Observations > Positions

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Appendix T – Positioning when GPS is unavailable or unsuitable

GPS may be unavailable, or unsuitable, when recording positions. For example:

- Indoors
- In small enclosures or at close range
- Under forest canopy or near buildings
- Near power lines (because compass is affected)

Behayve offers three alternatives for such cases:

- Relative positions (2D or 3D)
- Areas (2D)
- Grid (2D).

Relative positions

Exports of fixes include the following three values, which can be positive or negative:

- Rel.East = distance eastwards from observer to target (2D or 3D recording)
- Rel.North= distance northwards from observer to target (2D or 3D recording)
- Rel.Height = height of target above observer (3D recording)

If the observer remains in the same place while recording, these values locate targets within a 2- or 3-dimensional space. They can easily be graphed in a spreadsheet, and the distance between two targets can be calculated in a spreadsheet using only Pythagoras' theorem.

Here, the *PositionRecording* setting must not be disabled.

For range accuracy, a laser rangefinder may be useful. There is also the option of using a wireless laser rangefinder to speed recording – see Appendix C – Wireless laser rangefinder.

The *ObservationMode* setting determines whether recording proceeds in 2D or 3D fashion.

Areas

An Area may be configured as a polygon whose vertices are Places. Such polygons may be contiguous but must not overlap. Alternatively, an Area may be configured with nothing but a name, where the user simply has a mental map of different areas.

When recording a fix, the user can select an Area manually without providing any compass bearing, zenith angle or range. In the case of polygonal areas, an option directs Behayve to automatically assign an area based on compass bearing and range.

The *AreaRecording* setting can be set to *Manual*, *Auto* or *None*.

If areas have a name only, *AreaRecording* should be set to *Manual* and the *PositionType* setting must additionally be set to *None*.

Grid

In the field under forest canopy, GPS may be unreliable, and Grid mode may be used instead. See Appendix N – Grid mode.

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Appendix U – Filtering subjects using selectors

To simplify recording where a group has a large number of subjects, you might wish to restrict which subject buttons appear during sampling, based on a criterion that you define. This may be done on a per-group basis.

As an example, suppose you want to control which subject buttons appear, based on the size of animals in a group.

1. In Configuration, select *Choices* and choose *Selector*.
2. Use the + button to add three Choices named *Large*, *Medium* and *Small*.
3. For each large subject in Group B, edit the subject and select *Large* from the *Selector* dropdown. Similarly for Medium and Small.
4. If you want to study only large animals in group B at the moment, edit group B, choosing Large from the *Selector* dropdown. For group B, only the buttons for large subjects will appear during sampling.
5. To resume studying all animals in group B, edit group B, choosing *None* from the *Selector* dropdown.

NOTE: Color-coding of subject buttons might be an alternative.

NOTE: In a similar way, subject *Personality* may be configured. Select *Choices* and choose *Personality*, then add desired Personalities.

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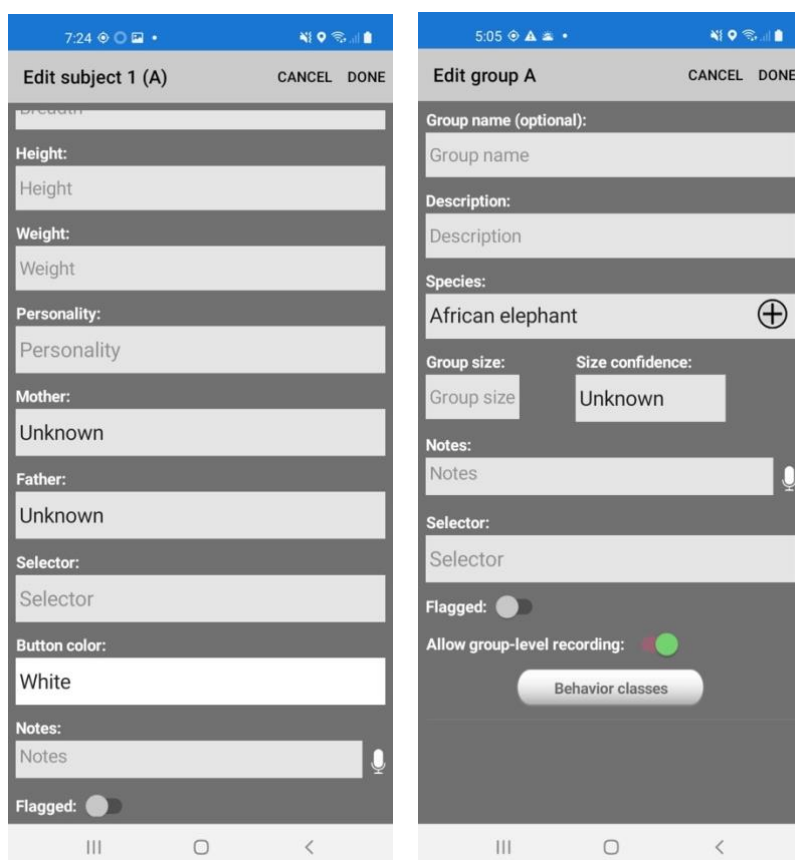
Appendix V – In-app subscriptions and purchase

Free usage

Capabilities

With the free Behayve app, you can:

- Familiarize with the app using a supplied [sample study](#)
- [Configure](#) your own custom study
- Test your study
- Record behavioral, positional and environmental data in the field, and
- View your recorded data on -screen.

There is no time limit on free usage.

Restrictions

The free version offers all features of Behayve with the following exceptions:

- Data export to:
    - Spreadsheet
    - GIS
    - KML (Google Earth / Google MyMaps)
- Export of onboard database and backup/restore
- Team data sharing
- Connection to wireless rangefinder
- Wireless connection to external instruments (ship's instruments, differential GPS)

A restricted data export facility is provided for demonstration purposes. This allows you to familiarize with data export formats.

Offers

In the app, you can sign up for monthly or quarterly subscriptions to features not present in the free version, or buy them outright:

- *All Features Monthly* subscription, cancel any time
- *All Features Quarterly* subscription, cancel any time
- *Citizen Scientist Quarterly* subscription, cancel any time
- *All Features Permanently* (one-time purchase)

Unlike the other offerings, *Citizen Scientist Quarterly* does not include data export to spreadsheet, GIS or KML. It does, however, include export of onboard database, enabling a team leader who has *AllFeatures* to [merge](#) citizen scientists' recorded data into a shared pool and export to spreadsheet, GIS and KML from there - a low-cost solution for small- to medium-sized research groups.

Data recorded before and after a purchase may be exported.

Pricing

Behayve is priced at educational levels: a major educational discount has already been applied, for all users.

In most cases, the cost of an all-features subscription can be compared to the cost of a cup of coffee at a café every couple of weeks.
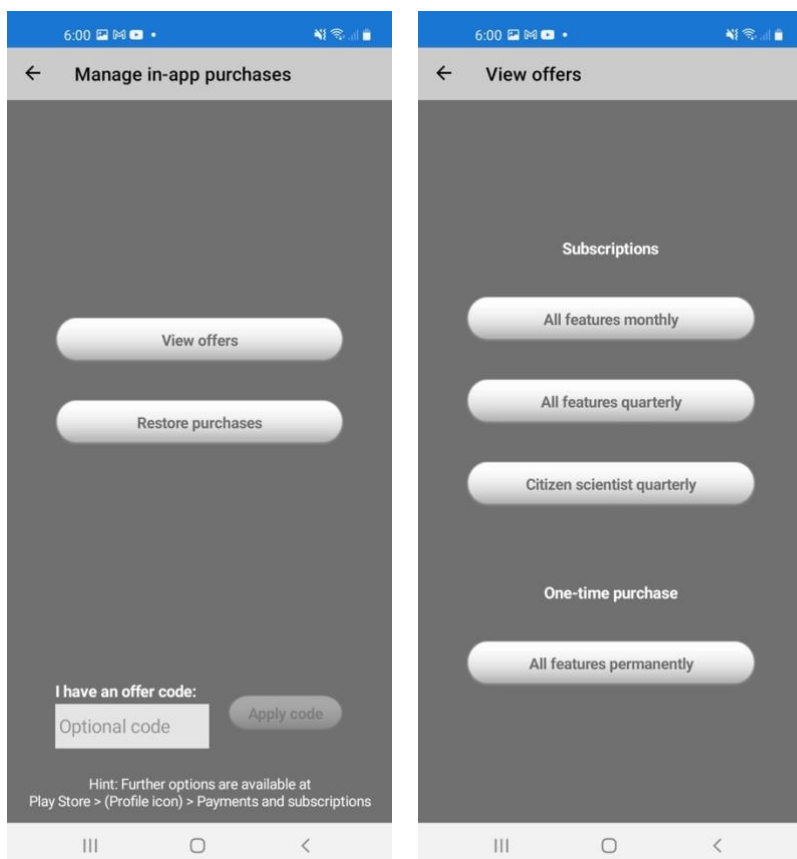
How to subscribe or purchase

On the home page, tap the menu and select *In-app purchases*.
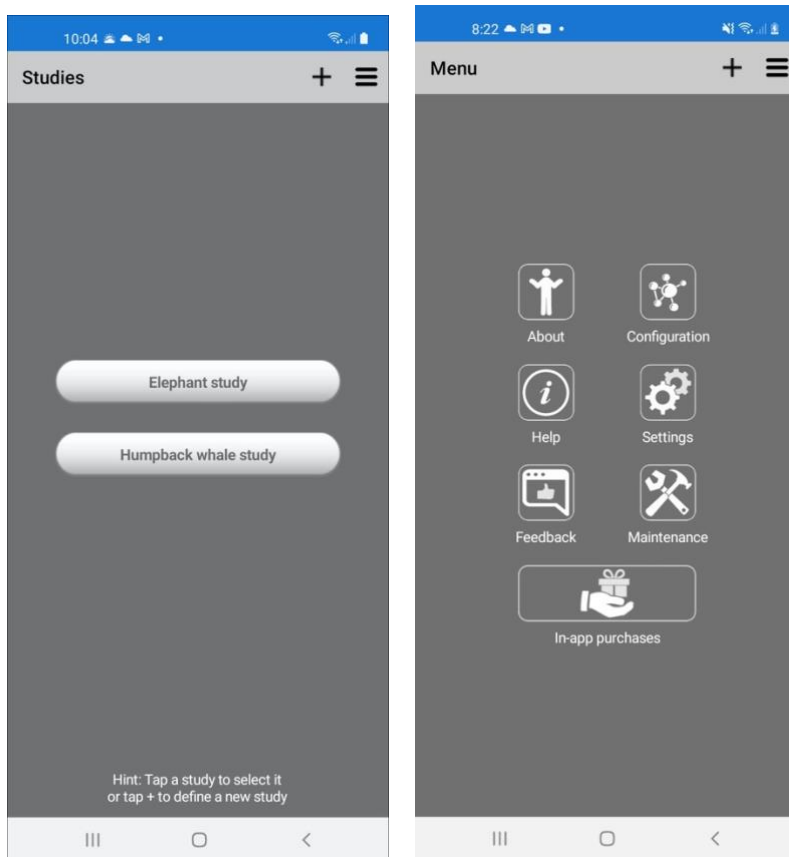
1. On the *Manage in-app purchases* screen, tap *View offers.* On the *View offers* screen, tap an offering. A page will appear with price, description and a purchase button. The purchase will be charged to your Google account.

Restoring purchases

If you get another phone, you'll need to restore your in-app purchase on your new phone. To do this, simply tap *Restore purchases* on the *Manage in-app purchases* page.

Other functions

Other functions involving your in-app purchase, including cancellation, are available at:

Play Store > (Profile icon) > Payments and subscriptions

Volume and tax-exempt purchases

Google does not appear to have a schools program and advises tax-exempt users that tax must be paid upon purchase and users should contact the developer directly to request a tax refund. You can contact us at support@behayve.com.

Depending on the country in which you live, it may be possible to avoid taxes by uploading tax documents to Google Pay in your payment settings.

Sharing product across multiple phones

Apple and Google policies require a separate purchase for each phone or tablet, with the exception that several devices having the same Apple Id or Google account can share a purchase. The limit may be around 10 iPhones or 10 Androids. A potential drawback here is that emails, photos and so on may get mixed and shared across devices if you are not careful, or maybe even if you are.

Phones without access to the Store

For phones where access to the Play Store is disabled, it is enough for an admin to enable the store, make the in-app purchase or subscription, and then disable the store again. The purchased functions will be available without the store, and in fact without internet.

Gombe Stream, Tanzania