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The Overview Effect: From cognitive awe to psychophysiological challenge in modern spaceflight

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The Overview Effect refers to a self-reported shift in worldview associated with viewing Earth from space, typically involving awe, perceived planetary unity and fragility, interconnectedness, or planetary responsibility. Self-report is its primary operational measure, while neurophysiological and cognitive measures capture associated processes. As commercial human spaceflight expands and long-duration missions become more common, this phenomenon is no longer only an inspirational narrative. It is increasingly relevant to behavioral health. Recent studies have documented physiological and behavioral changes during spaceflight, suggesting that mission demands can challenge psychological stability. We argue that the Overview Effect is better understood as a psychophysiological event that unfolds within the wider ecology of spaceflight stress. On that basis, we propose a framework that links experience triggering, psychophysiological integration, and mission-stage management. We further propose that differences in training history and mission preparation may shape how individuals integrate such experiences. Given the broader demographic and occupational variation and generally shorter preparation periods of non-professional crews, their integration trajectories may be more heterogeneous. This possibility requires direct event-linked testing. Future research should move beyond showing that Overview-Effect-like experiences can be induced in VR. More important questions concern how these experiences develop over time in real missions and how psychological support can be adapted for increasingly heterogeneous crews.

FOCUS ON THE OVERVIEW EFFECT

Human spaceflight is entering a new stage characterized by data-driven research and increasing diversity in crew composition.[1] The 2024 *Nature* SOMA initiative reflects a transition in space medicine from fragmented observation to systematic monitoring. The Inspiration4 mission also demonstrated the feasibility of whole-mission behavioral monitoring in non-professional crews. These developments point toward a longitudinal view of adaptation in which astronaut health is tracked across pre-flight, in-flight, and post-flight phases.[2,3] The proposed conceptual framework is summarized in Figure 1.

Within this framework, Earth visibility should be separated by mission context. In LEO, Earth remains a large and recurrent visual presence. In lunar missions, visibility depends on orbital phase and surface location and may be intermittent or absent. In Mars-class missions, Earth becomes a distant point and may be visually unavailable during some phases. These conditions provide different opportunities for Overview-Effect triggering and different access to Earth viewing as a possible psychological resource. Nature- and VR-induced awe may share mechanisms with the Overview Effect. However, the Overview Effect involves the specific context of direct Earth viewing during spaceflight, and the extent of overlap remains to be determined through comparative studies.[4,5]

Because the Overview Effect involves awe and shifts in perspective, its relationship with emotion regulation and cognitive processing under mission stress warrants direct study.[4] We therefore frame it as a psychological process that may support resilience but may also require integration and support in some individuals.

EVIDENCE LANDSCAPE

The discussion below distinguishes direct in-orbit findings, indirect evidence from VR studies, and hypotheses requiring event-linked in-orbit testing. These sources cover both in-orbit observations and ground-based VR studies, bringing the integration of findings across different methodological approaches and mission contexts.

Current evidence suggests that the Overview Effect should not be treated as a free-standing psychological benefit detached from mission context. Astronaut accounts suggest that Earth viewing may contribute to well-being and a sense of meaning.[4] However, broader evidence on workload, cognitive change, and behavioral variation does not directly establish that mission stressors alter the Overview Effect. Their proposed interaction therefore remains a hypothesis requiring event-linked in-orbit testing.[3]

Recent commercial-spaceflight evidence helps define the operational conditions under which the Overview Effect may occur. Among 102 commercial spaceflight participants, ages ranged from 18 to 90 years, with greater educational and occupational diversity and generally shorter preparation periods than those of NASA astronauts.[1] During the three-day Inspiration4 mission, four civilian crewmembers reported moderate stress and high workload, showed slower response speed on four cognitive tests, and exhibited substantial interindividual variability.[3] Neither study measured the Overview Effect directly. These findings therefore motivate event-linked investigation of potentially heterogeneous integration trajectories among non-professional crews.

Although ground-based VR studies can induce awe and capture short-term physiological indicators such as electroencephalographic activity, these laboratory effects remain limited in their capacity to explain genuine long-term trajectories of psychological adaptation.[5] Progress in this field would benefit from complementing short-term induction paradigms with higher-ecological-validity research under in-orbit conditions in order to clarify how Overview-Effect-related experiences unfold under complex mission demands.

PARADIGM FROM MOMENTARY EXPERIENCE TO SYSTEMIC MANAGEMENT

To move beyond phenomenological description, we treat the Overview Effect as a process extending across the entire mission cycle. Experience triggering refers to the immediate Earth-viewing-related response, psychophysiological integration to its subsequent emotional, cognitive, and physiological processing, and mission-stage management to assessment and support across the mission cycle. These components may overlap rather than follow a fixed linear sequence.

The first stage is experience triggering. The Overview Effect has been described as a shift in worldview induced by perceived vastness, Earth's fragility, and a radical change in perspective. It may be associated with reduced self-salience and the modification of self-schemata.[4] Psychological preparedness and mission training may shape how individuals interpret the experience, although their effects on Overview Effect integration have not been directly tested.[1,3]

The second stage is psychophysiological integration. Changes in EEG β/γ frequency bands suggest that this experience may involve processes beyond a transient positive emotional state and may be consistent with a broader cognitive reorientation.[5] In the present framework, this is one point at which subsequent trajectories may begin to diverge. Whether integration trajectories differ by training background remains an open empirical question. Current commercial-spaceflight findings provide a basis for examining this possibility through event-linked in-orbit studies.[1,3]

The third stage is mission-stage management. The eventual consequences of the Overview Effect are likely to depend partly on the support available during and after the mission. Positive effects may not be sustained

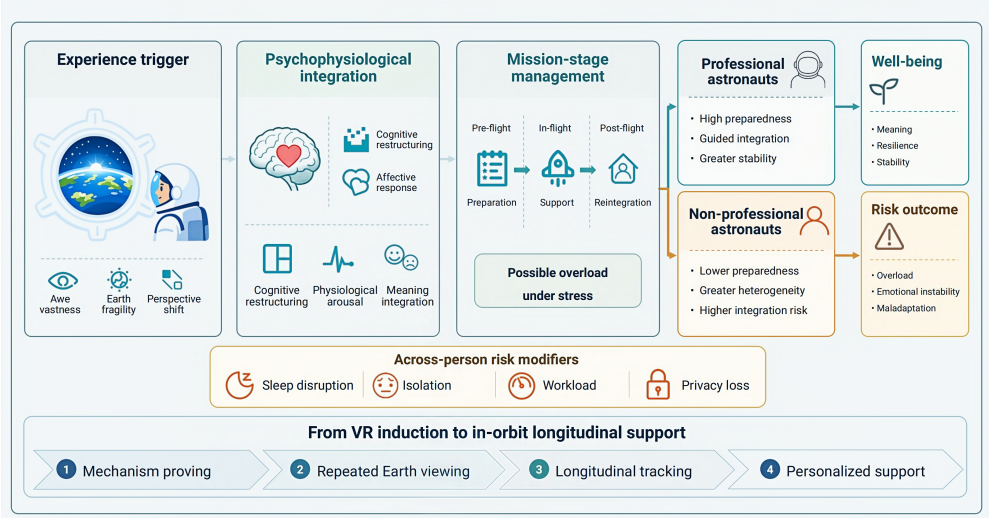

Figure 1. Proposed conceptual framework of the Overview Effect.

through individual coping alone. Support measures such as mission design, privacy protection, and real-time monitoring may help individuals work through the emotional impact of the experience. AI-supported informatics systems may further connect multimodal monitoring data with individual baselines and assist human-reviewed assessment of meaningful changes. For non-professional astronauts, defined as civilian space participants without traditional professional astronaut training pathways,[1,3] such monitoring should be established through independent ethics review and consent procedures that distinguish research from operational use. Repeated exposure is another unresolved issue. For future civilian crews with varied psychological backgrounds and uneven levels of preparedness, repeated Earth viewing may produce habituation and desensitization, or a deepening of meaning. Clarifying this question will matter for the design of deep-space protection strategies.

FUTURE RESEARCH ON THE OVERVIEW EFFECT

We urge that the focus of the next phase of research should move beyond repeated demonstrations that Overview-Effect-like experiences can be induced in VR and examine their long-term trajectories in actual missions. Existing VR studies suggest that immersive Earth viewing can induce awe-like responses and measurable neurophysiological changes, which makes VR useful for early work on possible mechanisms.[5] Still, VR mainly captures immediate responses. It cannot yet tell us how repeated Earth viewing under real in-orbit conditions may affect sleep, workload, emotional regulation, and the construction of meaning. A feasible pathway is an event-linked longitudinal design with pre-flight baselines, brief self-reports around planned or spontaneous Earth-viewing episodes, wearable autonomic measures, sleep logs, short cognitive tasks, and post-flight follow-up. VR and high-fidelity analogs can validate measures and sampling schedules before in-orbit deployment. Standardized event timestamps and interoperable data structures could align psychological, physiological, sleep, cognitive, and mission-context data across mission phases. They could also support longitudinal and cross-mission comparison under privacy-aware access controls. AI-supported informatics systems could then integrate these multimodal time-series data, establish individual baselines, detect meaningful change points, and generate human-reviewed alerts for adaptive assessment and support. As non-professional astronauts become more common in orbit, this question matters for theory as well as for psychological stability, meaning maintenance, and post-mission adjustment under extreme conditions.

BENEFITS AND SUSTAINABILITY

VR studies provide a useful foundation for examining how Earth-viewing experiences affect people.[5] A more pressing question is how increasing numbers of individuals without professional astronaut training may interpret and integrate these experiences under extreme conditions, and what forms of support may facilitate this process. Such research should undergo independent ethics review and use consent procedures that distinguish research from operational monitoring, specify data access and intervention thresholds, minimize identifiable data, and permit withdrawal from non-essential monitoring where feasible. Given the stress, workload, and behavioral variability documented in current missions, future research should prioritize tracking the long-term trajectories of repeated Earth viewing under real in-orbit conditions.[3] That evidence will be needed if psychological support for non-professional astronauts is to rest on firmer empirical ground. More broadly, such work can clarify how intense Earth-viewing experiences are integrated at the individual level and what they may mean for human spaceflight in the era of deep-space expansion.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used ChatGPT (OpenAI) to improve language and readability. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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AUTHOR CONTRIBUTIONS

All authors contributed to the manuscript and approved the final version.

DECLARATION OF INTERESTS

The authors declare no competing interests.