

Memory Bites: From Earth to Space and Back

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Imagine yourself on a NASA one-year mission to the International Space Station (ISS), with just a few crewmates in a small, isolated environment that blurs the line between familiar and unfamiliar. You have access to food for sustenance, but its appearance, taste, and the way you interact with it are all different from on Earth. Your senses adapt to the unique environment, as the specially designed food serves its functional purpose of delivering the nutrients that you need, considering the limited availability of resources. Beyond its nutritional value, though, food holds a profound significance in human society.

Think of any meal. It involves the food but also an atmosphere, specific utensils, and often other people. It might involve your favorite comfort food or perhaps food that reminds you of something, someone, or a special occasion. Food is an essential part of life, and sharing a meal sometimes transcends the food itself, as in the case of Thanksgiving or Christmas. These special occasions show us that although food keeps us alive, it also serves other purposes in our societies.

Scott Kelly's memoir *Endurance* [1] captures the profound significance of food in human life. Only 48 hours after Kelly's return to Earth, he was back home in Houston, sitting at the head of the dining table. He describes being surrounded by his family and enjoying the simple act of sharing a meal after yearning for it in space. The familiar faces, the joyful chatter, the clinking of silverware, and even the sensation of gravity felt somewhat foreign to him yet also cherished.

Designing space food is a complex endeavor that needs to consider the multiple roles food plays in our lives, especially the context in which it is eaten. How would you feel celebrating a special occasion in the absence of your loved ones and the familiar places where you would typically meet them, while eating freeze-dried fruits, energy-packed cereal bars, tortillas for various fillings, and specially formulated beverages?

In this article, we examine the importance of food in human society, focusing on its role during space missions on special occasions such as Thanksgiving in the U.S. We present a design concept called *Earth Memory Bites*, which considers various dimensions of eating experiences in space, such as nutrition, sensory aspects, emotional connections, social interactions, and environmental factors, to support an astronaut's well-being. This concept uses advanced technologies, including 3D printing, virtual reality, and projection mapping, to create immersive, personalized dining experiences for astronauts.

Eating Experiences Unpacked

The significance of food in human societies extends beyond nutrition. While it is essential for our survival, food also offers a pleasurable component for the senses. It has the power to evoke a range of feelings, including joy, nostalgia, and comfort. Moreover, food has a social dimension, as it is often shared with others and serves as a central element at celebrations and special occasions. Thus, food not only serves a nutritional purpose but also plays a crucial role in our sensory, emotional, and social well-being.

We have highlighted how food encompasses multiple dimensions that contribute to its significance in our lives [2]. First, there is the *functional* aspect, which relates to nutrition, health, and maintaining a balanced diet that provides necessary vitamins and sustenance. Second, the *sensorial* aspect encompasses the diverse qualities of food, such as texture, smell, taste, flavor, freshness, and the availability of different foods to choose among. Food also holds an *emotional* significance, comforting us, surprising us, and making us happy, among other emotions. Furthermore, it has a *social* dimension, fostering connections and shared experiences through communal meals and the pleasure of dining with loved ones. Lastly, the *environmental* context plays a key role, considering factors such as atmosphere (e.g., eating by the beach, in the country, or, say, in space).

As such, any compelling food experience should, at the very least, consider these five dimensions. Indeed, considering the broader implications of food, researchers in the field of space exploration have recognized the importance of understanding the psychological effects of food on both individuals and astronaut crews (e.g., [3]). The unique challenges and isolated environment of space travel necessitate a comprehensive understanding of how food can affect the well-being of astronauts. By acknowledging the psychological significance of food in this context, researchers can strive to enhance the overall experience of space exploration and ensure the well-being of astronauts during their missions.

Special Eating Occasions in Outer Space

Imagine that you are an astronaut halfway through your one-year stay on the ISS, or perhaps on a trip to Mars, and it is Thanksgiving or some other important holiday. How would you design that experience?

Thanksgiving embodies the multifaceted nature of food in our lives. It serves a functional purpose by providing a well-balanced, nutritious meal. The sensory experience is enhanced through a diverse yet season-specific range of tastes, flavors, and textures found in traditional dishes (e.g., the scent of roasted turkey and spices like cinnamon, nutmeg, and cloves used in pumpkin pie). Emotionally, it may evoke feelings of comfort and nostalgia through cherished family recipes and the act of gathering with loved ones. Socially, it fosters togetherness and communal celebration as family and friends share a memorable meal. The environment typically involves a welcoming atmosphere and a focus on creating a special space for dining.

Similar experiences are applicable to Christmas, Chinese New Year, Diwali, Eid al-Fitr, and other special annual occurrences that define culture, tradition, and who we are as part of a society. How can we capture all these dimensions of food and eating for the astronaut who has already spent six months in a closed environment in space? How do we enable individual experiences while also being considerate of the cross-cultural influences and origins of the crew?

Memory Bites: A Design Concept

Inspired by advances in human-food interaction (HFI) design, we previously developed three design concepts (see [2]) that integrate and tackle the functional, sensorial, emotional, social, and environmental/atmospheric aspects of eating experiences in space. Here, we will present one of the three concepts, namely the design concept Earth Memory Bites, as it is closely interlinked with special occasions such as Thanksgiving.

The Earth Memory Bites concept proposes the design of small bites that contain distinct flavors representing different regions, cultures, or specific experiences related to Earth food. It also involves predefined options to provide comfort through familiar flavors and treats such as fresh berries, cheese, and chocolates (see Figure 1 for examples).

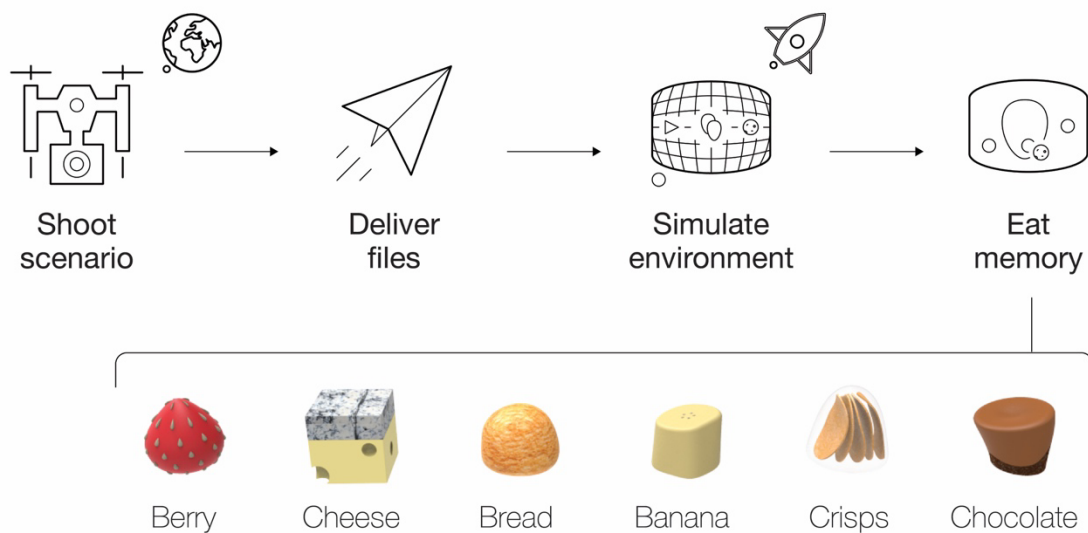


Figure 1. From the preparation of foods and specific flavors to the presentation in a simulated dining environment by Obrist et al., 2019/CC BY.

Each of the bits of Earth Memory Bites is integrated and embedded in a specific dining environment such as a beach or in a park (Figure 2), enabled through the integration of projection mapping and virtual reality (VR) technology.

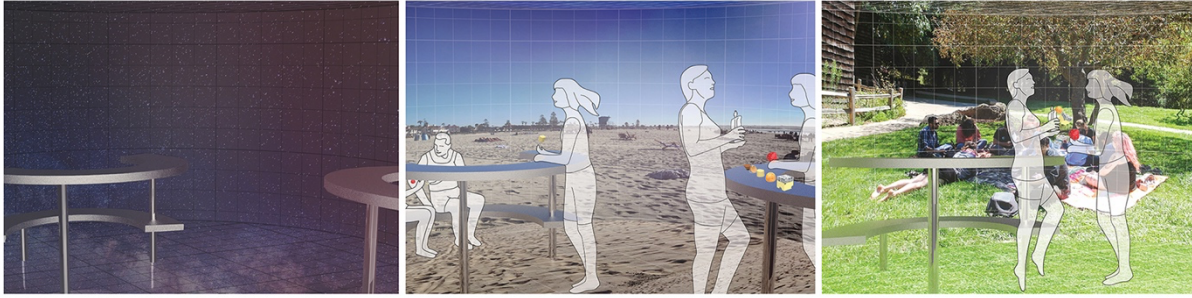


Figure 2. The illustration on the left is the deactivated state of the simulation environments; the illustrations in the middle and on the right are examples of environmental dining simulations in space, including beach and park by Obrist et al., 2019/CC BY.

Now, imagine Thanksgiving is approaching and an astronaut is craving a taste from home. The Earth Memory Bites concept envisions that people can order a given combination of a flavor profile and multisensory experience. They have two options: 1) order both the desired flavor and dining environment or 2) order the flavor and receive it along with a suggested dining environment. The latter could be generated through an automated algorithm that creates the perfect dining environment in VR, based on available research on atmospheric influences on eating experiences (e.g., ambient lighting, sounds [4]). The different flavors would be prepared as a 3D-printed recipe using advances in food 3D-printing technology and then sent with a carefully chosen multisensory environment to the person. The person can print the flavors of the memory bites and experience them, either alone or with others, in an immersive dining environment on the spaceship. All the bites would be self-contained and edible as one-size bites to avoid having different items floating around the spaceship. Each bite would contain the specific selected flavor and would be printed in the form and texture of the actual food item (e.g., a strawberry bite, a banana bite; Figure 1).

This concept design considered key factors of food experiences outlined above:

- *Functional:* Developing bite-size appetizers or snacks that do not crumble.
- *Sensorial:* Using music, visual projections, atmospheric lighting, temperature, and humidity to match distinctive Earth atmospheres (e.g., familiar places), or new eating scenarios created to match the desired multisensorial experience of the bite series.
- *Emotional:* Re-creating and eliciting a nostalgic and comfortable eating environment (e.g., a restaurant, a bar, a park) through an ambient projection (i.e., panoramic theater) that could be shared with others.
- *Social:* Astronauts can share their favorite flavors (bites from Earth) with their crewmates. This helps alleviate homesickness by allowing them to feel connected to home while also strengthening their social ties with others aboard the spaceship.

While Earth Memory Bites is still in the concept stage, this idea has the ambition of fostering the sensory, social, and emotional aspects of eating experiences in particular by accounting for the multisensory influences of the environment in which a person or group of people is

eating. Food experiences are more than just the food we put into our mouths; they are everything that surrounds us and affects us, making the experience memorable. How can we move from the concept to its realization, or at least enable steps toward it being more than just an idea?

Advances in Technology for Novel Eating Experiences

Advances in immersive mixed reality (XR) technologies, including virtual and augmented reality (VR/AR), offer unique opportunities to simulate dining environments in ways that are not possible in the physical world. For instance, the color of the environment can be changed instantly and without any physical constraints, allowing the creation of personalized, themed dining environments based on individual preferences and special occasions. This domain of XR HFI is relatively novel and the design space has only begun to be formalized.

Research increasingly explores the effects of different sensory elements on users' experiences in XR environments. Wang and colleagues [5] explored how food color perception can benefit from VR technology, by allowing for the easy alteration of the visual appearance of stimuli. Their results revealed that beverage color as viewed in VR significantly influenced perceived creaminess, with light-brown coffee rated creamier than dark-brown coffee. However, color did not influence perceived sweetness or whether a participant liked the beverage. Cornelio et al. [6] used VR to investigate the effects of colored virtual environments (red, blue, neutral) on taste perception (sweet, neutral) of differently shaped taste samples (rounded or spiky shapes according to the Kiki-Bouba paradigm). The results showed increased ratings of sweetness when participants tasted bouba-shaped (rounded) samples relative to kiki-shaped (spiky) samples, suggesting that tactile attributes perceived inside the mouth can influence sweetness perception. Furthermore, they concluded that lighting color in a virtual setting might dampen experiences of sweetness. This effect, however, may only be present when there is a cross-modal correspondence with taste.

Research on cross-modal effects and the digitalization of the chemical senses has enabled a range of investigations into the design of multisensory HFI experiences. Technological advancements allow us to create even more experimental and novel experiences, such as eating food that is levitated [7].

Eating like an astronaut on Earth is enabled through novel sound manipulation techniques, as demonstrated through TastyFloats [7]. This contactless taste-delivery system uses two phased arrays of low-cost ultrasonic transducers positioned opposite each other to form a standing wave of ultrasound between them. This enables the levitation of small amounts of liquids and solids in the nodes of the wave. Changing the phase can move these nodes in

three dimensions, pulling the contents along with it, and allowing the materials to be transported in 3D space as long as they stay between the arrays.

While this food levitation system is not meant for outer space—at least not in its current form—it offers immense opportunities to explore novel eating/food experiences on Earth. More complex food experiences can be created through combining this technology with insights into cross-modal effects and XR environments.

What Does This All Mean for Us on Earth?

What if we can not only have Earth Memory Bites in outer space but also “Space Memory Bites” on Earth for those who have been (and in the future will be) in space but can’t go back? Would we simulate spaceship environments for future Thanksgivings while being on Earth? Also, what can we learn for the here and now when looking far into the future and into outer space explorations? How can we use space food experiences to disrupt food experiences on Earth?

Food holds great significance in human society, serving not only as a means of sustenance but also nurturing emotional connections, sensory pleasure, and social bonding. Therefore, it is essential to view our eating experiences through these multifaceted lenses. By considering the functionality of nutrition; sensory appeal encompassing elements such as taste, texture, and aroma; emotional impacts including comfort, nostalgia, and happiness; social interactions and shared meals; as well as the environmental context of the setting and atmosphere, we can better understand the psychological effects of food on us.

Appreciating and capitalizing on the impact of the dining environment, including ambience and setting, can significantly enhance our overall enjoyment of meals and create longer-lasting memories. Additionally, exploring the role of our senses and how they influence our experiences, as well as considering technologies that engage the senses, opens up new opportunities for experimental and unique dining experiences.

As an example, Earth Memory Bites seamlessly combines diverse flavors with virtual dining environments, enriching astronauts’ journeys. By leveraging advanced technologies such as AR, VR, and 3D printing, we can create personalized and immersive dining experiences for anyone on Earth, fostering creativity and innovation in food design. Embracing an exploratory approach to food design allows for the emergence of novel culinary experiences, expanding the boundaries of how we perceive food in our daily lives, and potentially enhancing our well-being.

Indeed, this understanding becomes crucial not only for space missions but also for our well-being here on Earth. Designing space food for everyday life, as well as special occasions, requires a thoughtful approach. As such, we should apply this approach in our lives on Earth.

Conclusion

Food has a profound significance in human society that not only involves nutrition but also sensory, emotional, and social dimensions. We presented the design concept Earth Memory Bites, which offers a novel approach to enhance eating experiences in space, considering the aforementioned dimensions. By integrating flavors from diverse cultures and creating immersive dining environments through advanced technologies, astronauts can experience the essence of special occasions like Thanksgiving even in the isolated setting of space. This concept fosters a sense of connection to home and shared experiences as well as promotes cultural preservation and social bonding among crewmates.

As technology continues to advance, implementing these innovative eating experiences in space can greatly contribute to the well-being and satisfaction of future space explorers, bridging the gap between space missions and cultural traditions on Earth. We are at the dawn of a new era of innovation, where the senses meet technology [8], enabling the creation of the previously unthinkable.

Endnotes

1. Kelly, S. *Endurance: My Year in Space, a Lifetime of Discovery*. Vintage, 2017.
2. Obrist, M., Tu, Y., Yao, L., and Velasco, C. Space food experiences: Designing passenger's eating experiences for future space travel scenarios. *Frontiers in Computer Science* 1, 3 (2019).
3. Pandith, J.A., Neekhra, S., Ahmad, S., and Sheikh, R.A. Recent developments in space food for exploration missions: A review. *Life Sciences in Space Research* 36 (2022), 123–134.
4. Spence, C. *Gastrophysics: The New Science of Eating*. Penguin UK, 2017.
5. Wang, Q.J., Meyer, R., Waters, S., and Zendle, D. A dash of virtual milk: Altering product color in virtual reality influences flavor perception of cold-brew coffee. *Frontiers in Psychology* 11 (2020), 3491; <https://doi.org/10.3389/fpsyg.2020.595788>
6. Cornelio, P. et al. Virtually tasty: An investigation of the effect of ambient lighting and 3D-shaped taste stimuli on taste perception in virtual reality. *International Journal of Gastronomy and Food Science* 30 (2022), 100626; <https://doi.org/10.1016/j.ijgfs.2022.100626>
7. Vi, C.T. et al. TastyFloats: A contactless food delivery system. *Proc. of the 2017 ACM International Conference on Interactive Surfaces and Spaces*. ACM, New York, 2017; <https://doi.org/10.1145/3132272.3134123>
8. Velasco, C. and Obrist, M. *Multisensory Experiences: Where the Senses Meet Technology*. Oxford Univ. Press, 2020.

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