Gravity Well: Underwater Play

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Figure 1. Gravity Well: *Underwater Play* performed in a pool.

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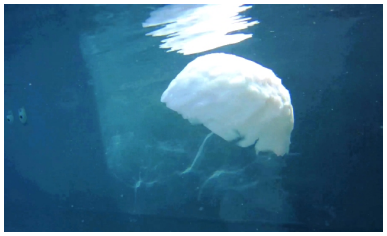
Abstract
More and more technology supports utilitarian interactions in altered gravity conditions, for example underwater and during Zero-G flights. Extending this, we are interested in digital play in these conditions, and in particular see an opportunity to explore underwater bodily games. We present an interactive shallow-water system that supports bodily play through water-movement interactions: Gravity Well. Through designing the system and combining aquabatic principles with exertion game design strategies, we identified a set of design tactics for underwater play based on the relationship between the afforded type, and level, of bodily exertion relative to pressure change and narcosis. With our work, we aim to inspire designers to utilize the unique characteristics of bodily interactions underwater and guide them in developing digital play in altered gravity domains.

Keywords
Diving, exertion games, game design, aquabatics.

ACM Classification Keywords
H.5.2. [Information Interfaces and Presentation]: User Interfaces – Miscellaneous.



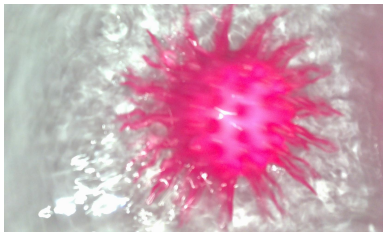


Figure 2, 3. Gravity Well smart underwater "Exploration Fish".

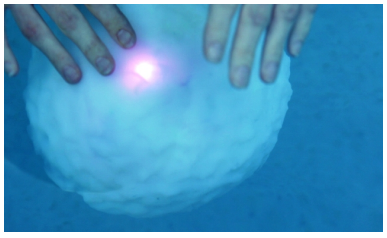


Figure 4, 5. Demonstrating underwater touch-motion response with the Gravity Well: underwater play prototype "Mother Fish".

Introduction

The kinds of bodily activity available to people in and with water differ from those on land. Underwater bodies can float, hover, sink, fly, and dive. We can move objects twice our body weight underwater, turn a triple-summersault and balance up-side-down on our little finger with half the effort required on land. Moving in water allows one to act out a fantasy element that one cannot experience in real life [1], reminding us of the power of computer games to facilitate fantasy elements [2] and equally, highlighting limitation of technologies to support full-bodied actual immersion in real, wet, and dynamic altered-gravity environments [1,10]. We are therefore particularly interested in bodily movement underwater engaged in digital play and call it underwater exertion play based on the fact that physical effort determines the interaction outcome [3]. We combine our experiences in Aquabatics and exertion games to drive this forward: Aquabatics combines commercial diving with live art to describe human performance underwater [1], and exertion games are digital games controlled by gross-motor movement [4].

Related Work

Other designers are considering interactive technology and water. For example, Deen et al. have shown that interactive technology in public swimming pools can facilitate engaging experiences [5]. Many of their games focus on interactions on the water surface or just above, while being in water, whereas we are interested in interactions while underwater (whether while holding breath, snorkeling or with deeper diving equipment). We reference underwater acoustic and dance-tech of artists working in shallow- water and recreational depths including *WetSounds,* 2008-2012 J. Cohen, Aquadelica, UK and *Portal* 2008, an exploration of underwater wheelchair play by artist Sue Austin, UK and related to the bodies of works by the early pioneers of Aquabatics [1] and altered-gravity performances and micro-gravity movement workshops by Kitsue Dubois and The Arts Catalyst, London. These works generate sensory-perception and bodily-motor movement knowledge critical to designing for underwater play in parallel to the fantasy-elements of virtual domain, i.e. computer games that produce many seductive experiences related to underwater play such as *flOw,* (PS3) 2007 SONY/That Game Company, and *Endless ocean,* (Wii) 2008 Nintendo/Arika.

Gravity Well

The player's experience of engaging with Gravity Well is as follows: the player either dives in to a body of water i.e. a pool (Fig. 1) or reaches in to a water tank depending on availability. Gravity Well encourages communication between smart objects we call "exploration fish" and the body of water (Fig. 2,3). The larger "mother fish" provides a real-time visual response to the player's human-aquatic movement interactions and touch (Fig. 4). It emits local sound and communicates accelerometer and positioning data (Fig. 5) to remote autonomous fish. The through-water Bluetooth data signal controls the "baby fish" (Fig. 6). In response, "baby fish" light up and mimic the player's altered-gravity movements (Fig. 7). By communicating with and through the water, the player engages in an aquabatic performance through play (Fig. 8-9).

Design tactics

Through the process of creating Gravity Well, we learned that many designers are not familiar with pressure-change variables [6]. Furthermore, many land-based exertion game design assumptions are not suitable for underwater systems [10]. The gap in this knowledge inspired us to create a set of design tactics for other designers creating underwater systems.

As a framework, we refer to signs and symptoms of Narcosis [6] to scaffold our set of design tactics [8]. We suggest designers first consider a) mood b) intellectual function c) visual and auditory stimuli and d) balance and coordination related to underwater play as each issue relates to measurable Narcosis experience [6].

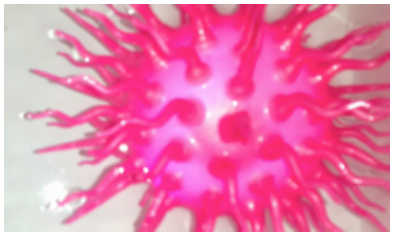


Figure 6. Waterproof robotic "Baby Fish" receives Bluetooth commands to perform multi-axis motion-mimicry and thus requires an array of silicone tentacles to propel, orientate and stabilize in water.

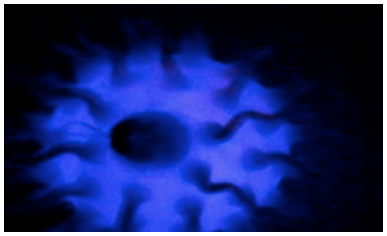


Figure 7. Underwater robotic "Baby Fish" light up when receiving motion data from "Mother Fish". This input controls a real-time movement response to mimic the remote human-aquatic-movement by the player.

The installation uses low lighting to amplify the changing states of illumination by the "baby fish" creating highly visible displays of movement and refraction through the water. This design choice enhances the sci-fi futuristic theme and fantasy element.

NARCOSIS	ABOVE/0-30m BELOW	EXPLANATION	NOTES FOR DESIGNERS	*GRAVITY WELL*
MOOD	Nominal state/feeling	Narcosis produces a narcotic-like effect.	Design to harness mild euphoria mood – but not to distract from water safety.	Sci-Fi futuristic theme adding to euphoric feeling.
	UW Mild euphoria			
INTELLECTUAL FUNCTION	Open to ideas/rational	See above. Eventually leads to hallucinations, stupor death >90m.	Clear, concise simple tasks OR open play design. Rules aid concentration at depth. Tasks assist direct focus.	Low-level intellectual function required for play. Open to interpretation. User determining rules.
	UW Fixed ideas & mild reasoning impediment			
AUDITORY & VISUAL STIMULI	See color spectrum & hear direction of sound	See above. Lens of eye must adapt. Vestibular disturbance too. Vibrations reach the ear simultaneously.	Sound travels 5x faster in water than air. Sound attenuates less UW. Most sound is reflected at surface. Water absorbs visible spectrum.	Vibrant LED color tones easily detected underwater. Low-intensity LED array shows movement. Ambient sound.
	UW Delayed response, omnidirectional sound, loss of visual spectrum			
BALANCE & COORDINATION	Stable axis. Fixed gravity reference	Pressure effects vestibular function & nervous system. Buoyancy affects all aspects of balance and coordination.	Water creates drag and resistance. Design to harness both the abilities and challenges to the body and the properties of movement due to buoyancy.	The overt design feature. A user-designed interaction sensing aquabatic motion (body & body of water)*. Physically altered buoyancy, balance and coordination.
	UW Little impediment, slowed movement, altered-buoyancy			

Table 1. Signs and symptoms of narcosis 0-30m underwater (UW) compared to land and implications for game designers.

Discussion

We apply this work for underwater digital play by comparing the effects of with a pedestrian-fixed frame, to describe implications for the design of underwater exertion play [Table 1]. We also express these considerations in the shallow-water Gravity Well.

We believe there is an opportunity to take advantage of movement underwater and changes to sensory perception caused by pressure changes to design unique exertion games that facilitate full-bodied play experiences [1,7,9]. We also see further opportunity to develop underwater exertion games that support the wellbeing of players at various recreational and commercial diving depths from 0-30m, promote new human- computing-aquatic approaches to design, and positively contribute playful interaction design in other altered-gravity domains such as Zero-G flights, low Earth-orbital flights and human spaceflight. [10].

Conclusions

We have explored digital play in altered gravity conditions by investigating underwater bodily games, exemplified by an interactive underwater system that supports bodily play through movement interactions called Gravity Well. Through designing the system and

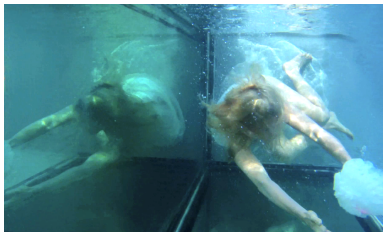


Figure 8, 9. Player engaged in full-bodied immersion and interactions with Gravity Well "Mother Fish" underwater.

combining underwater and game design principles, we identified a set of design tactics for underwater play. These design tactics – based on Narcosis - are only an initial set, and future design guides may relate to oxygen toxicity, decompression sickness, refraction and other topics. We also focused on shallow-water interactions, thus future work will explore how interactive technology would need to be designed for depth. Nevertheless, our work offers a unique exploration into digital play design for altered gravity conditions. With our work, we aim to inspire designers to utilize the unique characteristics of bodily interactions underwater and guide them in developing digital play in altered gravity domains.

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