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Psychomotor Vigilance Self Test on ISS (Reaction Self Test on Expeditions 21 & 22)

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Experiment addresses the following high-priority NASA Risk Gaps in the Behavioral Health and Performance (BHP) area:

- Identify brief, valid objective measures of changes in cognitive functions during spaceflight that astronauts can use with minimal burden.
- Find a practical objective aid for astronauts to quickly identify and manage the effects of fatigue (from sleep loss, circadian disruptions, workload and other factors) on their performance during space flight.

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Identification of the ideal task

Criteria for task:

1. Task assesses operationally relevant cognitive functions
2. Task has brief duration
3. Task is not affected by aptitude (skill)
4. Task is not affected by learning (training or practice)
5. Task has known neurobiological basis
6. Task is experimentally validated for sensitivity to fatigue
7. Avoiding, gaming or faking the task is detectable
8. Task is operationally feasible in work environment
9. Task is software based (no upmass)
10. Task can be based on normative data from astronauts

An extensive scientific search for tasks meeting these criteria revealed the **Psychomotor Vigilance Test (PVT)** met all of the above criteria.*

* Van Dongen et al., (2003); Belenky et al. (2003); Balkin et al. (2004); Dorrian et al. (2005); Drummond et al. (2005); Durmer & Dinges (2005); Lim & Dinges (2008)

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Reaction Self Test measures vigilant attention performance (PVT), which has been extensively documented in scientific studies to be very sensitive to fatigue (>100 published studies).

The Reaction Self Test uses repeated reaction times to a light stimulus to measure the following aspects of vigilant attention during a 3-minute performance period.

- Optimal visual reaction time and psychomotor speed
- Wake state instability as measured by lapses (errors of omission)
- Impulsivity as measured by errors of commission

Computerized 5-minute Reaction Self Test has the following features.

- 3-minute test is done after answering questions about activities (2 minutes).
- Test provides feedback on performance level (0-100%) relative to astronaut norms.
- Test has no aptitude or learning effects that contaminate other tests (WinSCAT).
- Test is intended as a personalized aid to astronauts for fatigue management.

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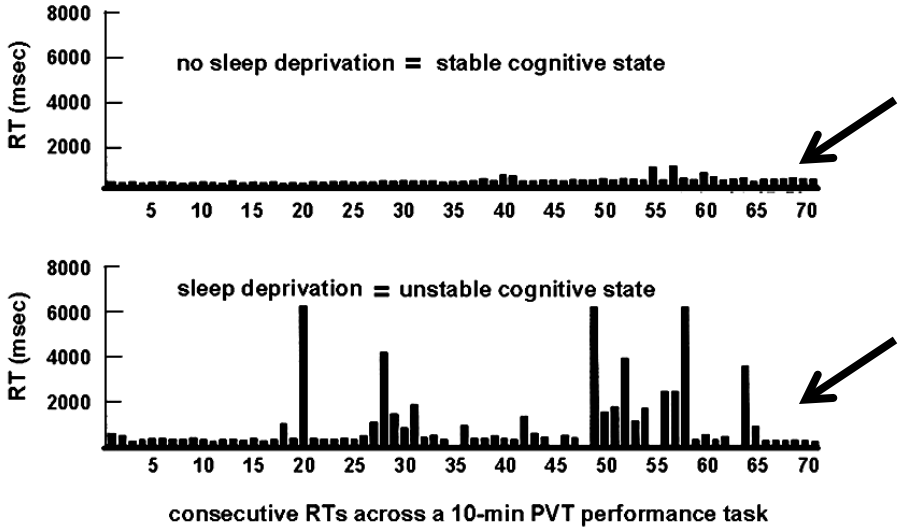
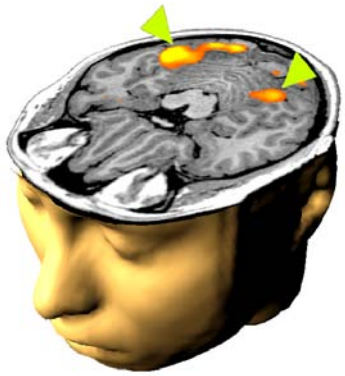
Reaction Self Test reveals the psychomotor slowing and wake state instability produced by fatigue from inadequate sleep and high workload.



No fatigue: Stable (normal) vigilant attention responses

Fatigue: Unstable vigilant attention responses (erros of omission and commission comingle with normal responses)

Neuroimaging studies have documented that fatigue affects vigilant attention performance by causing unpredictable reductions in neural activity in distributed brain regions that include cognitive control areas in the prefrontal cortex, visual processing areas in the occipital lobe, and the thalamus.



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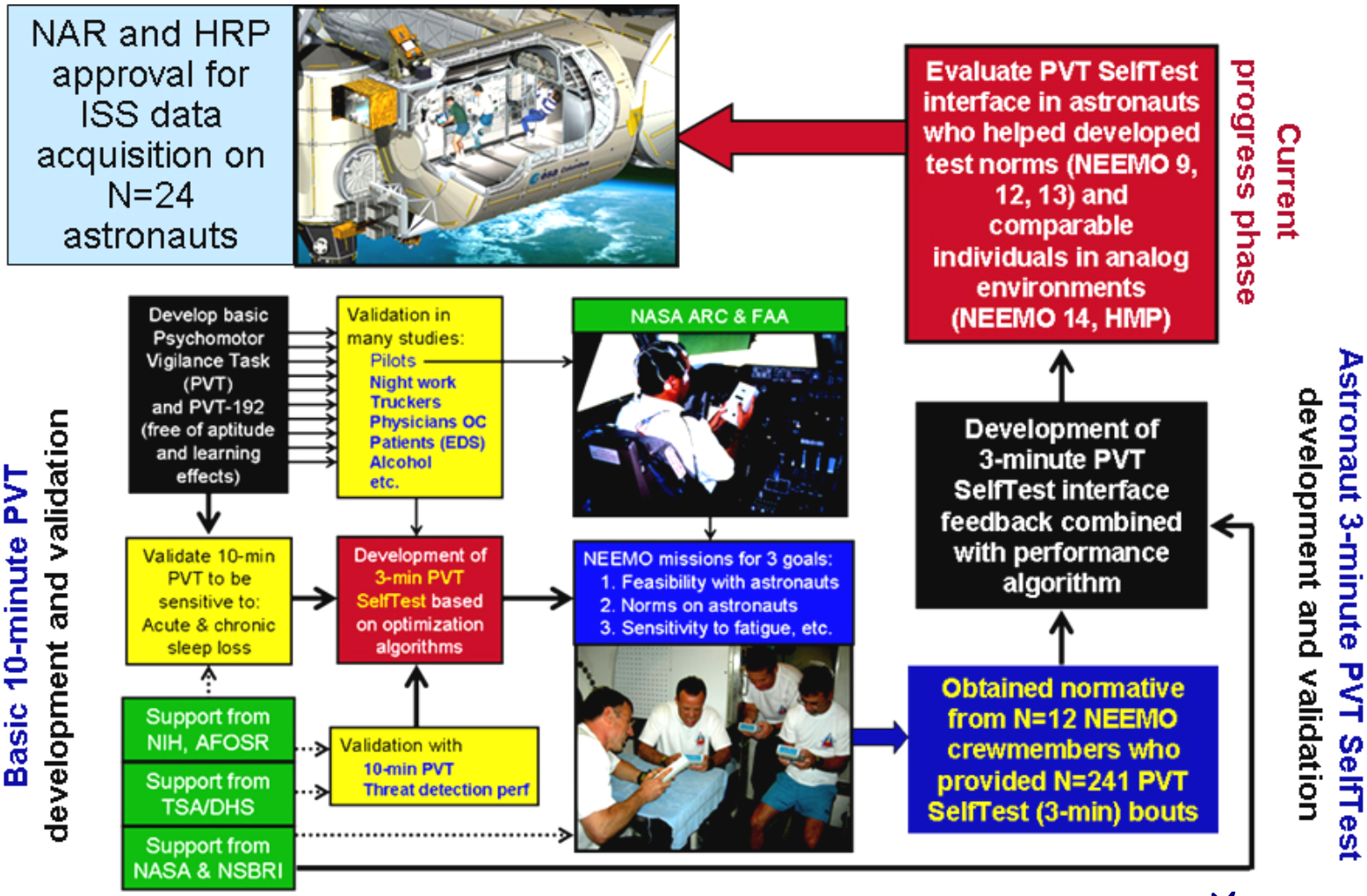
The Reaction Self Test was algorithmically optimized for astronauts based on normative data on astronauts working in analog environments.



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Objectives and Hypotheses

1. Evaluate the extent to which Reaction Self Test performance of astronauts is sensitive to fatigue from **sleep loss and circadian disruption** during ISS missions.

   Hypothesis: Reaction Self Test performance will decline in response to wake durations >16 hours; sleep restricted to <6 hours per day for 3+ days; sleep shifts

2. Evaluate the extent to which Reaction Self Test performance of astronauts is sensitive to fatigue from **work intensity** during ISS missions.

   Hypothesis: Reaction Self Test performance will decline in response to extended work periods >12 hours per day; >6 work days without a day off for rest; EVAs.

3. Evaluate the extent to which Reaction Self Test performance of astronauts declines with **time in mission**.

4. Evaluate the extent to which Reaction Self Test performance of astronauts will be sensitive to the **carry-over effects of medications** for sleep on ISS.

5. Evaluate the extent to which Reaction Self Test performance is **useful to astronauts** for assessing performance capability and utilizing fatigue countermeasures on ISS.

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Measurements

Preflight	In-Flight	Postflight
1) Familiarization session prior to L-180 BDC 2) BDC Sessions: Reaction Self Test (5 mins per session) 2/day (post sleep & pre-sleep) L-180 L-150 L-120 L-90 L-60 L-30 L-7 to L-1 (daily, if possible) Total Time =130 mins	Reaction Self Test (5 mins per session) 2/day (post sleep & pre-sleep) • MD-1 to MD-180, every 4th MD (180/4 = 45 days) • EVA-1 & EVA+0 (for 3 of 6 EVAs) • Sleep Shift (SS) (for 1 of 9 SS) SS-3, SS-2, SS-1 SS+0 SS+1, SS+2, SS+3, SS+4, SS+5 Total Time = 605 mins	Reaction Self Test (5 mins per session) 2/day (post sleep & pre-sleep) R+0 to R+7 (daily if possible) R+30 R+60 R+90 Total Time = 110 mins

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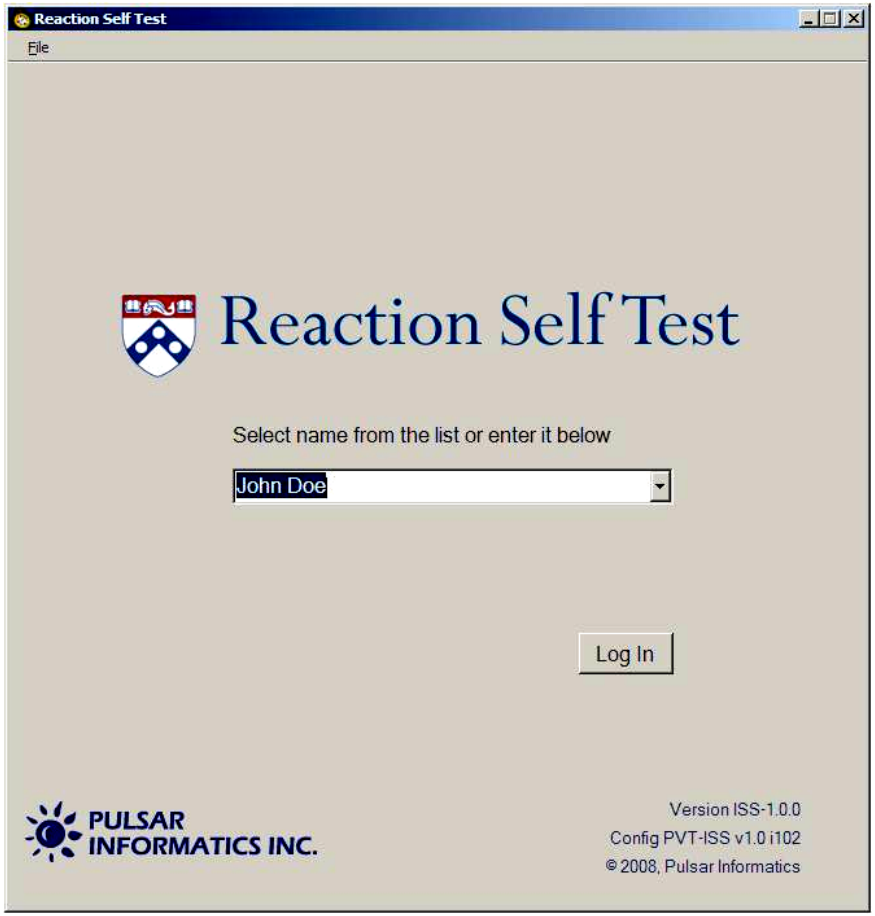
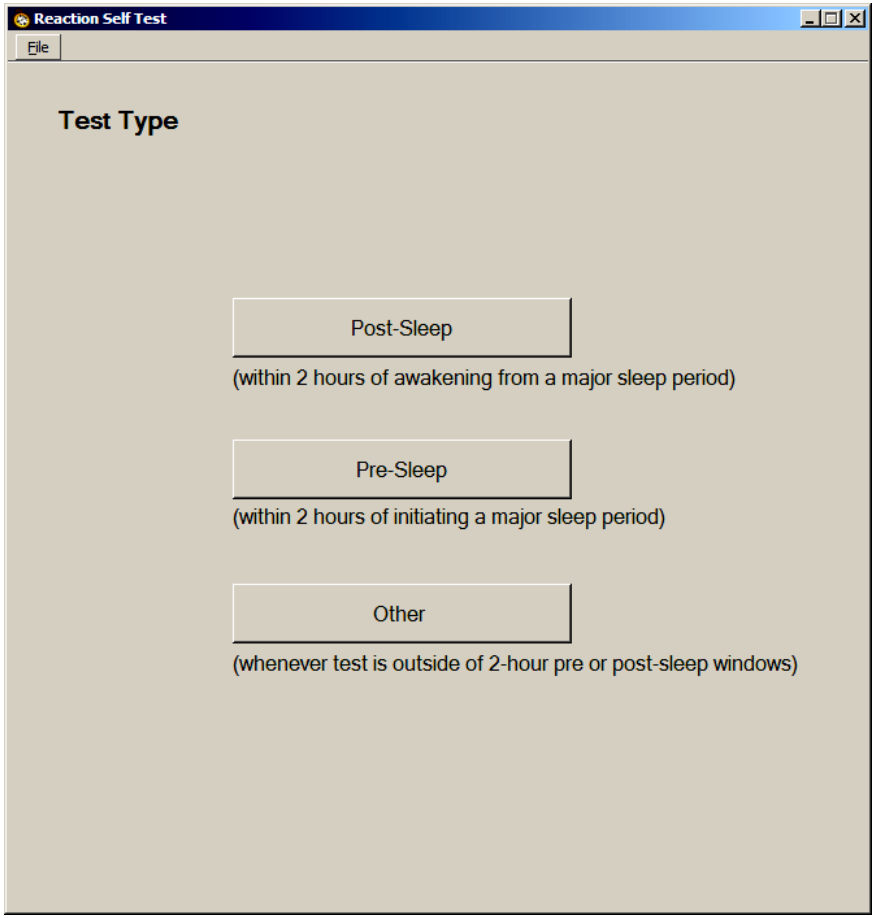
Reaction Self Test Screen Shots





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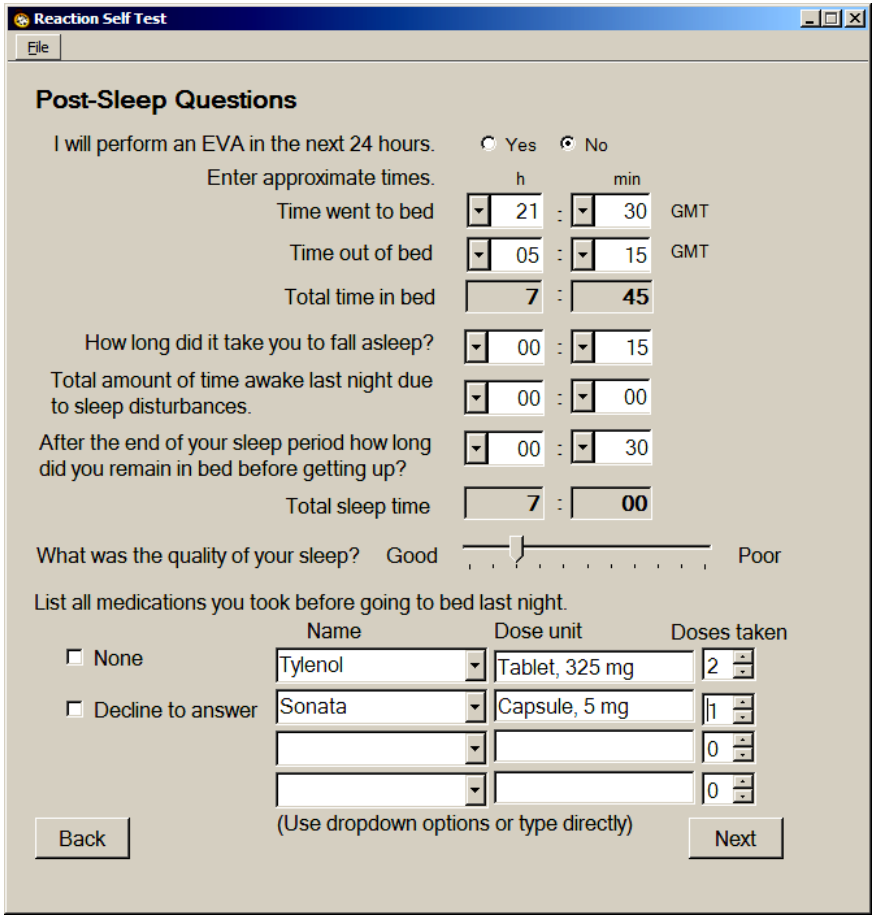

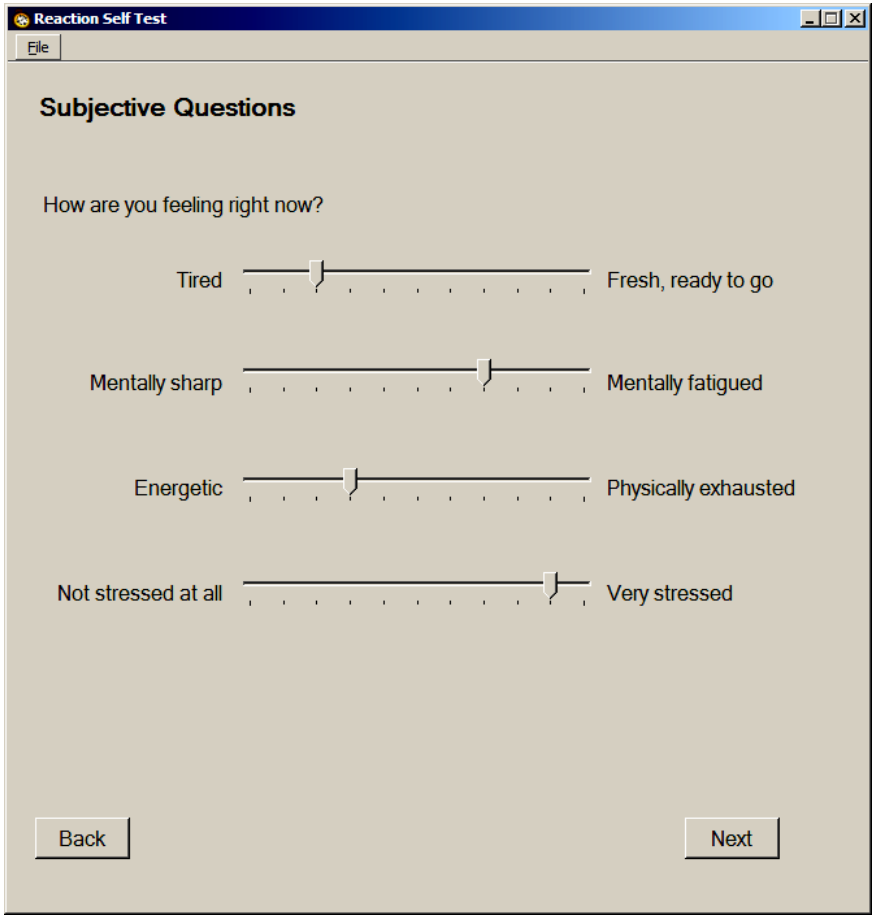

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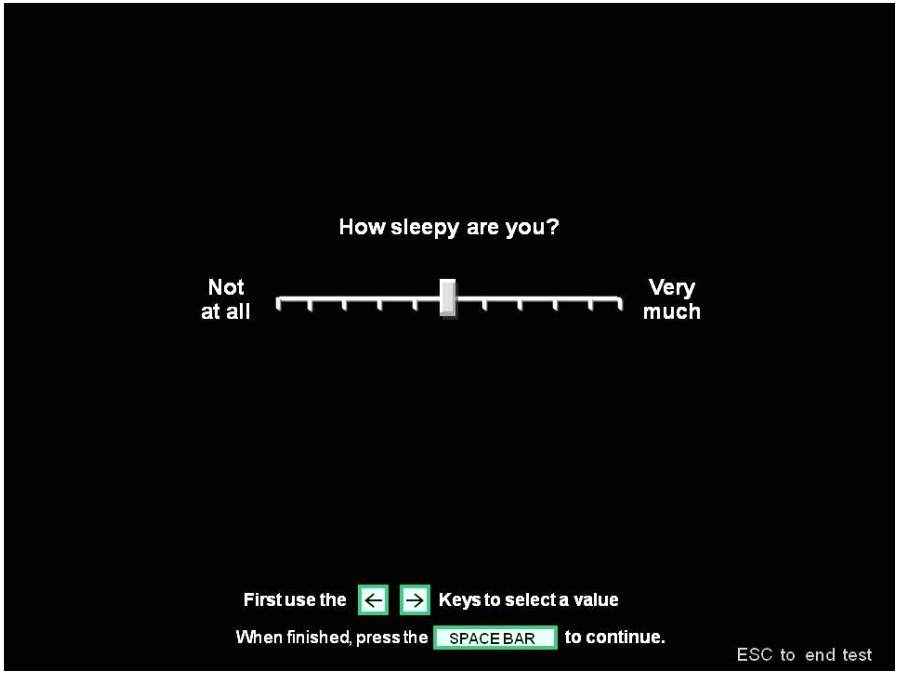

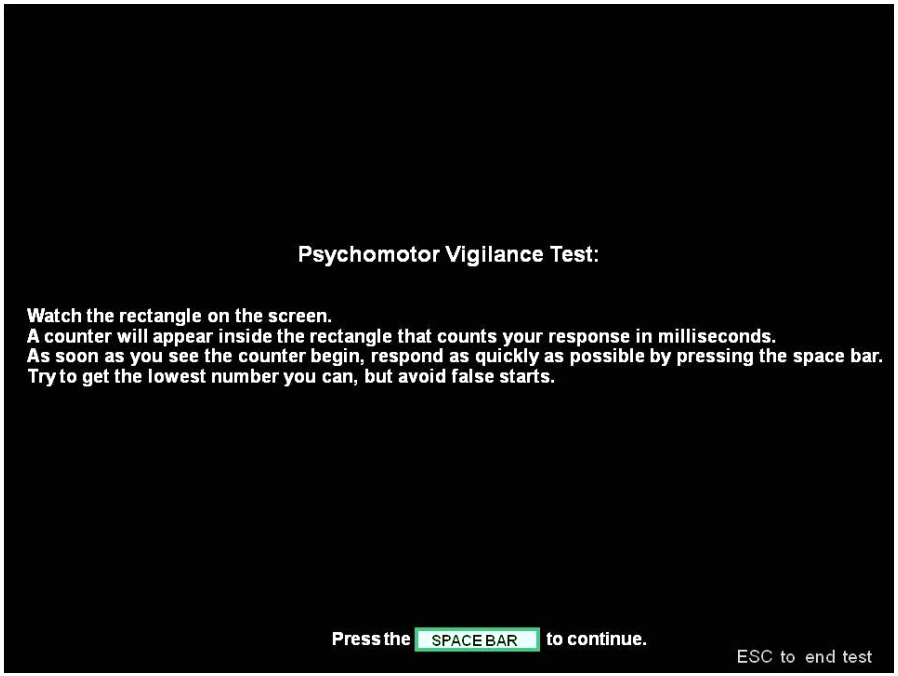

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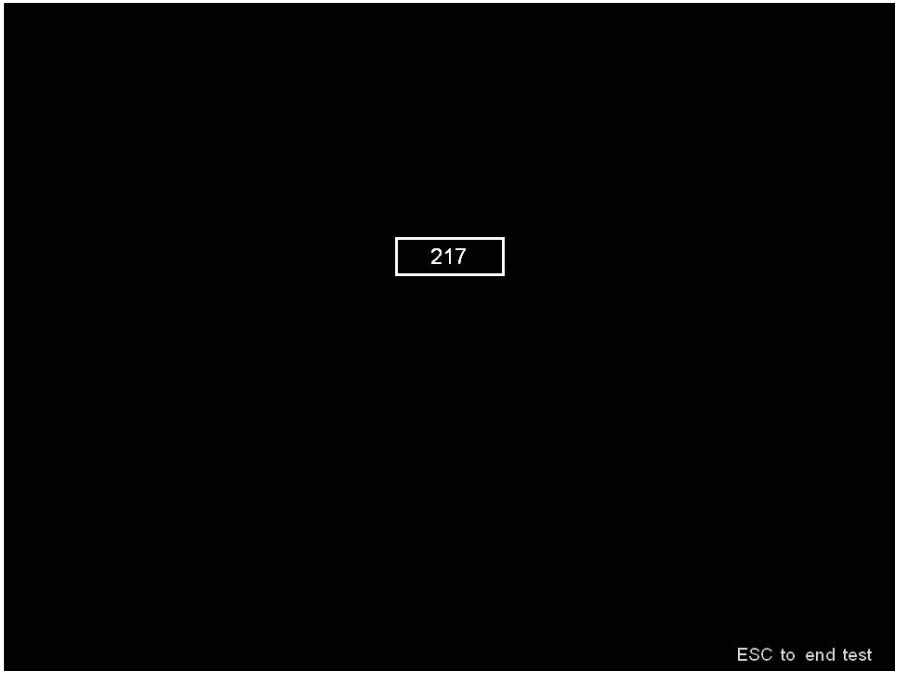

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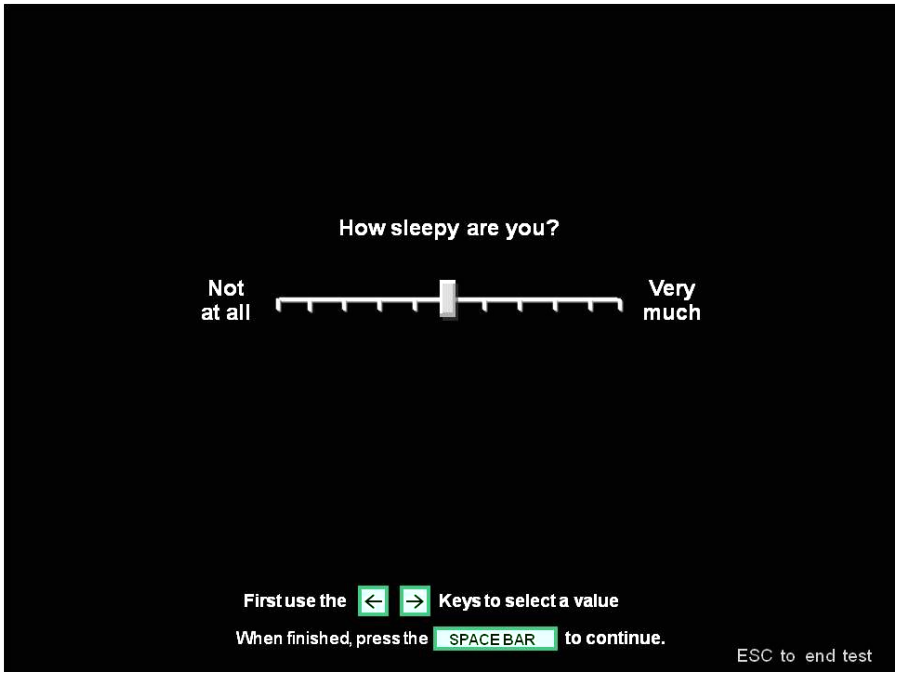

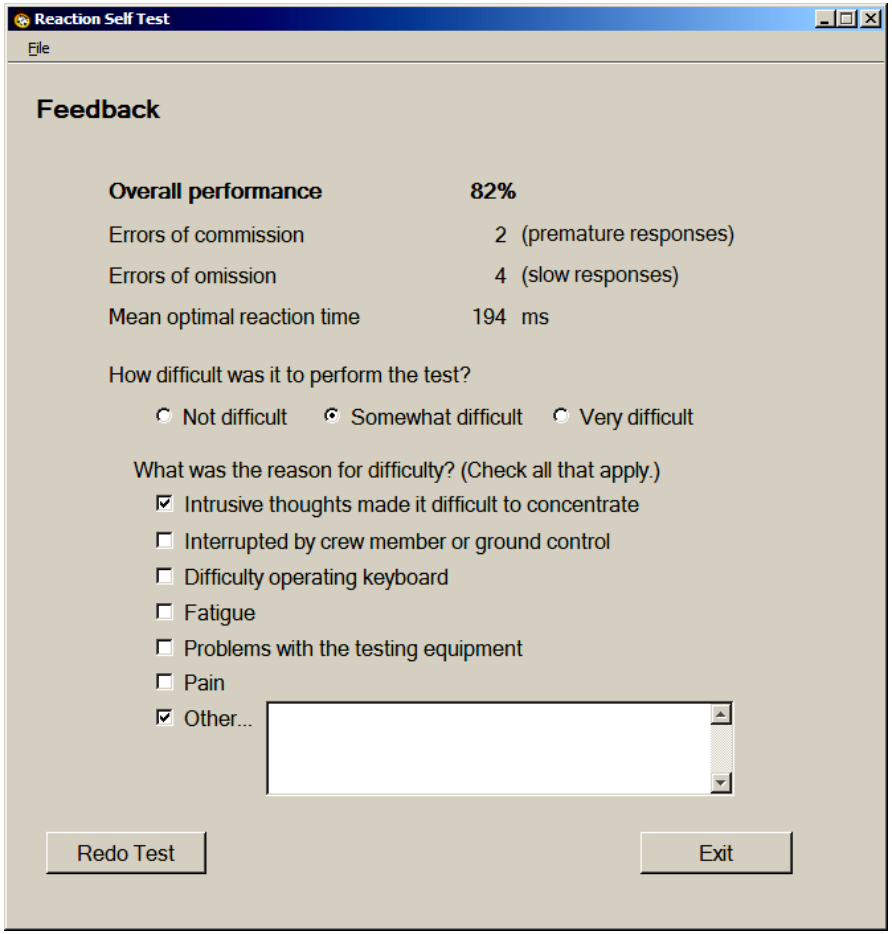

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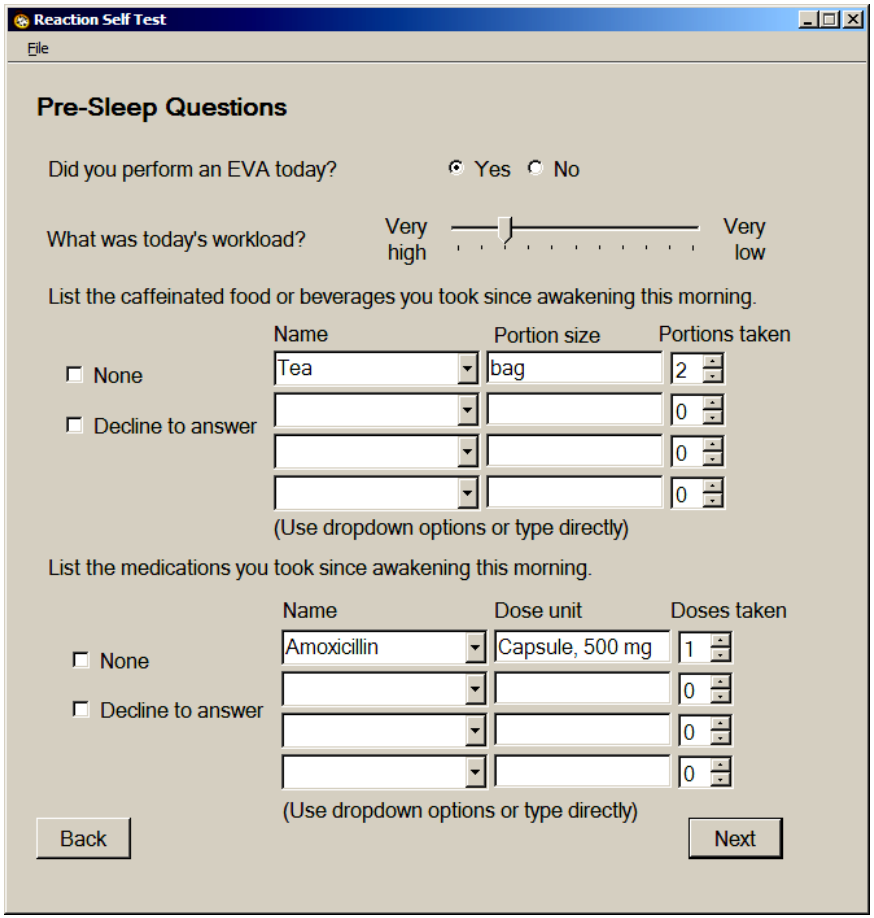

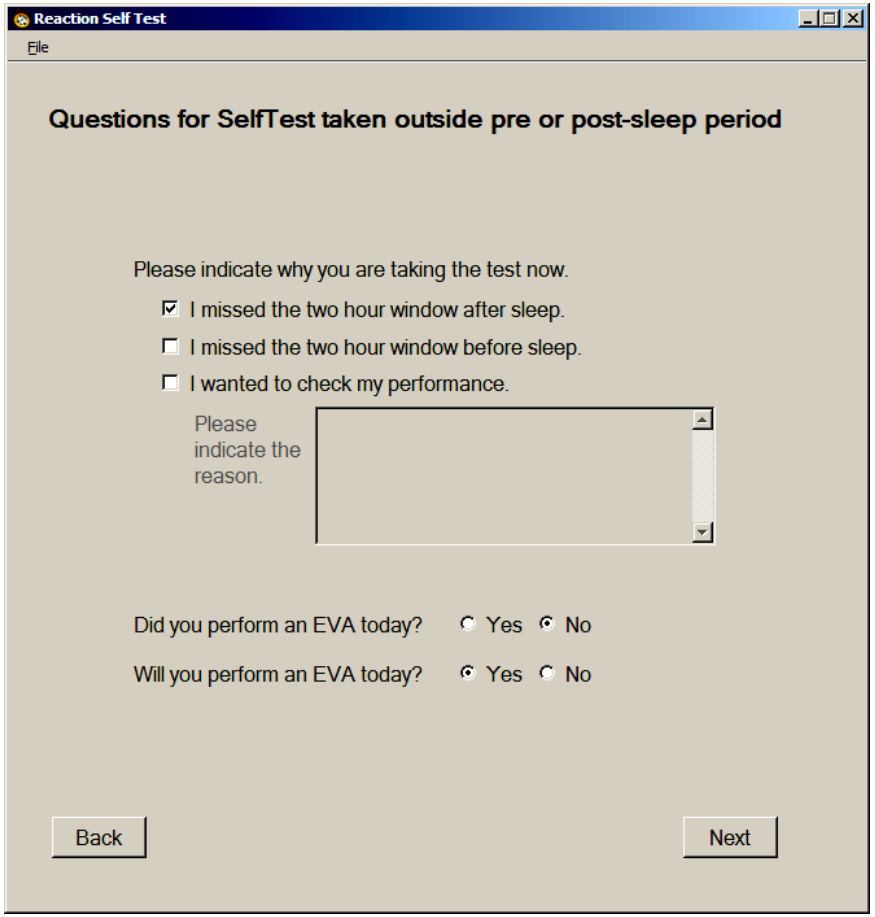

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Measurement Approach

Reaction Self Test Ease of Use

- No training required to learn Reaction Self Test
- No stow/unstow time required to do Reaction Self Test
- No more than 5 minutes required for Reaction Self Test
- Reaction Self test software on all ISS SSC and HRF computers
- If necessary, preflight and postflight Reaction Self Tests can be done on notebook computer at location convenient for astronaut
- Encrypted data will be stored on the hard drive and ISS data server and down-linked once per month

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Experiment Benefits

The experiment must be performed on astronauts on ISS.

It addresses the following high-priority NASA research gaps:

- Identify a brief objective measure of cognitive function in spaceflight
- Find a practical objective aid for astronauts to identify the effects of fatigue

The experiment could provide the following space flight benefits.

1. Tool for astronauts to detect effects of fatigue from sleep/circadian disruptions.
2. Tool for astronauts to detect the effects of fatigue from EVA and high workload.
3. Objective information on effects of time in mission.
4. Possible identification of differential carryover effects of medications for sleep.

Earth-based benefits The experiment could provide the following benefits.

The PVT Self Test has wide application to any group that must operate remotely at high levels of alertness, such as first responders, Homeland Security personnel, flight crews, special military operations, police and firefighters.

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