Microgravity Playscapes
Play in Long-Term Space Missions

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The authors examine the potential impact of play on astronauts adapting to the extreme conditions of space travel. They cite research showing that well-trained astronauts, though in general physically fit and emotionally stable, can suffer from—among other things—boredom and sensory deprivation in the confines of the microgravity capsules of space flight. Astronauts on duty, the authors argue, are overscheduled, understimulated, isolated, and—importantly—play deprived. Introducing play into space flight routines, they contend, keeps astronauts saner, boosts their morale, and provides leisure-time pleasure. They discuss the importance of play and its uses in Ackermann's Whole Child Development Guide, which, they argue, is also suitable for adult space travelers. And they provide guidelines for designing a playscape in microgravity that taps the unique, inherently playful qualities of weightlessness itself. **Key words:** Microgravity Playscape Adaptation approach; play and astronauts; playscapes in microgravity; space travel and play

Introduction

Space travel has long captured the human imagination. The very notion of breaking away from the Earth's ultimate constraint of gravity and floating around in weightlessness is inherently playful. Hence the attraction—not just to children but, increasingly, to grown-ups—to embark! Yet, scientists report that living and working for long periods in a confined, isolated microgravity habitat take a toll on those real space travelers, astronauts. In this article, we suggest that play alleviates the boredom, sensory deprivation, confinement, isolation, apathy, and conflict that make up life in a crowded capsule beyond Earth's orbit. Levitating in a man-made station adrift in space epitomizes the displacements and disorientation characteristic of play. No surprise, then, that it enthralls both children and astronauts. But we wish to get beyond the fantasy of

American Journal of Play, volume 8, number 2 © The Strong
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the dreamy voyager, child or adult, to the current research on ways to keep the reality of prolonged habitation in confined microgravity capsules even tolerable, not to mention enjoyable, despite its psychological and physical hazards. Our argument? Although microgravity presents one of the most playful conditions imaginable, space mission planners so far have failed to weave it through the everyday life of disciplined astronauts, leaving them open to the harmful effects of play deprivation. Considering microgravity a playscape offers space travelers options for a more personalized leisure and highlights the value of play as an experience of pure communication and freedom.

Living in Microgravity—Astronauts, Cosmonauts, Heroes, Humans

Since April 12, 1961, 547 people have traveled to space, at least reaching low Earth orbit, and some of them have reached the surface of the moon. From Neil Armstrong and Buzz Aldrin (the first humans to walk on the moon) to Sergei Krikalyov and Gennady Padalka (who spent a world-record eight hundred days in space flight), astronauts report that weightlessness is their single most intense experience. Space program scientists in human research have been examining every feature of the human body, a highly complex living organism that evolved over millennia to survive in a world with light, water, oxygen and, of course, gravity, none of which characterizes space. It is no surprise, then, if everything we ever took for granted regarding human life on Earth had to be "rethought, relearned, and rehearsed" (Roach 2010).

Everyday life in microgravity takes a great toll on the human body. The interior of a space station may be a secure, high-tech environment in which to live, but it is confined and noisy, devoid of fresh air and natural light, lacking any daily or seasonal indication of time passing, and characterized by a perpetual state of free fall. Within this environment, astronauts in long-duration space missions experience the deconditioning of their bodies in five major areas: bone health, muscle function, cardiovascular response, sensorimotor system, and immunology (Kennedy 2009). Their bones become brittle and weak. Their muscles lose mass and grow weak. Their hearts suffer fluid shifts and shrink. Their inner ears do not function as designed and make it hard for them to orient their bodies. And their natural killer cells decrease. So far, mission planners and space-life scientists have managed to tackle the astronauts' physiological adaptation through a series of custom-tailored exercises and training programs, along with personalized medicine, diet, and nutritional supplements. This targeted approach gives astronauts some level of control over the potential deconditioning and guarantees a sense of accomplishment.

At times during a space mission, however, the burden of isolation, the constant threat to life, and the intense workload affect the astronauts' psychosocial conditioning. With their senses deprived by low or monotonous visual, auditory, and tactile input—and given their constant sense of being "on duty" (Suedfeld 1991)—astronauts experience both short-lived and chronic psychophysiological stressors that create numerous behavioral and health issues. The most commonly mentioned stress-related conditions include depression, emotional strain, anxiety, discomfort, boredom, social monotony, isolation, forced socialization, relational stereotyping, homesickness and nostalgia, irritability and aggression, suppressed sexual drives, cognitive impairments (such as lack of concentration and loss of memory), loss of motivation, lowered attentiveness, decreased performance, sleep disorders, and excessive worries about health (Levine 1991; Mohanty, Jørgensen, and Nyström 2006; Pierce 1991; Schlacht 2012). In addition, research by Kanas and colleagues (2009) shows that the strain on group cohesion aboard a spacecraft leads to serious problems such as: "1) decreased crew morale and compatibility, 2) withdrawal or territorial behavior as crew members cease to interact with each other, 3) the scapegoating of an individual as a solution to group conflict, and 4) the formation of subgroups that destroy crew unity" (32).

In recent years, growing evidence suggests that the demanding conditions of a space mission need to be mitigated at both the individual and the team level and that more leisure time should be programmed to lessen the burden of confined living. Abeln and Schneider (2012) advocate as much free time as possible in the astronauts' daily routine with a balanced schedule of activity and inactivity. This, in turn, leads to a quest for more enriching recreational activities during leisure time. Artist Kirsten Johannsen (n.d.) explored the concept of Creative Activities in Space (CAiS) and came up with a unique book of principles and design parameters for art works in long-term expeditions. Along the same lines, Schlacht and her colleagues (2012) suggested the introduction of "creative performances," mainly through reenactments (as in pretend play) and visual art, as a means to improve daily life in space. Interestingly, though, in a series of interviews with astronauts, Schlacht also reported that "if persons with different (non-artistic) backgrounds are obligated to perform artistic expression and cultural activities, they may have a negative impression or get stressed" (6).

Levine (1991), however, interestingly points out that "the elimination of all stress is neither possible nor desirable" in a space mission (309). Instead, the goal should be to humanize the interior environment of a spacecraft and make astronauts feel comfortable—physically, mentally, and socially—inside their confined habitat.

Applying human-centered disciplines—industrial design, architecture, and psychology—to the space flight improved habitability in microgravity by introducing spatial amenities and environmental stimulants. Industrial designer Raymond Loewy served as NASA's first habitability consultant in 1967 to "help assure the psycho-physiology, safety, and comfort of the astronauts" through design (Mohanty, Jørgensen and Nyström 2006, 2). Clearwater and Coss (1991) shed new light on the issue of "functional aesthetics," that is the "blending of science, engineering, and art toward ensuring environments that will be both functionally and aesthetically supportive of human well-being and productivity [through] the development of interior decor elements (color, lighting, graphics and surface materials) that affect perceived habitability" (331–32). Oungrinis and his colleagues (2014) developed the design of a "sen-sponsive habitable interior" for the creation of a human-centered, transformable, intelligent environment that "responds with sense" to the astronauts' activity, aiming at their spatial and psychological comfort (243). The authors' Intelligent Spacecraft Module (ISM) project involves the design of a spatial context-aware system that imbues the interior environment of the astronauts' personal quarters with "smarts" and playful qualities programmed to create a sentient and humanizing augmented reality for the astronauts to enjoy. Häuplik-Meusburger (2012), on the other hand, proposes a different type of augmented-value environment by introducing plants, the "green friends of man," and greenhouses in extraterrestrial habitats as a means of humanizing space travel.

Currently art is still perceived of as a hobby, leaving open the question whether it can mitigate the stresses associated with a space mission, and architectural features and amenities only partly humanize the interior of a habitable spacecraft. Most astronauts can, by character or by training, overcome the resulting stresses and accomplish mission goals. It seems to us, though, that hard-core science has neglected the most obvious countermeasure to stress—with equally important physical and psychological health benefits and a unique ability to humanize any harsh environment—play. In our view, many of the unwanted tensions among crew members could be lessened through play activities specially

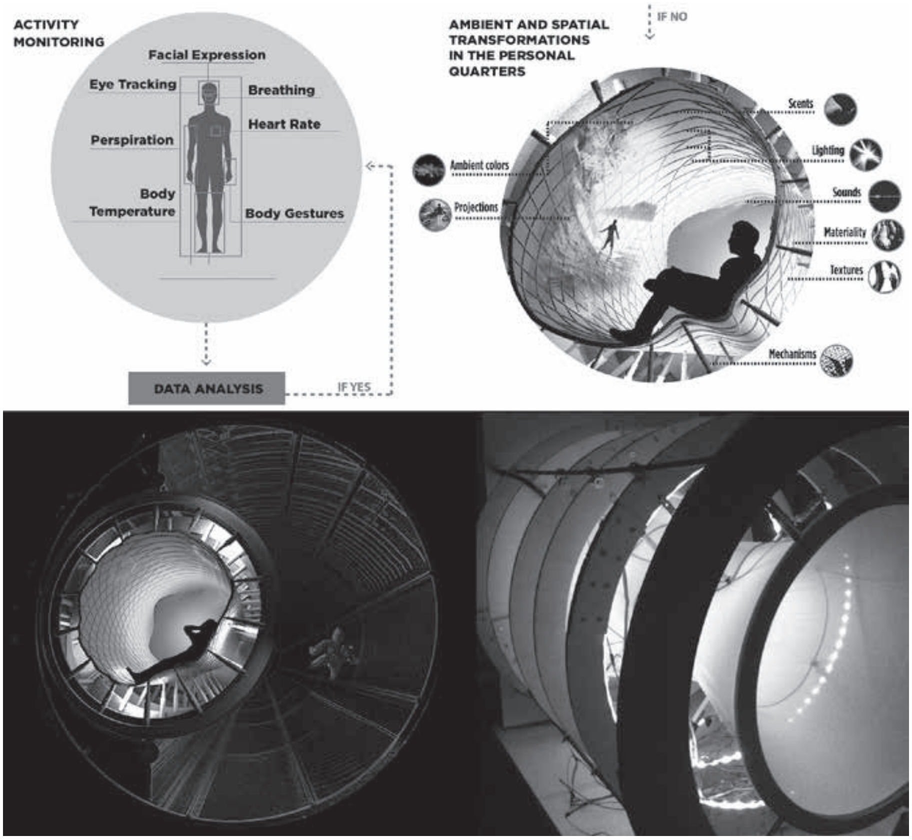

Figure 1. Diagrammatic representations (top), visualization (bottom left), and a photograph of the interactive scaled study model (bottom right) of the proposed living compartment, 2014. Courtesy of Transformable Intelligent Environments Laboratory, Technical University of Crete.

designed to uplift astronauts' spirits and restore their "general satisfaction with spaceflight conditions" (Kanas et al. 2009, 32). Indeed, we might uplift astronauts' mood and humanize their unusual habitat by tapping its own inherently playful nature. In other words, the very quirkiness of living in microgravity can itself be transformed into an artform.

Play is often portrayed as a child's most serious work—and for good reasons. Without the joyful suspension of disbelief characteristic of play, there is little room for imagination. And without imagination, the constraints of the here and now can be overwhelming. Alas, the more pressure individuals experience, the more important it is for them to play. Through an interdisciplinary lens, we seek to humanize the alien environment of a spacecraft by focusing on the regulatory function of play as a key dimension in the promotion of astronaut health and well-being. Play can enable adult space travelers (AST) to draw their "creative footprint" (Williams 2013, 93) and derive a personal ideal version of their microgravity habitat where they can envision new possibilities and reasons to deal creatively with their isolation and to expand their sense of being there.

Could This Be a Child in the Spacesuit?

Adults often consign play to childhood and, thereby, overlook its contribution to their own, adult well-being. In fact, we can learn much by considering what children and astronauts—usually thought of as coming from disconnected worlds—have in common. From a developmental psychologist's perspective, they enjoy surprising similarities. For example, they both set out to discover and adapt to the spatial and environmental dimensions of a new world. They are both eager, fresh, and stubborn in their necessary search for advancement. And, as they venture into unknown territory, both have to learn to secure their "grounds" (i.e. remain securely attached) and to keep their bearings (i.e. know where they are headed) in a world by definition too vast to grasp and too unpredictable to take for granted. The child's journey involves development as a well-adapted earthling; the astronaut's adaptation addresses highly extraneous life conditions in microgravity.

We do not wish to make comparisons between toddlers and astronauts ad absurdum, but we think it fair to say that astronauts on their first journey into space, like toddlers venturing into uncharted ground, have little knowledge or experience of what to expect. Anecdotal information from the NASA Human Research Program indicates that when every new crew arrives at the International Space Station, the crew living there has to "childproof" the interior to help the newcomers avoid accidents until they have adapted to the floating environment of microgravity. The new crew members are invariably curious, playful, and ready to take on challenges, including learning how to use their bodies in space.

Both astronauts and children depend on trustworthy allies as well as reliable holding structures or safety nets—mission control center and experienced peers for astronauts and protective homes and caring parents for children. These provide our "travelers" with directions and routines while giving a sense of security and support. The similarities can also be more detailed, as in the specific science and continuous research that investigates the nutrition and hygiene of both groups. Finally, both child and astronaut are seen as symbols of an optimistic future unobstructed by social and cultural conventions.

Aside from the obvious differences between the two groups, one characteristic encompasses them all, and that is what Harvard psychologist Ellen Langer (1989) refers to as mindfulness (present in the moment) versus mindlessness (on autopilot). When mindful, Langer posits, we actively draw novel distinctions, rather than rely on distinctions we have drawn in the past, which, in turn, makes us sensitive to context and perspective. We become observant of how situations change. When mindless, our behavior is governed by rule and routine. In essence, our understanding freezes, and we apply only well-known categories and become oblivious to subtle changes that might have lead us to act differently had we paid attention.

Driven mainly by necessity, children are experts at exploring and inventing. To better place themselves in a grown-up world, they immerse themselves fully, yet pleasurably in every activity, provided they are in a state of mind psychologist Mihaly Csíkszentmihályi (1997) describes as *flow*. This mindfulness helps them look at things afresh, as if for the first time, with a desire to move off the beaten path. Astronauts, on the other hand, are often left mindless because they submit to an extremely regimented lifestyle in a confined and overcrowded spaceship that leaves little room for spontaneity, creativity, diversion, or play. This leads to the ultimate paradox: the hard training and professional discipline that enables astronauts to work in free fall tends to put them on autopilot and actually inhibits spontaneous responses. Such control does not help our free-floating space heroes cope with confinement, isolation, boredom, and psychological stress during their mission. Hence, we call on designers and mission planners to make more room for open play.

How do children sustain their blissful mindfulness? How do they break free from the orderliness of the adult world? And, more important, what can be done to help astronauts stay true to such a beginner's mindset of their own? The answer lies in the concept of play.

Play as a Countermeasure in Long-Duration Human Space Flight

Although we commonly associate play with entertainment, gaming, or simply goofing around, the current research about play emphasizes it as a vital psycho-physiological regulator, both in animals and humans. According to biologist Marc Bekoff (2011) rough-and-tumble play is "training for the unexpected," a regulatory mechanism that enables animals to rehearse for "real life" occurrences, such as attack and loss of balance. In humans, the addition of pretense or fantasy play, and of humor, holds the potential for provoking intense feelings on safe grounds, thus inducing physical and mental well-being.

Dutch cultural historian Johan Huizinga (1949) defined play as "a free activity standing quite consciously outside 'ordinary' life as being 'not serious,' but at the same time absorbing the player intensely and utterly. It is an activity connected with no material interest, and no profit can be gained by it. It proceeds within its own proper boundaries of time and space according to fixed rules and in an orderly manner" (13). And French philosopher Roger Caillois (2001) pinpoints the six characteristics of play that make it an essential element of human social and spiritual development. According to Caillois, play is free, separate, uncertain, unproductive, governed by rules, and make-believe. Most important in the context of this article, Caillois defines play as *illinx*, or disorientation.

Anyone can play. For children, play forms the foundation of every stage of their development, as Jean Piaget (1973) suggests. Play is equally important for adults because it helps the brain "make sense of itself through simulation and testing. . . . For adults, creating such simulations of life may be play's most valuable benefit" (Brown 2009, 34). But many adults mistaken play for childish behavior. Instead, play, being playful, serves us no matter our age. Adults usually play when they want to change their routine and break free of everyday constraints. Play also helps people move in and out of Huizinga's "magic circle," and thus experience what Aldo van Eyck considers one of play's most treasured qualities, that of *space* becoming a *place* and *time* changing to an *occasion* (Willoughby 2001). Any process that facilitates this mental shift opens up new ways of looking at things, gives us a sense of how things might be beyond what they are, leads to a deeper connection to and understanding of the reality in which we live, and offers us a more positive disposition and attitude.

Stuart Brown (2009), founder of the National Institute for Play in the United States, distinguishes eight play types, or personalities, which vary according to individuals' "preferred avenue into the alternative universe of play." He identifies the joker, the kinesthete, the explorer, the competitor, the director, the collector, the artist/creator and the storyteller. Brown's personae have been used to train adults to use fantasy (the art of possibilizing), as a means to deal with uncertainties. As Connors, Harrison, and Akins (1985) write: "The unexpected undoubtedly plays a very large role in what we see as the fullness of experience and needs further exploration as to how it can be utilized as a positive force in space flight" (79).

Playful Moments through the Eyes of the Astronauts

Early space missions were completely work oriented, leaving the astronauts little time for personal recreation. However, as missions grew longer, more time opened up in the daily schedule, raising the question of what off-duty activities, besides exercise, might be introduced to ameliorate the stresses of confinement. In her book *Architecture for Astronauts*, Sandra Häuplik-Meusburger (2011) presents an activity-based approach to extraterrestrial habitats in low Earth orbit and groups leisure activities in six categories: physical exercise (with treadmills, ergometers, and muscle-resistive devices); recreation activities (mainly with passive audiovisual media); viewing windows (a high-value activity); physical play with the body in free fall; exploring the three-dimensional floor area by rearranging objects; and intimate behavior (a taboo topic about which no official information was ever released).

In long missions, astronauts "have shown a clear preference for what might be described as passive or noninteractive recreation, i.e., movies, television, books, music, looking out of the windows, etc." (Connors, Harrison, and Akins 1985, 76–80). However, many of them tried to deal with the psychosocial stresses of confinement by devising impromptu games with objects from their surroundings or by creatively exploring the effects of weightlessness with their bodies. In their recollections (Häuplik-Meusburger 2011), they associate play with positive psychology (e.g., calmness, relaxation, dreaming) and stimulation (e.g., thinking, inventiveness). As early as the Apollo 15 and Apollo 17 missions in the 1970s, astronauts commented on their playful explorations of microgravity—for example, running in place and spinning objects. Astronaut Dumitru-Dorin Prunariu from Salyut 6, in his interview with Häuplik-Meusburger, put it well when he said: "We had a vacuum cleaner with back exhaust air, sold in Eastern European stores under the name 'Raketa,' that looked like a rocket . . . fed by a long cable from the station's electrical network, and sometimes . . . you just took the vacuum cleaner between the legs, turned it on and then you flew like a rocket inside the station." Many astronauts compare the movement of their bodies inside the station to swimming. "We swim in this huge aerial aquarium of a station like space amphibians" (267). Others take advantage of the weightlessness to practice gymnastics, somersaults, acrobatics, and dance moves. Some even played with their food, just like children. These efforts to learn about self-movement in a microgravity environment resulted in a most pleasurable, exploratory activity that we can only regard as play (Brown 2009).

The first mission to carry and test actual toys in space was STS-51D in 1985 with the space shuttle *Discovery*. The mission involved, among other experiments, the informal study of simple toys to demonstrate the physics of a zero-g environment to children at the Houston Museum of Natural Science. The mission crew tested a spinning top, gyroscopes, a spring-wound flipping mouse, a paddleball, a ball and jacks, a Slinky, a yo-yo, a Whee-lo, magnetic marbles, and a wind-up toy. Three missions aboard the International Space Station (ISS)—STS-54 in 1993, STS-77 in 1996, and Expedition 5 in 2002—followed with similar objectives for a school-based science lesson called "The International Toys in Space: Science on the Station," where astronauts enjoyed best playing with toys that did not behave as expected in the microgravity environment.

Beyond toys and playful experiments, the ISS was also the first habitable spacecraft to welcome the Internet. Astronauts appeared in videos posted to YouTube performing common everyday activities like eating, exercising, washing their hair, brushing their teeth, working, and playing. These videos often go "viral" on the web, which puts the astronauts on stage (and back stage as well), to present their world of microgravity creatively in scenarios similar to those seen on the TV series *MythBusters*. NASA astronaut Don Pettit, for example, explored how microgravity affects an object's trajectory by catapulting a Red Bird (from the *Angry Birds* electronic game) in a video called "Angry Birds & Pigs Go Weightless inside the ISS" (YouTube 2012). A year later, astronaut Sunita Williams offered earthlings an online tour of the station's interior. One of her videos highlighted the visit to the ISS cupola, which she described as the best place to hang out "because all you want to do is to look back at our planet" (YouTube 2012). The cupola inspired her to develop a game of her own in which she challenges fellow astronauts to guess from the cloud formations and land shapes the continent the ISS is passing over.

The astronauts' inventiveness, though, can not be expressed, or shared, if their living quarters do not support such initiatives. Aboard the ISS, for example, a clear demand exists for better "tools against boredom" and "use of empty 'not occupied' space" (Häuplik-Meusburger 2011, 277). In the current approach toward organized leisure time, astronauts remain limited either to prescribed devices and location-blind play kits or to their own impromptu play explorations. Mission planners have not factored in play, let alone credited the potential of microgravity itself as a unique play-friendly environment for astronauts to explore. Recognizing this gap, we suggest additional play options for a microgravity habitat and offer a list of play types to help astronauts occupy their daily time and space in microgravity creatively.

The Astronauts' Playscape

To counteract the deleterious physical, social, and psychological effects of long space flights, mission planners could allow astronauts to play out the disorienting qualities of microgravity itself. As part of our playscape investigation and based on the similarities between the development of a child and the astronauts' adaptation to the confined interiors of a spacecraft, we structured the Microgravity Playscape Adaptation (MPA) approach, which owes a conceptual debt to the Whole Child Development (WCD) Guide.

In what follows, we align widely recognized play types to four areas of an individual's development and stress their relevance to astronauts' adaptation to microgravity habitats.

Area of Personal Development

Mission planners can deploy play of several kinds and tailor them to astronauts' preferences. In this case, the focus stays on play types intended to help astronauts build a positive and accurate body image and self-concept to form a reliable frame of reference—themselves as agents in space—especially needed in a confined, isolated, extreme environment. The novel reality of living in outer space affords opportunities for the astronauts to experiment using their bodies, generate novel responses that will help them learn about themselves in space, and fine tune their motor skills. The MPA approach in this category focuses on functional play. It basically involves repetitive actions of the body, the manipulation of objects, and the enjoyable use of language. Mind and body work together

Figure 2. Astronaut candidates selected in 1996 take a minute for fun during microgravity training in the KC-135 aircraft. Courtesy of NASA.

to help astronauts stay centered and anchored in the confines of the spacecraft. This kind of play takes two directions. The first motivates astronauts to use their bodies in physical play, sports, and crafts. The second targets self-understanding through sensory play, role play, and gaming. Intentionally or not, these play types provide astronauts with sensory feedback to expand their knowledge about the physical properties of objects and about concepts such as cause and effect in

Figure 3. Skylab 4 Commander General Carr demonstrates microgravity by balancing Pilot William Pogue on one finger (1974). Courtesy of NASA.

microgravity. Body and self-awareness provide an internal compass that astronauts need to navigate in relation to the interior of the spacecraft and to others and to gain mastery in their unusual adaptive task as free-floating agents.

Area of Social Development

To counter the morale-sapping isolation and routine of life in space, mission designers should take advantage of the enclosed microgravity capsule to encourage team play. Hence, the main focus onboard of social development should provide astronauts with diverse opportunities to relate to and empathize with the feelings and thoughts of their fellow crew members and to make themselves available to others, all while preserving their own needs for privacy. Social (or group) play offers an interactive, open-ended process that brings the astronauts together in both routine and unscheduled yet engaging scenarios. This type of play, also, takes two directions to help in team building. One stimulates astro-

Figure 4. Astronauts Gorie and Mohri share a "flying" snack (2000). Courtesy of NASA and JAXA.

nauts to relate to their peers through role play, playful conversation, and co-dependancy games. The second supports the encoding and decoding of social and emotional cues through narrative play, onlooker play, and give-and-take interactions. Nurturing relations provides the mental flexibility needed to feel (psychologically) securely attached and able to cohabitate by graciously negotiating conflicting perspectives. Moreover, these play types provide training procedures for astronauts with the make-believe components necessary to enhance their reality orientation and representation skills.

Area of Cognitive Development

Mission planners are also responsible for providing astronauts with the brainpower they need to anticipate change and surprise. Constructive play offers

Figure 5. ISS Expedition 35 Commander Chris Hadfield explores the behavior of liquids in space by squeezing a wet cloth. Rather than dripping downward, the water wraps around Hadfield's hand like a glove made of gel (2013). Courtesy of Canadian Space Agency and NASA.

play types that advance rational thinking by involving hands-on inquiries to manipulate and explore known objects that behave differently in space. Here, again, the play takes two directions. The first fosters experimenting, tinkering, and understanding through exploratory and functional play. The second encourages astronauts to seek logic and coherence through rule-based play, make-it-work play, solve-it play, and puzzles. In exploring the microgravity world through playful yet sustained and rigorous inquiry, astronauts come to redirect their thoughts and actions and to understand the logic of how things work and cohere despite changes in gravitational forces.

Area of Creative Development

Many renowned scientists, including Albert Einstein, valued imagination over knowledge as the necessary ingredient for learning and innovation. Imagination, more than knowledge, envisions "what is not" instead of analyzing "what is there." In creative development, fantasy play triggers imagination. Here, our proposed play types target this act of envisioning through pretense and conversational play, on the one hand and helping realize it through dramatic and construction play on the other. Astronauts' playful imaginations and creative sparks generate novel ideas through lateral or divergent thinking: an oblique approach, or way of seeing, that questions established truths and seeks alterna-

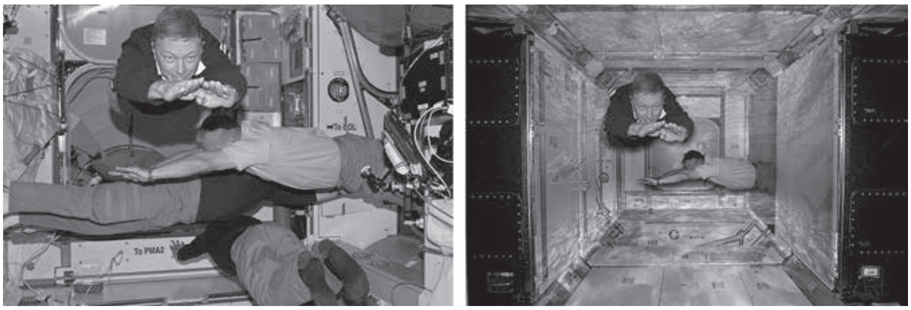

Figure 6. Left: Four members of the joint STS-135/Expedition 28 crews perform floating exercises (2011). Courtesy of NASA. Right: 3-D visualization of a simulation in the spacecraft's interior that creates the illusion of swimming in the ocean (2013). Courtesy of Transformable Intelligent Environments Laboratory, Technical University of Crete.

tive routes through an unpredictable environment. Furthermore, astronauts are able to work on "mediated symbol systems," like their symbolism-rich mission patch, that defines and strengthens them as a group (Pellegrini 2009, 183).

Axes of Astronaut Play

Based on French play theorist Roger Caillois's notion of "continuum between opposites" (2001, 13), we suggest that the design of a diversified play palette for astronauts involve points along the following axes.

Organized versus Spontaneous

Organized play describes playful activities that take place during scheduled leisure hours in the astronauts' daily program. Spontaneous play refers to playful activities that may occur at any place and any time in carefree moments of improvisation. Moreover, spontaneous play in microgravity makes the astronauts feel exuberant, but it does not—and, actually, should not—interfere with the smooth execution of mission tasks.

Passive versus Active

Passively, space stimulates intrinsic needs. Weightlessness sets the interior of a spacecraft in a default playful mode that invites the astronauts to take a break from whatever they are doing and play along. On the other hand, an astronaut engages in active play when he or she initiates playful activities.

Proximal (Close) versus Removed (Distant)

Spatial projections of the body and mind can be parsed into three zones, or concentric circles, depending on the level of immersion and closeness to the individual (Oungrinis et al. 2014). The first, and closest, circle is the personal-immediate "space of the body" (B zone). The second circle is the peri-personal "space around the body" (Env. I zone). And the third zone refers to the extended overall "space of navigation" that can be viewed from afar and reached physically with some effort (Env. II zone). Each zone affects the astronauts' senses differently and creates its own occasions for attunement during play (mostly through zoning in and out and scaling up and down) without interfering with the rules of conduct and permission relevant to other activities, especially those identified as work. In other words, the astronauts need to know that the same

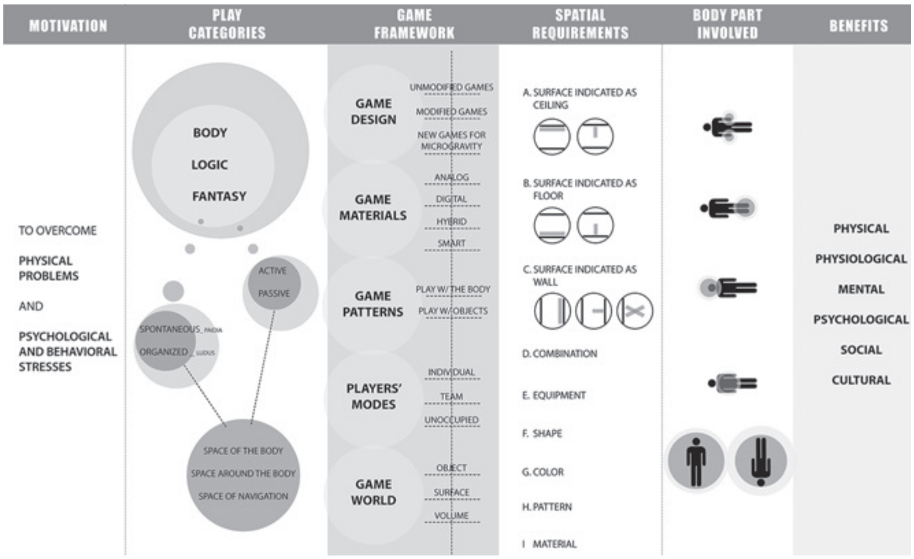

Figure 7. Left: Proposed game framework and design parameters (2013). Courtesy of Transformable Intelligent Environments Laboratory, Technical University of Crete.

physical components of the "magic circles" that allow them to break loose from their daily constraints (through play) should be bound, or clearly signaled, to avoid confusion.

Conclusion: Realizing the Benefits of Play in Microgravity

Whether on Earth or in space, an environment that facilitates play greatly enhances habitability and well-being. In an extreme environment where every mistake can be detrimental, if not fatal, the importance of play—spontaneous or organized—has been underrated in the past. However, it is evident that play has a regulatory function in the astronauts' adaptation process within a confined microgravity habitat. Play provides space travelers with a lightness of being, through feeling weightless, without which the mission would become impossible.

For astronauts, play not only humanizes their extreme habitat but also offers a tool to help them gradually acquire and refine microgravity-bound navigational skills important for their mission.

We hope researchers will take a second look at the importance of play, even in apparently unlikely situations, like space travel. Embarking on a space mission is, in itself, a rather adventurous and playful undertaking—hence our own initial musings on what makes children love and act like astronauts and how astronauts compare to children. It did not take long for us to connect the dots and focus on play types that may help astronauts who feel "spaced" get grounded, those who feel confined get apertures, and those who feel disoriented find their way. As an activity, play not only enhances creativity but, as we know, fosters mental readiness, confidence, positive framing, and commitment.

The astronauts' playscape in particular offers a unique setting that creates the possibilities and the reasons for the spacecraft crew members to unleash their imaginations, break loose from stifling constraints, and feel whole by becoming children again, forgetting for a while the disciplined scientist, and immersing themselves in a different world. A playscape can be a health and performance countermeasure to help crews adapt to the isolated environment of a spacecraft module by offering choice and personalized leisure options in everyday schedules. As Jane McGonigal (2010) puts it, play offers "an opportunity to focus our energy with relentless optimism." In this sense, living aloft should be seen as a chance to strip away extraneous elements, get back to the purest forms of experience and communication, and break free of gravity—the ultimate constraint. Maybe this is exactly what astronaut Harrison Schmidt had in mind when he bounced playfully on the moon while singing a personalized version of Ed Haley's *The Fountain in the Park*: "I was strolling on the moon one day. . . ."

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