Multidimensional usability assessment in spaceflight analog missions

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Why study usability in spaceflight?

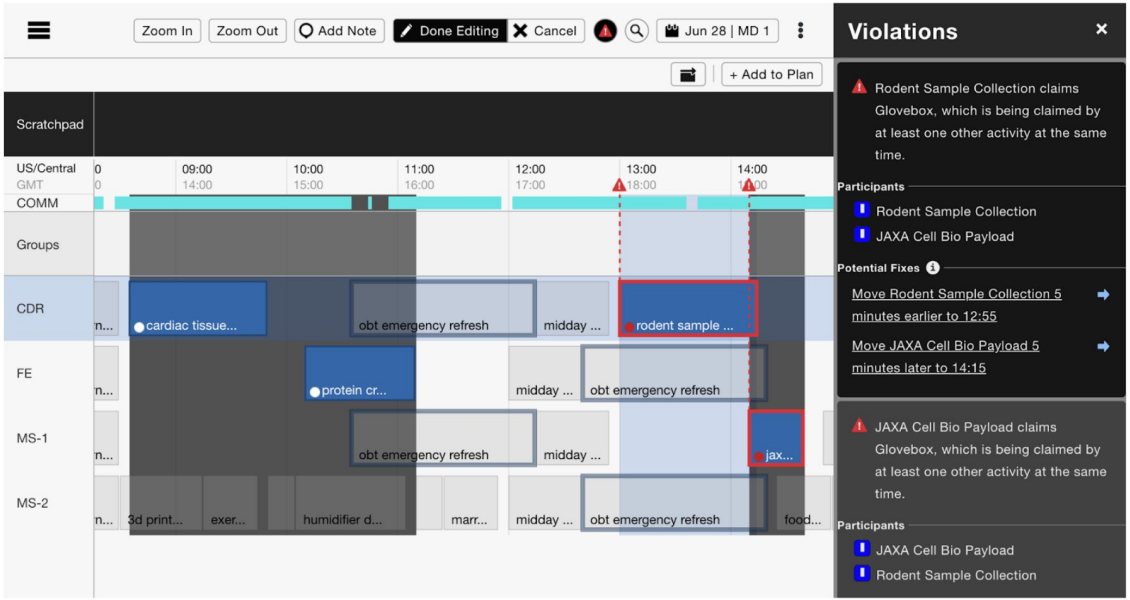
Long-duration missions into deep space require **crew autonomy**

Software tools that support autonomy must be **easy to use** under stress and isolation

Usability can shape crew operations and mission success

Human Exploration Research Analog (HERA), an isolation analog located at NASA Johnson Space Center that simulates future long-duration exploration missions

Playbook: A software tool for self-scheduling



Countermeasures:

"No-Go Zones" and "Suggested Fixes"

Playbook is a calendar-style interface for analog astronauts to schedule and reschedule their timelines (Marquez et al., 2017)

→ used during simulated 45-day missions in HERA

Research objectives

Here, we use a multidimensional survey-based approach to quantify Playbook's usability and compare with vs. without interface countermeasures

AIM 1

Do **unidimensional** and **multidimensional** measures of usability converge in a spaceflight analog?

AIM 2

Do Playbook **interface countermeasures** improve crews' usability perceptions?

Study design

HERA Campaigns 6 & 7

n = 32 astronaut-like crew members across eight missions

In-mission self-scheduling

use Playbook to create operational timelines

two conditions:
with (*n* = 16) vs. without (*n* = 16) countermeasures

Post-mission

System Usability Scale (SUS) — single score

Usability Experience Questionnaire (UEQ) — six subscale scores

Measures

System Usability Scale
(SUS; Brooke, 1996)

10 items
measures overall usability from 0 to 100

recommended by NASA's *Human Integration Design Handbook* (HIDH, 2010)

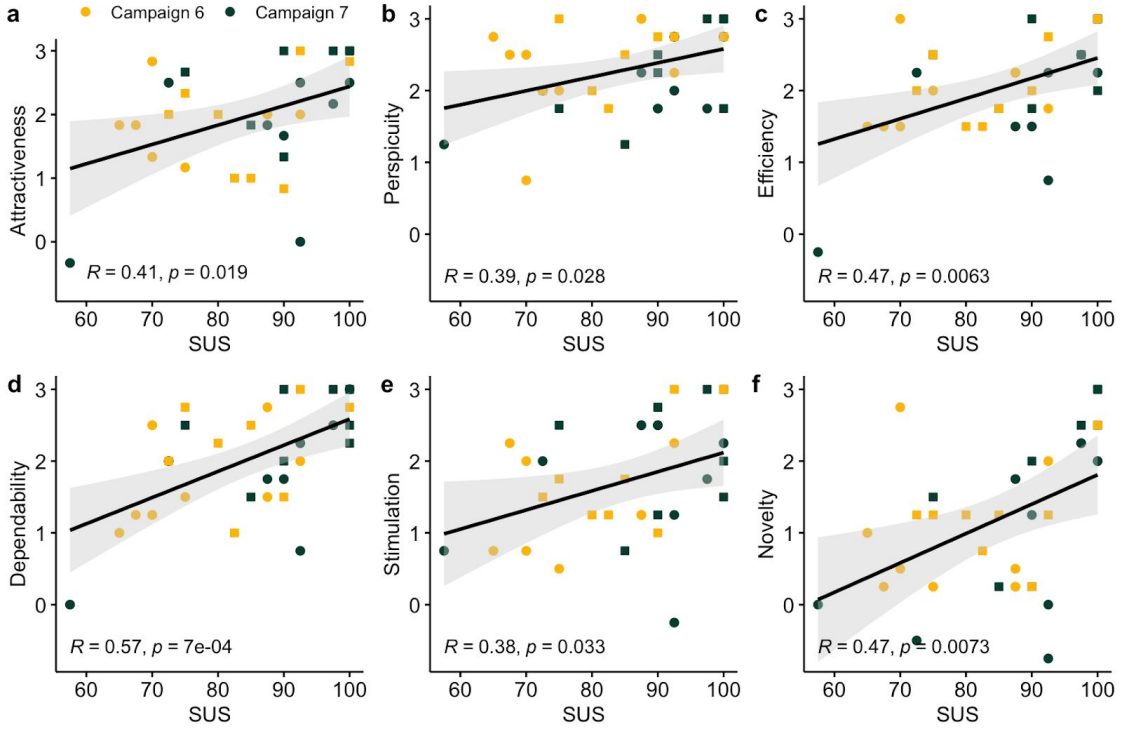
example item: "I found the various functions in this system were well integrated."

User Experience Questionnaire
(UEQ; Laugwitz et al., 2008)

26 items
measures six dimensions of usability from -3 to +3

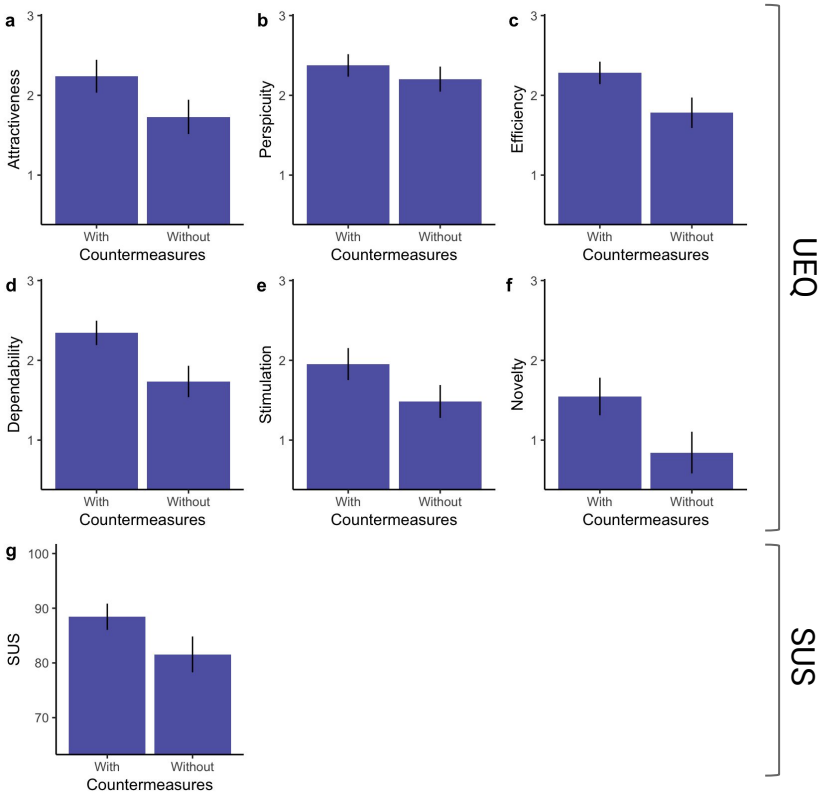
attractiveness (enjoyable)
perspicuity (understandable)
efficiency (practical)
dependability (supportive)
stimulation (interesting)
novelty (inventive)

AIM 1: SUS ⇆ UEQ convergence



SUS and UEQ subscales are consistently **positively correlated**

AIM 2: Countermeasures improve usability



Variable	Mean (standard deviation) With	Without	t	df	p	d
Attractiveness	2.24 (0.82)	1.73 (0.86)	1.71	29.94	0.092	0.61
Perspicuity	2.38 (0.56)	2.20 (0.63)	0.82	29.65	0.405	0.29
Efficiency	2.28 (0.56)	1.78 (0.76)	2.11	27.57	0.033*	0.75
Dependability	2.34 (0.61)	1.73 (0.79)	2.44	28.26	0.018*	0.86
Stimulation	1.95 (0.80)	1.48 (0.82)	1.63	29.98	0.106	0.58
Novelty	1.55 (0.94)	0.84 (1.04)	2.00	29.68	0.059	0.71
SUS	88.44 (9.61)	81.56 (13.10)	1.69	27.52	0.090	0.60

Countermeasures confer the greatest benefit to **efficiency** (d = 0.75, p = .033) and **dependability** (d = 0.86, p = .018)

see also Shelat et al. (2022)

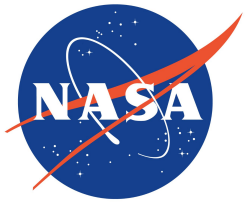
What do these results tell us?

Multidimensional usability tools like the UEQ can offer **richer HCI insights**

Countermeasures **measurably** boost perceptions of efficiency and dependability

Usability metrics are viable in **extreme analog environments**, allowing us to generalize to actual space missions

Thanks for your attention!



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