

USER GUIDE



NASA PVT+ for iOS

Fatigue Countermeasures Laboratory
Human Systems Integration Division
NASA Ames Research Center

This user guide is meant to be used by the experimenter using the NASA PVT+ app.

This guide contains information about:

- [A detailed description of the app and the tests included in the app](#)
- [Setting up the app for a study](#)
- [Notes about test administration](#)
- [Downloading the data from the device](#)
- [Notes about PVT data analyses](#)
- [Articles to cite when publishing data using the app](#)

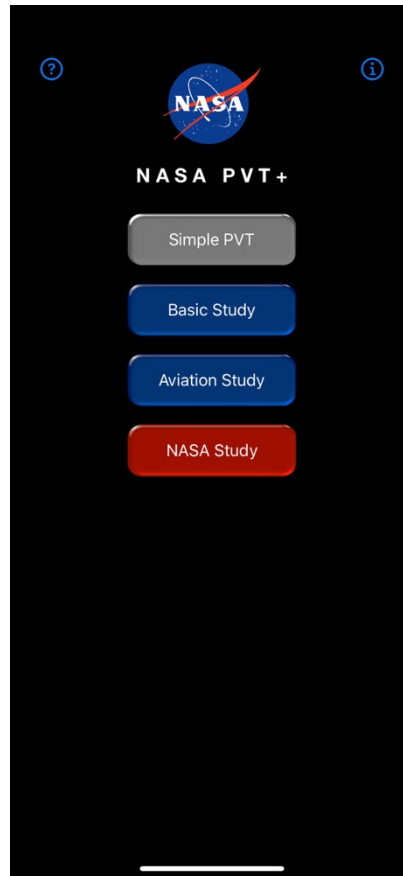
ATTENTION! When deploying the app on study devices, ensure that both the app and the data download process have been tested in advance. This is especially important when using company-issued devices. In some cases, company security settings may prevent data from being downloaded, and resolving this may require assistance from the IT department. However, even with IT support, these restrictions cannot always be lifted.

INTRODUCTION

The NASA PVT+ application includes a collection of questionnaires and the Psychomotor Vigilance Task (PVT) used to measure sleep loss and circadian misalignment in field and laboratory environments. A detailed description of the tests included in the app is provided in the [Appendix](#) at the end of this guide. The app is suitable to be used on iPod Touch, iPhone, and iPad.

The Main Menu screen of the app displays:

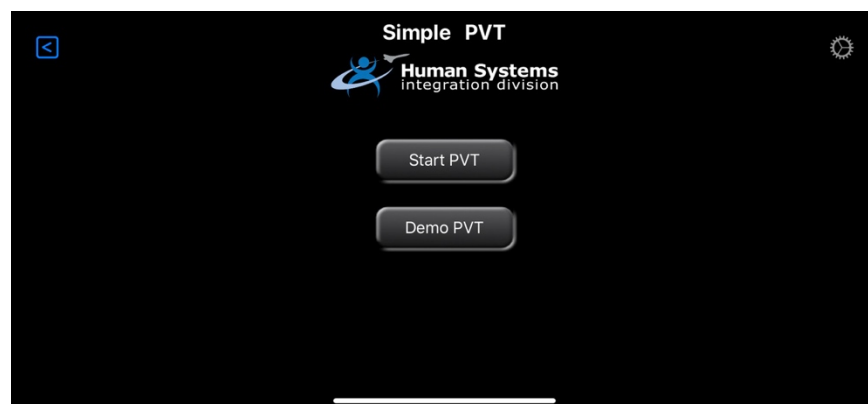
- 4 different study modes to choose from (Simple PVT, Basic, Aviation, NASA Study).
- a link to a start guide for the app through (?) in the upper left corner.
- a link (i) in the upper left corner that takes you to NASA Privacy Policy, License Agreement, Application Warnings and Notices, and a link to the Fatigue Countermeasures Laboratory website providing additional information about the app.



The NASA PVT+ app has 4 different study modes to choose from on the Main Menu screen.

1. Simple PVT

The Simple PVT is the Psychomotor Vigilance Task (PVT) – a simple reaction time test.

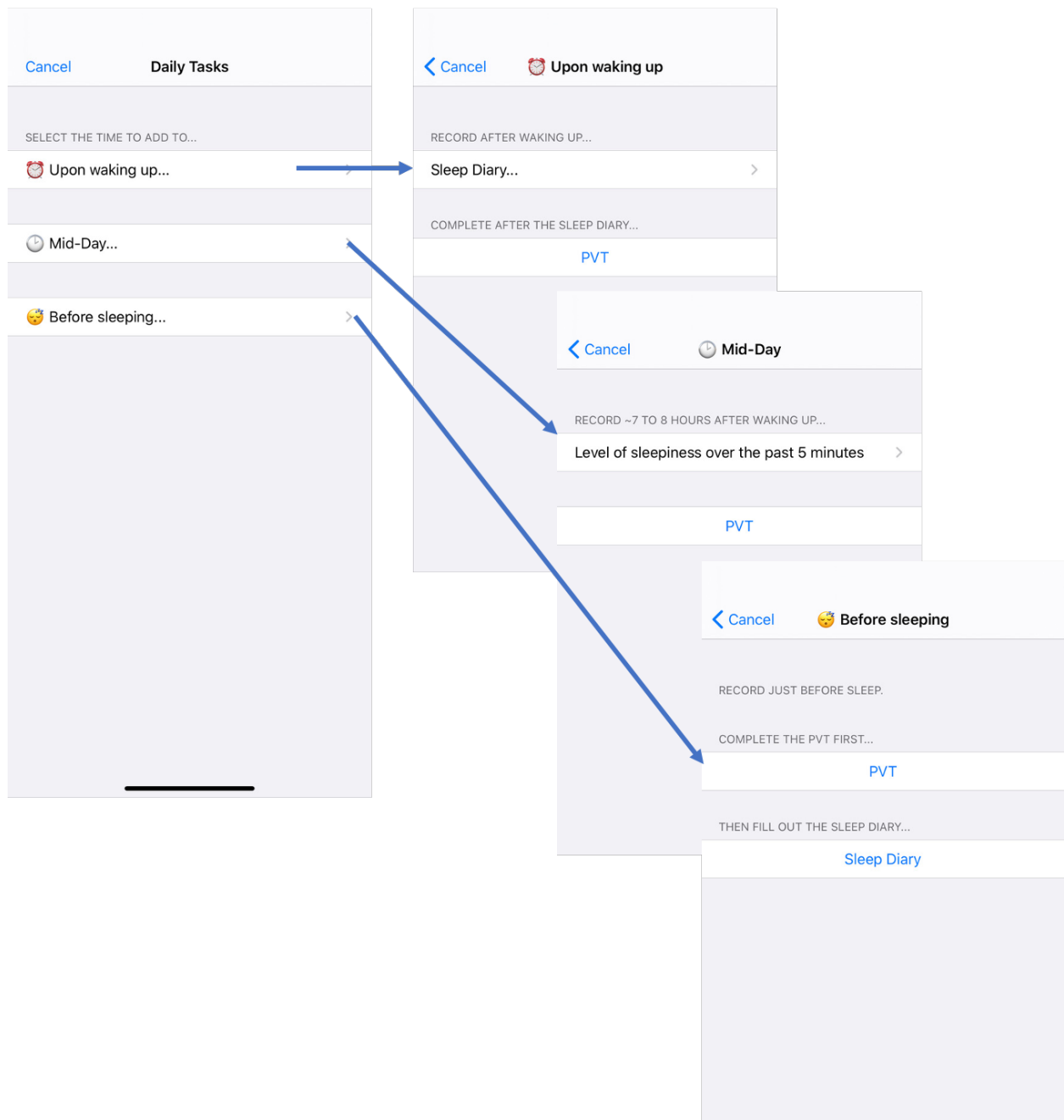


2. Basic Study

The Basic Study is designed for full day data collection with daily tasks: Upon waking up, Mid-day, Before Sleeping.

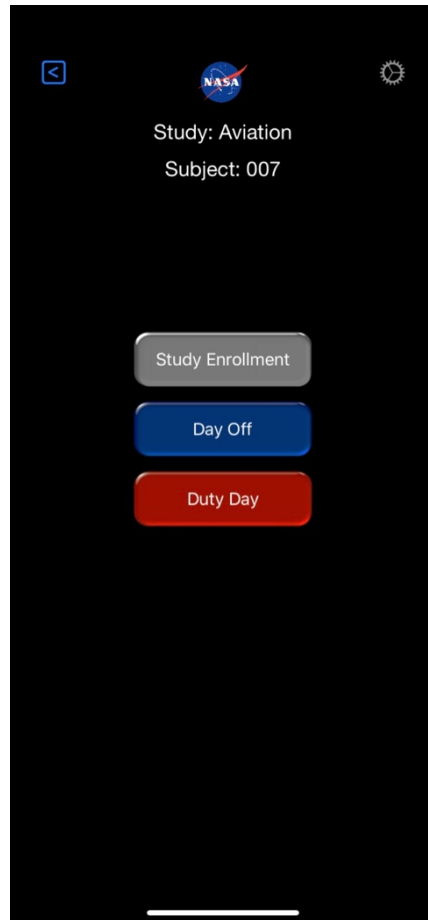
- Upon waking up - includes a sleep diary, and a PVT.

- Mid-day - includes a Karolinska Sleepiness Scale (KSS) and a PVT.
- Before Sleeping - includes a PVT and a sleep diary.



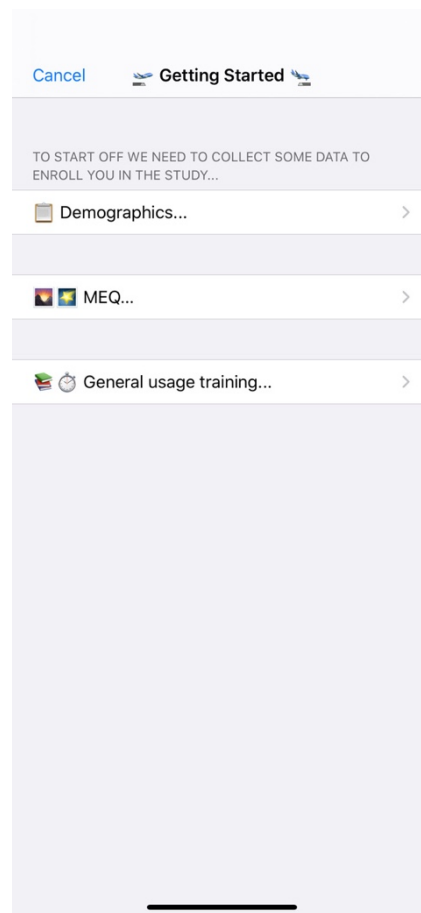
3. Aviation Study

The Aviation Study is designed for a multi-day study with Day Off and Duty Day tasks.



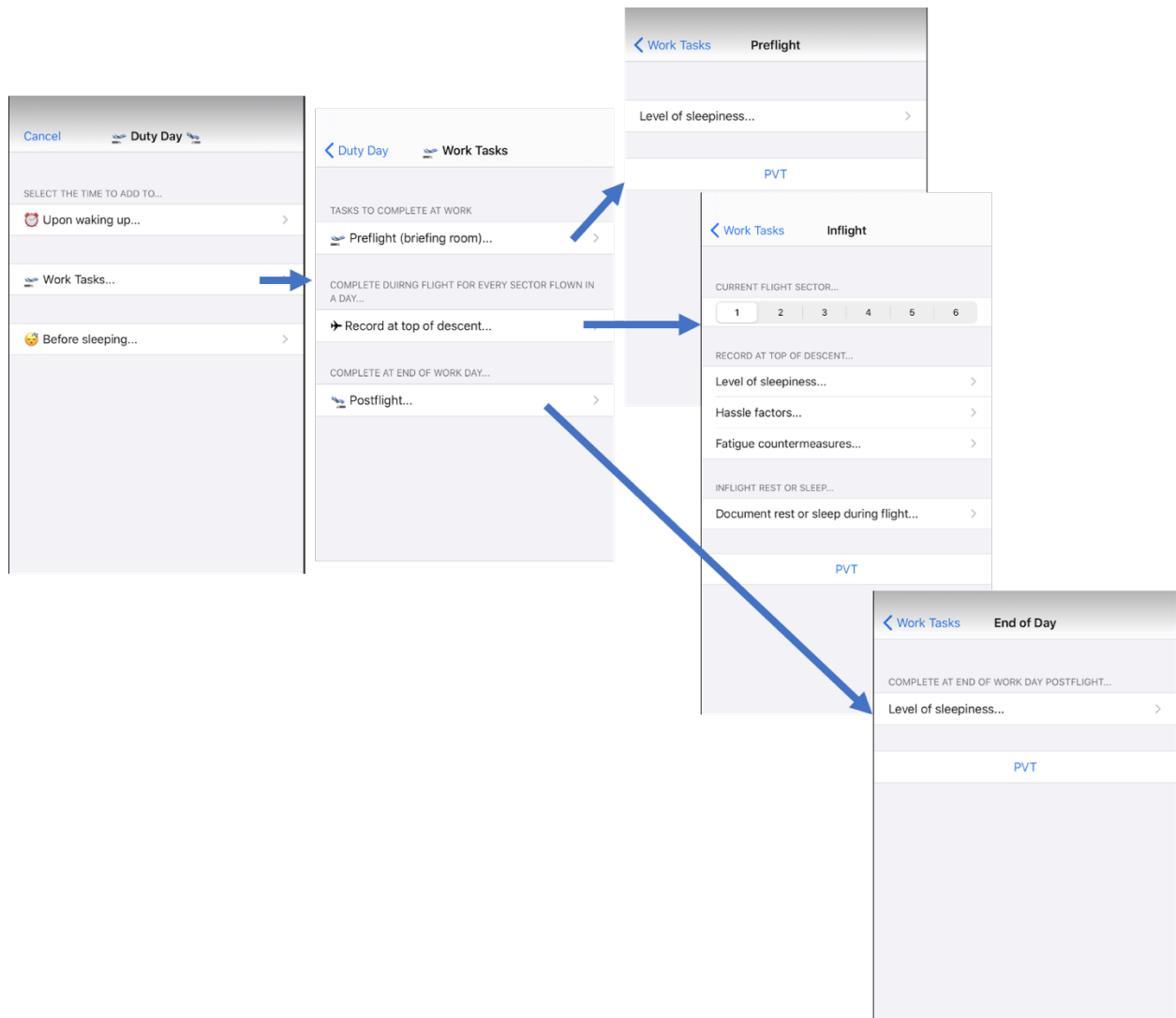
The main page of the Aviation displays three tabs:

1. Study Enrollment - includes a Demographic Questionnaire, a Morningness-Eveningness Scale (MEQ) and a section of General usage training to be used for training participants on the study tasks and procedures. This section is given once at the beginning of the study. After the participant completes this section this tab will no longer be visible on the main screen.



2. Day Off has three sections (similar to the Basic study daily tasks):
 - Upon waking up - includes a sleep diary and a PVT.
 - Mid-day - includes a KSS and a PVT.
 - Before sleeping - includes a PVT and a sleep diary.

3. Duty Day has three sections:
 - Upon waking up - includes a sleep diary and a PVT.
 - Work tasks. This section contains tasks to be completed on duty days:
 - Preflight – includes a KSS and a PVT. This section should be completed before each flight.
 - Record at top of descent (Inflight) – For each flight sector, the participant is asked to complete a KSS, hassle factors, fatigue countermeasures, inflight rest (if any), and a PVT. This section can be completed during each flight sector. The number of sectors is displayed on the first row of the screen. After data for a sector is completed, the app will take the participant automatically to the next sector.
 - Post-Duty (the end of duty) – includes a KSS and a PVT.
 - Before sleeping - includes a PVT and a sleep diary.



4. NASA Study

This mode is accessible only to NASA Ames Fatigue Countermeasures Laboratory and their collaborators.

SETTINGS

The study setup is similar for each of the four study choices (Simple PVT, Basic, Aviation, NASA Study).

By default, the settings of the app are:

- Study ID: Unregistered (for Simple PVT), Basic, Aviation
- Group ID: Optional

- Subject ID: **Unregistered**
- Dominant Hand: Right
- PVT Length: 5.00 Min: **300** sec
- Timeout Length: **10** sec

Done **Settings** Version: 1.2.0 B.1884

STUDY INFORMATION:
⚠ ANY CHANGES MADE AFTER THE START OF A STUDY WILL RESET THE STUDY TO THE BEGINNING!

Study ID

Group ID

PARTICIPANT INFORMATION:
⚠ ANY CHANGES MADE AFTER THE START OF A STUDY WILL RESET THE STUDY TO THE BEGINNING!

Subject ID

Dominant Hand

PVT SESSION TIMING SETTINGS:
⚠ CHANGES WILL AFFECT STUDY DATA COLLECTED! THE DEFAULT PVT LENGTH FOR NASA PVT IS 300 SECONDS OR 5 MINUTES. THE DEFAULT TIMEOUT INTERVAL LENGTH IS 10 SECONDS.

PVT Length: 5.00 Min Sec

Timeout Length: Sec

⌘ COMPLETE STUDY

WHEN A SUBJECT HAS REACHED THE END OF DATA COLLECTION FOR A STUDY YOU CAN RESET THE APP FOR A NEW SUBJECT BY HITTING THE COMPLETE STUDY BUTTON.

ANY DATA ALREADY COLLECTED WILL REMAIN STORED IN THE APP. ONLY THE SUBJECT ID, HANDEDNESS AND INTERNAL TRIAL COUNT WILL BE RESET. ALL OTHER SETTINGS WILL REMAIN THE SAME.

⚠ THIS CAN NOT BE UNDONE !!

Setup

1. Connect to WIFI
2. Open the app; the first page displays four choices: “Simple PVT”, “Basic Study”, “Aviation Study”, and “NASA Study”.
 - 2.1. Select the study of your choice
 - 2.2. Click on the cog wheel ⚙ (right upper corner).
 - 2.3. In the “Study ID” box:
 - 2.3.1. For Simple PVT - Enter your study name/code
 - 2.3.2. For Basic Study and Aviation Study – These fields are pre-filled and cannot be changed.
 - 2.4. In the “Group ID” box, enter information relevant to your study (i.e., your study name). This box can be left empty.
 - 2.5. In the “Subject ID” box, enter the participant code.

- 2.6. For “Dominant Hand”, select “Left” or “Right” depending on the handedness of the participant.
- 2.7. Check under “PVT Timing Settings” if “PVT Length” is 300 seconds and “Timeout Length” is 10 seconds. (Note: The “PVT length” and “Timeout Length” can be selected to the length of your choice.)
- 2.8. To exit out of Settings, you must hit Done.
3. Disconnect from WIFI and turn Airplane Mode ON before giving device to the participant.

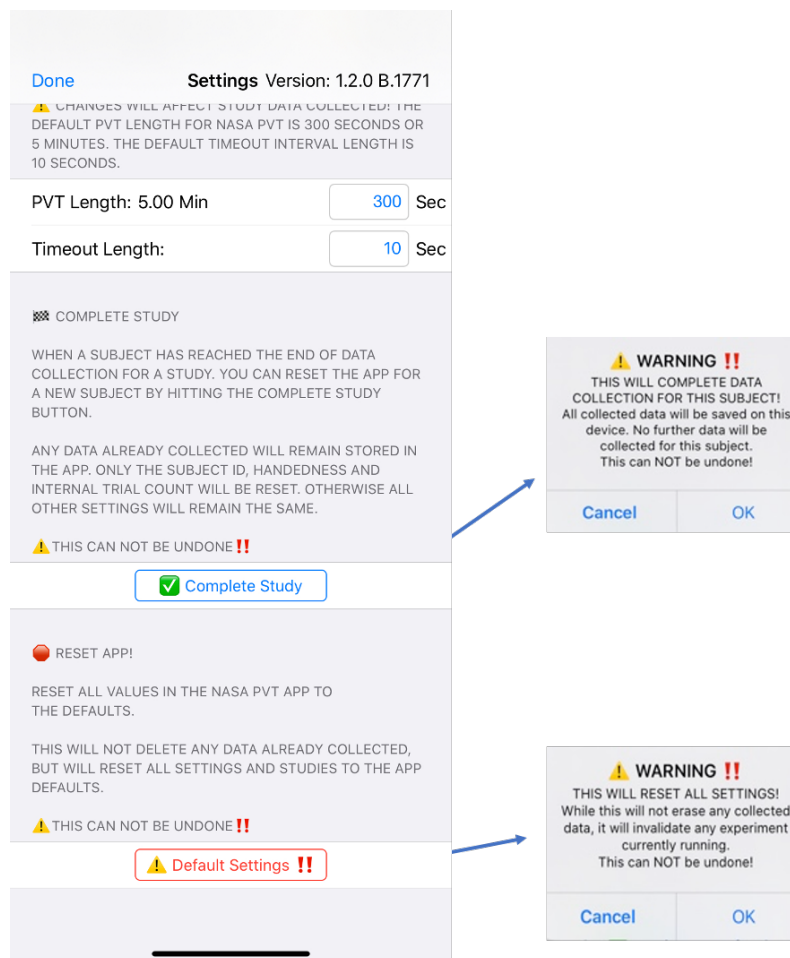
The screenshot shows the Settings app interface with the following sections and annotations:

- Header:** "Done" button and "Settings Version: 1.2.0 B.1884".
- STUDY INFORMATION:**
 - Warning: "ANY CHANGES MADE AFTER THE START OF A STUDY WILL RESET THE STUDY TO THE BEGINNING!"
 - Study ID:** Text field with "Basic" → This field can be changed ONLY for Simple PVT
 - Group ID:** Text field with "Optional" → Enter the name of your study
- PARTICIPANT INFORMATION:**
 - Warning: "ANY CHANGES MADE AFTER THE START OF A STUDY WILL RESET THE STUDY TO THE BEGINNING!"
 - Subject ID:** Text field with "Unregistered" → Enter participant code
 - Dominant Hand:** Radio buttons for "Left" and "Right" → Select Left or Right based on participant' handedness
- PVT SESSION TIMING SETTINGS:**
 - Warning: "CHANGES WILL AFFECT STUDY DATA COLLECTED! THE DEFAULT PVT LENGTH FOR NASA PVT IS 300 SECONDS OR 5 MINUTES. THE DEFAULT TIMEOUT INTERVAL LENGTH IS 10 SECONDS."
 - PVT Length:** Text field with "5.00 Min" and a numeric input field with "300" and "Sec" → Change PVT Length to your choice
 - Timeout Length:** Text field with "10" and "Sec" → Change Timeout Length to your choice
- COMPLETE STUDY:**
 - Text: "WHEN A SUBJECT HAS REACHED THE END OF DATA COLLECTION FOR A STUDY YOU CAN RESET THE APP FOR A NEW SUBJECT BY HITTING THE COMPLETE STUDY BUTTON."
 - Text: "ANY DATA ALREADY COLLECTED WILL REMAIN STORED IN THE APP. ONLY THE SUBJECT ID, HANDEDNESS AND INTERNAL TRIAL COUNT WILL BE RESET. ALL OTHER SETTINGS WILL REMAIN THE SAME."
 - Warning: "THIS CAN NOT BE UNDONE!"

Note: Any changes made to Group ID and Subject ID after the start of a study will reset the study to the beginning, meaning the internal trial count will be reset and start from 0. The data collected up to that point is saved on the device.

When a study is completed, you can click the “Complete Study” and/or “Default Settings” buttons in the Settings.

- **Complete Study** – Click on “Complete study” button when you decided that the data collection for that participant is complete. The data will be saved on the device, and no further data will be collected for that participant. Only Subject ID, handedness and the internal trial count will reset; all other settings (including Group ID and PVT Length) will remain the same. In order to continue to collect data for the same participant, you can re-enter the Subject ID. The new data will not overwrite the old data. If you want to continue to collect data for the same study but a different participant, you have to enter a new Subject ID and select the dominant hand for the new participant.
- **Default Settings** – Click on “Default Settings” button when you want to reset all values of the NASA PVT app to the defaults. This action will invalidate the experiment currently running but it will not delete any of the data already collected with the device.



ADMINISTRATION

Important study notes

1. Do not enter any personal data on the devices; only the assigned participant code/number.
2. Obtain birth date or the age of the participant or any other personal identifiable information at the beginning of the study separately and do not include it on any device.
3. Turn the device's WIFI off before giving it to participants.
4. Instruct participants to ensure the device is on Airplane Mode especially when taking the PVT to reduce test variability.
5. Ask participants to keep the device charged 100% as much as practicable.
6. Instruct participants to not change time settings or to update the device to a new iOS while completing the study (as this may change the latency for the PVT test).
7. In completing the PVT test, participants must respond with the thumb of their dominant hand. Thus, the experimenter must know the participant's handedness when setting up the device.
8. Read instructions to each participant for taking the PVT (included in the Appendix).
9. Instruct participants that if any of the app tests except for PVT, are not displayed correctly in portrait mode, turn to landscape mode and vice versa.

DATA DOWNLOAD

For Mac users:

1. Use a cable to connect the Apple device (iPod, iPhone, iPad) to the Mac.
2. You should get a message on the Mac asking if you want to trust the Apple device. Tap "Trust".
3. You should get a message on your Apple device asking if you want to trust the Mac you connected the device to. Tap "Trust" and enter the security code of the device.
4. Open "Finder" on the Mac.
5. Go to "Location". The Apple device you just connected with the Mac should be listed there.
6. Click on the Apple device icon. A window with several tabs displayed on top will open on the right side.
7. Click on the tab named "Files". A list with several apps from your device will be displayed.
8. Click on NASA PVT+. You should now see the files that have been captured by the app.
9. Click the first file, then hold down on the Shift Key on the keyboard and click the last file. This will select all the files. Also, you can type Cmd+A and it will highlight them all.
10. You can then hit the Save button. A pop-up will appear and let you choose where to save the files to.
11. Ensure that all .csv files have been transferred to the folder you created.
12. Eject the Apple device from the Mac.

For PC users:

1. Open iTunes on your computer.

2. Use a cable to connect the Apple device to the PC.
3. You should get a message on the Apple device if you want to trust the Mac or PC. Tap "Trust" on the iPod.
4. If you get a message on iTunes that there is a new iOS update, click "Don't Update" or "Cancel".
5. If this is the first time this Apple device has been connected to the computer, a dialog will pop up prompting you to "Setup as new device" or "Cancel." Select "Setup as new device."
6. You should now see a small iDevice icon show up in the upper menu bar of iTunes. Click on it.
7. iTunes should now show you info about the Apple device. (Note: If first time connecting this device to the computer, click Get Started to see info). From the list on the left, select the File Sharing option.
8. This should open up the File Sharing panel. From here select the NASA PVT App icon.
9. You should now see the files that have been captured by the app. Click the first file, then hold down on the Shift Key on the keyboard and click the last file. This will select all the files. Also, you can type Ctrl+A and it will highlight them all.
10. You can then hit the Save button. A pop-up will appear and let you choose where to save the files to.
11. Ensure that all .csv files have been transferred to the folder you designated for downloading.
12. Eject the Apple device from iTunes.

PVT DATA ANALYSES NOTES

It is known that touchscreen devices exhibit latency in recording a response after a touch was made on the device. This latency varies among Apple devices and iOS versions. We analyzed the latencies for the iPod 6th and 7th generations, iPhone 10R with several iOS versions using a high-speed video camera. The mean latency (in milliseconds) listed below should be subtracted from the raw PVT scores before analyses. This list will be updated as more devices and iOS versions are tested.

NASA PVT Latency for iPod 6th generation

iOS version	Mean (ms)	Standard deviation (ms)
10.2.0	81.83	15.51
10.3.3	82.61	12.99
11.3.1	84.94	15.39
11.4.1	84.94	15.27
12.3.1	82.21	16.41
12.4.5	82.16	13.58
12.5.3	79.51	15.8
12.5.4	77.02	15.66

NASA PVT Latency for iPod 7th generation

iOS version	Mean (ms)	Standard deviation (ms)
13.3	87.75	18.06
15.3.1	86.74	14.79
15.5	83.55	15.94
15.7.3	83.18	17.34

NASA PVT Latency for iPhone XR

iOS version	Mean (ms)	Standard deviation (ms)
13.3.1	77.25	6.09
16.1.1	58.22	7.88

NASA PVT Latency for iPhone 11

iOS version	Mean (ms)	Standard deviation (ms)
16.1.1	54.04	7.27

NASA PVT Latency for iPad 13

iOS version	Mean (ms)	Standard deviation (ms)
18	64.71	9.00

CITATIONS

1. When publishing results using the Simple PVT, please cite:
 Arsintescu, L., Kato, K. H., Cravalho, P. F., Feick, N. H., Stone, L. S., & Flynn-Evans, E. E. (2019). Validation of a touchscreen psychomotor vigilance task. *Accident Analysis & Prevention*, 126, 173-176. <https://doi.org/10.1016/j.aap.2017.11.041>
2. When publishing results using the Basic and/or Aviation studies or using other functions of the app, please cite:
 Arsintescu, L., Kato, K. H., Hilditch, C. J., Gregory, K. B., & Flynn-Evans, E. (2019). Collecting sleep, circadian, fatigue, and performance data in complex operational environments. *Journal of Visualized Experiments: JoVE*, (150). DOI: [10.3791/59851](https://doi.org/10.3791/59851)
3. For mentioning issues related to system latency, please cite:
 Arsintescu, L., Mulligan, J. B., & Flynn-Evans, E. E. (2017). Evaluation of a psychomotor vigilance task for touch screen devices. *Human factors*, 59(4), 661-670. DOI: [10.1177/0018720816688394](https://doi.org/10.1177/0018720816688394)

APPENDIX

Questionnaires and Tests

A detailed description of the questionnaires and tests included in the NASA PVT+ application is provided below.

Demographic questionnaire

This questionnaire collects information about participants (e.g., age, gender, BMI, etc.), experience (e.g., commercial hours), sleep needed per 24 hours, most alert and most tired times of day.

Morningness-Eveningness Questionnaire (MEQ; Horne & Östberg, 1976).

This scale determines the subject's chronotype and is filled out once at the beginning of the study. It is comprised of 19 multiple choice questions on a 4-5-point scale. The sum gives a score ranging from 16 to 86; scores of 41 and below indicate "evening types", scores of 59 and above indicate "morning types", scores between 42-58 indicate "intermediate types".

Sleep diary

This sleep log diary enables subjects to input information immediately before "lights-out" and 20 minutes after waking, thereby facilitating more accurate fatigue and sleep quality ratings. The morning sleep diary includes queries about wakeup time, post-sleep sleepiness level (KSS), sleep quality, time and duration of awakenings during sleep. The evening sleep diary includes queries about bedtime, KSS sleepiness scale, naps taken during the day (time, duration, and comments), and exercise taken during the day (time, duration, comments for various types of exercise). Both sleep diaries contain a comment section where participants can provide additional information about sleep and daily habits relevant to the study.

Karolinska Sleepiness Scale (KSS; Akerstedt & Gillberg, 1990)

The KSS is a simple questionnaire that asks individuals to rate their level of sleepiness over the past 5 minutes on a 9-point scale (from 1 = "extremely alert" to 9 = "very sleepy, great effort to keep awake, fighting sleep"). This test takes about 10 seconds to complete.

Psychomotor Vigilance Task (PVT)

The PVT is a simple reaction time test and is the most sensitive and reliable test for measuring the effects of sleep loss and circadian misalignment. The individual is presented with a stimulus and is instructed to respond to the stimulus by tapping the screen as quickly as possible. The PVT test was developed by the NASA Ames Research Center Fatigue Countermeasures Laboratory for use on Apple devices. Its development retained all features of the original PVT-192 (Dinges and Powell, 1985). The duration of the test can be changed based on study design.

To ensure consistency throughout testing, follow these steps:

1. Read the following instructions to each participant to ensure that each individual receives the same training:

“Please hold the device in the landscape position each time and hover each of your thumbs over the device within a few millimeters of the screen the entire time you are taking this test. During the test tap the screen using the thumb of your dominant hand, that is, the hand you typically write with, as soon as you see the red numbers scrolling in the box. You must use your thumb from your dominant hand to respond to the stimuli in all tests. The numbers in the display show how fast you responded each time – the smaller the number, the better you did. Try to do your best and get the lowest number you possibly can each time. If you tap on the screen too early (before the numbers appear) you will see an error message, “FS,” indicating a false start. If you tap using your non-dominant thumb, then you will see the message “ERR,” indicating an error. Avoid “FS” and “ERR.”

2. Instruct participants to keep the touchscreen device in Airplane mode with WIFI turned off at all times.

Note: This is especially important for the PVT task where the accuracy of the internal stopwatch is influenced by connectivity functions thus, potentially influencing the recorded reaction times.

3. Instruct participants to initiate the PVT at a time that is free from distractions. If distractions occur, then have participants note the number of distractions within the application when prompted following the test.

Hassle factors

The hassle factors questionnaire contains a list with the most frequent operational hassles encountered in aviation. It includes airport facilities, cabin activity, ATC, external environment, aircraft environment, training, airline disruption, procedures and documentations, human factors, team factors, experience and other. Participants are asked to select from the list each hassle factor experienced during flight. The list ends with a comment section where individuals can add other hassle factors experienced or comment on the ones provided on the list.

Fatigue countermeasures

The fatigue countermeasure questionnaire contains a list with the most frequently used countermeasures during flight. This list is based on previous surveys with pilots and includes activity breaks, caffeine intake, in-flight rostering, increased crew communications, cockpit lighting, etc. Participants are asked to select from the list each fatigue countermeasure used during flight. The list ends with a comment section where individuals can add other fatigue countermeasures used or comment on the ones provided on the list.

Inflight rest or sleep

This questionnaire is comprised of several questions asking participants if they obtained controlled rest and sleep, crew bunk rest and/or sleep, and whether they fell asleep unintentionally. The questionnaire has a comment section where individuals can provide additional information related to rest and sleep.

REFERENCES

Arsintescu, L., Mulligan, J. B., & Flynn-Evans, E. E. (2017). Evaluation of a psychomotor vigilance task for touch screen devices. *Human factors*, 59(4), 661-670.

Arsintescu, L., Kato, K. H., Cravalho, F. P., Feick, N. H., Stone, L. S., Flynn-Evans, E. E. (2017). Validation of a touchscreen psychomotor vigilance task. *Accident Analysis & Prevention*, Online 2 December 2017. <https://doi.org/10.1016/j.aap.2017.11.041>

Arsintescu, L., Kato, K. H., Hilditch, C. J., Gregory, K. B., & Flynn-Evans, E. (2019). Collecting sleep, circadian, fatigue, and performance data in complex operational environments. *Journal of Visualized Experiments: JoVE*, (150). DOI: 10.3791/59851

Horne JA, Östberg O. (1976). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms". *International Journal of Chronobiology*, 4 (2): 97–110.

Akerstedt T, Gillberg M. (1990). Subjective and objective sleepiness in the active individual. *International Journal of Neuroscience*, 52(1-2):29-37

Dinges, D. F. & Powell, J. W. (1985). Microcomputer analysis of performance on a portable, simple visual RT task sustained operations. *Behavior Research Methods, Instruments & Computers*, 17 (6), 3.