Designing Sports: A Framework for Exertion Games

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ABSTRACT

Exertion games require investing physical effort. The fact that such games can support physical health is tempered by our limited understanding of how to design for engaging exertion experiences. This paper introduces the Exertion Framework as a way to think and talk about Exertion Games, both for their formative design and summative analysis. Our Exertion Framework is based on the ways in which we can conceive of the body investing in game-directed exertion, supported by four perspectives on the body (the Responding Body, Moving Body, Sensing Body and Relating Body) and three perspectives on gaming (rules, play and context). The paper illustrates how this framework was derived from prior systems and theory, and presents a case study of how it has been used to inspire novel exertion interactions.

Author Keywords

Exertion Interface, whole-body interaction, exergame, exergaming, bodily interaction, kinesthetic, sports.

ACM Classification Keywords: H5.2. Information Interfaces and presentation (e.g., HCI): User Interfaces.

General terms: Design, Human Factors

INTRODUCTION

Within the field of HCI, there is a trend towards interactions that place the human body at the center of the experience, fostering "exertion" interactions that require intense physical effort from users [35]. Computer games currently provide the most buoyant genre for exertion systems. The Nintendo Wii and Microsoft Kinect, along with research projects such as virtual reality stationary bikes [32], mobile games fueled by exercise [8, 26] and our own systems [35, 36, 38] have all contributed to a design space that highlights the value of such mediated exertion experiences. We define an Exertion Game (sometimes called exergame [52]) as a digital game where the outcome of the game is predominantly determined by physical effort.

Researching these exertion games is important, as they can offer physical health benefits [24, 29], which can contribute to weight loss and address the obesity epidemic. Research has also found that exertion facilitates social behavior in games, suggesting that we can create more engaging and social experiences if we know how to design for exertion [5, 27]. Unfortunately, at present we have a limited understanding of how to describe and design for compelling exertion experiences [11, 57].

Framing exertion games as "sports" helps illustrate why this understanding is difficult to attain. Sport is a highly complex social phenomenon centered on moving bodies [15] which engage in a wide spectrum of physical behaviors. These behaviors are often mediated by tools – both simple (e.g. a ball) and complex (e.g. a bike), and take place anywhere from small backyards to national stadiums. In addition, the complex cultural processes that shape our desire to engage in sport often focus on extreme experiences and emotions, ranging from delight and togetherness to violence and injury.

When designing for Exertion Games, we need to understand not only the bodily experience, but also the technological challenges of digitally capturing, interpreting, and communicating exertion. The goal of our Exertion Framework presented in this paper is therefore to encourage a systematic consideration of the ways in which the body engages in exertion experiences as well as the ways in which game design and technologies can support such experiences.

KEY EXPERIENCES

To address the challenges outlined in our introduction and to illustrate our Exertion Framework, we begin with a look at three of our own exertion systems – Table Tennis for Three [37], Jogging over a Distance [39] and Remote Impact [34] and draw on our rich history of designing for exertion [35, 36, 38]. The examples we illustrate here exploit the potential of networked computer games to allow players to communicate over long distances [45]. However, we illustrate how our framework is applicable in both distributed and non-distributed settings.

TABLE TENNIS FOR THREE

Table Tennis for Three is inspired by the game of table tennis, but accommodates three players at three different tables, rather than two players at one table.

Fig. 1. Table Tennis for Three.

Each player has an identical setup, which includes a ball, a paddle and a modified table tennis table. The table is set up so that the ball can be hit against a "backboard" – a vertically positioned opposite half of the table (Fig. 1). Digital bricks are projected onto the backboard so that the bricks exist in a virtual world shared by all three players. In addition, side-by-side video feeds of players' opponents are projected behind the bricks, thus creating a sense of "playing together" [37]. The goal of the game is for each player to break the bricks using their physical paddle and ball. The bricks crack a little, a lot, and then break after three strikes from any ball and any player. However, only the third striker receives the point. Play continues until all bricks are broken, and the player with the most points wins.

JOGGING OVER A DISTANCE

Jogging over a Distance is a jogging support system that uses heart rate data to control spatialized audio between geographically distant joggers. The aim of the system is to support "social" joggers, i.e. people who use exercise to socialize and socialize through the exercise [42].

Joggers run in pairs and each jogger wears a headset, a heart rate monitor, a mini computer and a mobile phone (Fig. 2). Before the run, users enter their target heart rate into the system. Each jogger hears the spatialized audio feed from their distant jogging partner. The spatialized audio appears to come from the front, side, or rear, according to whether the user's relative heart rate is lower than, equal to, or greater than that of their partner's. If both joggers diverge from their target heart rates by the same percentage, the spatialized audio remains "side by side". For example, if both joggers raise their heart rate to 110% of their target heart rate, the spatialized audio sounds as if it is "next" to the jogger. However, if their relative heart rates are at different levels, the audio will sound as if one person is in front and the other is behind. The spatialized audio therefore acts as a sign of relative effort and tells the joggers when they need to speed up or slow down to "stay" with their partner [40].

Fig. 2. Jogging over a Distance.

REMOTE IMPACT

Remote Impact is inspired by combat sports which encourage intense physical exertion (Fig. 3) [34].

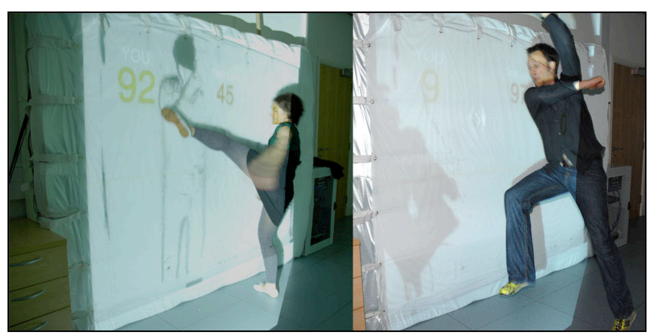

Fig. 3. Remote Impact

In this game, each remote player interacts with a padded playing surface (mattresses). The shadow from both the remote and the physically present player are projected onto the surface. Each player tries to make forceful contact with their opponent's shadow without getting "hit" themselves. Any impact on the remote person's shadow with any body part is counted as a successful hit and an audiovisual effect is played (e.g. POW!). Points are awarded according to the force of the impact and the player who scores the most points within a set time limit wins the game.

Summary of the experiences

Despite the differences in type of exertion and technology used, our three systems share many common features: they support physical effort through gaming experiences; they engage players through physical as well as virtual spaces and objects; and they facilitate digitally mediated social play. In the next section, we integrate these concepts into our Exertion Framework and discuss how using different "lenses" to investigate the body can help us understand how these concepts support engaging game experiences both arising from and in spite of the effects of bodily exertion.

THE EXERTION FRAMEWORK

Understanding Exertion Games begins with an appreciation of the fundamental and central role that the body plays in such interactions. It is important to note that our intention is not to provide a framework which stresses optimizing health or fitness benefits to the body, but rather to describe how designers can use technology to create more engaging exertion experiences mediated by technology. We believe that more engaging experiences will lead to increased physical investment, and health benefits will follow naturally as a result.

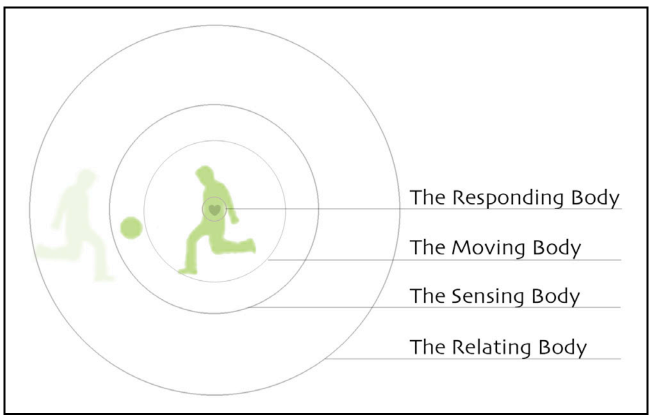

Fig. 4. The Four Lenses for Exertion Interactions

Four lenses

Our approach leans on Jacob et al.'s framework which describes the contextual factors arising from users' interactions with the environment as well as "social others" to explain bodily interaction with non-keyboard controlled devices [18, 19]. Jacob et al. suggest that a "four lens view" provides sufficient detail and abstraction to analyse new systems that feature the human body. As such, our perspective of the human body is similarly structured using four lenses: the Responding Body; the Moving Body; the Sensing Body; and the Relating Body (Fig. 4). Each lens is inspired by van Manen's phenomenological approach to the analysis of "lived" experience in terms of corporeality, temporality, spatiality and relationality [56]. While these lenses often overlap (for example, the moving and sensing body are often integrated [31]), our interest is in providing a simple structure for viewing the body and promoting creative design thinking when designing for exertion games.

Lens 1: The Responding Body

At the heart of the exertion experience is the *Responding Body*. The Responding Body is a view of the body "from the inside", or how the body's internal state changes over time as a result of the exertion - any activity from an outer layer necessitates a physiological response from the inner layer. The Responding Body emphasizes how both corporeality and temporality, or the body and change, are at the heart of people's experience of exertion [43].

The body reacts to physical activity by responding internally in a way that maintains balance, or "homeostasis" [43]: the user's heart rate typically increases, breathing becomes more frequent, and sweating occurs. These are consequences of exercise the user has not consciously initiated, but is usually aware of.

The body responds not just in anticipation of and during exertion, but also after such activities. For example, the body might lose weight, initiate the increase of muscle-mass, repair broken tissue, etc. These are all responses that continue to develop and persist beyond the "magic circle of play" [45] when the game ends. They can also affect how the body responds in subsequent exertion experiences: a participant might lift more weight on further exposures to the same exercise as a consequence of becoming stronger. The body's response is not always a positive experience however, for example, users might become aware of their bodies' response through muscle soreness or injury.

This lens of the Responding Body can be applied to each of the systems described in our Key Experiences section. In Table Tennis for Three, the external responses such as sweating and panting that are transmitted over the videoconference are in contrast to the internal responses of changing heart rates utilized as a core game mechanic in Jogging over a Distance. In Remote Impact, players became exhausted very quickly and needed resting breaks; as a consequence, games were played in several short sets that together made one full match.

Other games have used both heart rate [41] and EEG (electroencephalograph) feedback [23] from the Responding Body as control mechanisms. Smith notes that adjusting the game challenge based on participants' Responding Body could contribute to engagement [53] – something we exploited in Jogging Over a Distance.

Lens 2: The Moving Body

The *Moving Body* focuses on participants' muscular repositioning of body parts relative to one another during the course of physical activity. Temporality and spatiality are combined in the Moving Body – movement causes a body to respond (however, a Responding Body might not necessarily imply movement). This lens highlights movement characteristics such as intensity (movement can carry "weight"), continuousness (movement exhibits preparatory and follow-through phases) and variety (the richness of human movement) [31]. Loke et al. [28] has also found that space, weight, time and continuousness are useful in providing both constraints and resources for designing exertion experiences. Prior research concerning movement and dance has helped to identify these expressive characteristics [25, 28, 31].

The Moving Body also highlights the kinesthetic sense, or proprioception, an area that has been underexplored in HCI [13, 31, 48]. The kinesthetic sense governs users' awareness of the position of body parts [31]. Moen calls this a "bodily intelligence", a sense that allows humans to react intuitively without having to think about every single movement [31].

We can apply the Moving Body to each of the systems described in our Key Experiences section. In Table Tennis for Three, the preparatory and follow-through movements players made to hit the ball were secondary to the game and were communicated directly via videoconference, which enabled playful engagement such as "fake starts". In Jogging over a Distance, however, participants' jogging movements were primary to the experience but communicated only indirectly as spatialized audio in a virtual world. In Remote Impact, the need for both offensive and defensive movements led to players experimenting with tactics ranging from rapid, continuous arm and leg strikes to forcefully throwing the entire body at the surface.

Movements are related to the surrounding lens of the *Sensing Body*, or how the body perceives and acts within the hybrid physical and virtual Exertion Game environment and we discuss this in the next section.

Lens 3: The Sensing Body

The *Sensing Body* describes how the body is sensing and experiencing the world. In the world of sports, many popular games involve physical objects, which aid in shaping the exertion activity. Artifacts range from basic equipment such as balls to very specialized equipment (e.g. bicycles). The physical and technological environment also shapes the activity – playing in a big stadium is not the same as playing in the park [56], nor is running in a park the same as running on a treadmill. The Sensing Body therefore aims to offer a contextual perspective, highlighting the body and its interactions with the world. This perspective differentiates Exertion Games from conventional sports in that the world of Exertion Games consists of both physical and virtual objects and spaces. Previous research on tangible interfaces [16] has highlighted the potential of the body in relation to digitally augmented physical objects. Fogtman et al. have also speculated on the effects that physical objects can have on exertion actions [13]. Others suggest that adding virtual objects and spaces creates even more opportunities for exertion game design since participants must navigate the additional challenges of a hybrid space [4].

Adopting this lens of the Sensing Body, we can appreciate that Jogging over a Distance balances the risks of running outside with the reward of an ever-changing environment. Unlike in conventional jogging, this environment unfolds in a different way for each jogger, as jogging happens at different times of the day and joggers are separated by multiple time zones. In Table Tennis for Three, this lens highlights interactions with the physical ball (in contrast to a virtual one), while in Remote Impact it highlights the experiential correlation of the body physically hitting a mattress at the same time as the body is being hit via its digital shadow.

Lens 4: The Relating Body

The outer layer of the *Relating Body* is borrowed directly from van Manen [56], and encompasses the ways in which bodies and people relate to one another through digital technology. Such social interactions are highly diverse, mediated by a wide variety of roles such as co-players, opponents and audiences [48] and joint exertion can contribute positively to social outcomes [27, 54, 58]. A social view of exertion also helps us to understand the barriers and motivators for exercise [30]. Studies focused on physical activity participation have confirmed that "social interactions" are amongst the most common reasons for people being physically active [1, 55]. The ability to maintain existing relationships while also being able to develop new social networks are two of the key benefits of participating in physical activity [1]. Social facilitation theory suggests that social sportspeople will improve their athletic performance [15] and that athletes exhibit a higher tolerance to pain when exercising with others [7].

Using the lens of the Relating Body we see that the participants in Jogging over a Distance experienced their heart rate in relation to their partner's heart rate. In Table Tennis for Three, this lens illustrates how players relate to abstract virtual blocks that are shared amongst the players. In Remote Impact, this lens highlights that players relate to a virtual representation of their opponent.

EXERTION GAME SCHEMAS

As our exertion experiences center on digital games, we borrow gaming schemas from game literature: rules, play, and culture [45]. Each of these schemas helps us to explore: the formal structures of a game; the experiences of the people involved; and the larger context in which the game takes place (in this paper, we focus on the "immediate" context rather than the notion of culture). With these schemas, we can group the concepts we identified in our investigations of Exertion Games. These concepts can be considered from each of our four body lenses, offering a comprehensive breakdown of the ways in which we can think and talk about exertion experiences (Fig. 5).

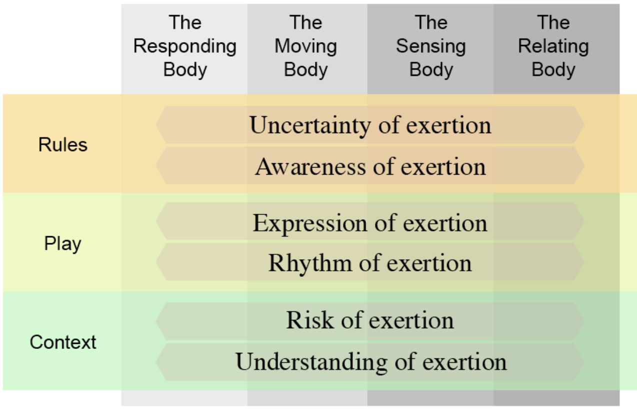

Fig. 5. The Exertion Framework

We now explain each concept in detail and show how they can be viewed using our body lenses by illustrating it through an example from one particular body lens.

RULES: Uncertainty of exertion

An important element of many games is uncertainty [45]: the ball dancing on the net before going over in a game of tennis, an adverse weather change in golf affecting some players but not others, and so on. Uncertainty contributes to an element of suspense and facilitates surprise in games through random or chance events, which can play an important part in what makes a game engaging.

In conventional button-press computer games, any chance encounters need to be artificially introduced through explicitly programmed code – simply pressing a key does not often offer a rich set of possibilities for uncertainty in terms of action and effect. For example, in a computer tennis game, the ball balancing on top of the net before dropping off either side might be controlled by a random function in the code that is not intuitively understandable to the players involved who might simply consider it a bug in the game [14]. In exertion games, on the other hand, uncertainty can also arise through the body. The body's response to exertion is hard to predict for player and technology alike ("how long can I keep up?"), and the variety of bodily movements can cause even simple actions to go wrong (e.g. missing a free-throw in basketball or a short putt in golf). Exertion as Uncertainty makes designers aware that they need to manage the relationship between the uncertainty arising from the body and the programmed uncertainty in the virtual world.

Uncertainty of exertion & the Sensing Body

The physicality of objects such as balls often amplifies the richness of bodily movement and draws on the nonlinearity between bodily actions and effects. This resulting uncertainty between bodies and objects has been exploited in sports [10] and mixed reality games [47]. In Table Tennis for Three, players react very emotionally when the ball hits the edge of the table and bounces off in unexpected ways as a result of "lucky" shots. With practice, players can achieve these shots intentionally, but even so these movements still carry an inherent risk and "fluke-factor" that heightens suspense for both players and audience.

RULES: Awareness of exertion

In Exertion Games, players aim to overcome the limitations of their bodies, for example wanting to run faster in Jogging over a Distance. The advantage of introducing computers to this bodily struggle is that digital technology can selectively hide bodily information from players as well as reveal it [44, 45] so that the player can then benefit from both increased and decreased awareness of their exertion. A person's awareness of the physical effort invested can entice participants to compare their energy expenditure over time and with others, fostering competition that motivates them to invest even more effort [8]. Alternatively, design can focus on distractions such as playing music, supporting anti-awareness that dissociates the user from the discomfort that comes with strenuous physical activity [20].

Awareness of exertion & the Responding Body

In Jogging over a Distance, participants noted that the social interaction with the other person distracted them from the discomfort of jogging, helping them to keep running. At the same time, participants reported that the audio enabled them to identify through their partner's breathing rate how much effort they invested, and whether they wanted to "push" their partner more.

PLAY: Expression of exertion

Exertion as a form of self-expression highlights the richness and expressive power of the human body beyond the merely pragmatic [5, 6, 25, 48], affording performative interactions [16, 48, 49]. Performative expression using the body is common in sports, often in the form of gestures such as "throwing fists" to oneself or to the opponent, and celebratory dances.

In Exertion Games, expression can be considered a form of "metagaming". Metagaming refers to "what happens during a game other than the game itself" [45]. Trash-talking is one example of metagaming in VoIP-supported computer gaming [45]. Exertion Game participants can draw on a wider range of metagaming strategies that leverage the expressive power of the body. Although such actions require the expenditure of bodily energy and hence one might come to the conclusion that they do not support making progress towards the goal of the game, they can significantly contribute towards the experience [5, 25].

The notion of exertion as a form of expression also resonates with work on interactive performances for an audience [3, 44, 48], but extends it by highlighting the various ways expression can be supported by the body. For example, participants could express themselves using their responding body by making heart rate visible to co-players, and variations could be rewarded through gameplay (e.g. the star-power points given for lifting up the guitar in Guitar Hero [5]).

Expression of exertion & the Relating Body

In Table Tennis for Three, participants hit balls not only to score points, but also to "send a message" to their remote partners, often smashing the ball at their heads. Such actions served a dual expressive role: that the players were "taunting" beaten opponents or "attacking" them after a loss, but only within the playful realm of the game in which the smasher of the ball would then have to retrieve the ball, watched by their two opponents through the video feed.

PLAY: Rhythm of exertion

Rhythm of exertion is about the ability of a system to support a uniform or patterned recurrence of a beat in bodily action. Rhythm in movement can exist within movement itself or without music, reflecting the inner pulse of the user [31]. It has been shown that the rhythm of music during exertion activities can regulate arousal, improve athletic performance, positively impact the acquisition of motor skills and dissociate from the discomfort of exercise [20]. Dance Dance Revolution is probably the most widespread example of an exertion game based on rhythm [2]. Players synchronize their movements to both the music and also to their partner, which makes for better performance and ultimately a better spectacle for the audience [2].

Rhythm of exertion & the Moving Body

From a Moving Body perspective, rhythm is supported by the continuousness of movement [48]. In Jogging over a Distance, participants tried to find a rhythm in their own jogging actions, but also used the rhythm they identified through their partner's footsteps and breathing in order to synchronize their movements with their partner's movements.

CONTEXT: Risk of exertion

Risk of exertion highlights the vulnerability of the body to overexertion and injury as a result of the exertion activity. Being injured, recovering from injury, and discussing injuries are prominent elements of the sports experience [17]. However, exposure of the body to risk in sport is different to risk-taking in computer games [45]. In computer games, risk is virtual, as most actions can be undone easily [21]. Dreyfus says that risk is a key differentiator between virtual and physical experiences [12]. With no real risk in virtual worlds, choice becomes meaningless. Risk-taking means committing to an act, and exertion is a commitment to physical actions as well as any potential consequences. Would choice in computer games become more meaningful if the physical risk was introduced to the experience?

When playing with a virtual game character, a player might experience an affective response when his/her avatar gets hurt, however, getting injured in an Exertion Game results in a different bodily response – the feeling of physical pain. This pain can obviously end the game, or worse, impact one's life well beyond gameplay. However, the feeling of putting the body at risk and succeeding contributes to the engagement of sports and Exertion Games alike. Dreyfus argues that bodily vulnerability can lead to a constant preparedness for danger and surprise, and that this readiness shapes one's life experience [12]. Participating in exertion experiences means exposing oneself to risk, and the realization of this risk can lead to a complex emotional response such as thrill [46]. However, it is important to note that striking the right balance between successful risk-taking "thrills" and the bodily risk of failed "spills" is non-trivial.

Risk of exertion & the Moving Body

The design of Remote Impact showed how designing for exertion can facilitate a reduction of risk in that the participant cannot be physically hurt by the distant partner, although it was still possible for players to hurt themselves.

CONTEXT: Understanding of exertion

Understanding of exertion refers to the potential of a system to support the development of knowledge about the body. For an understanding of the exerting body two key aspects come to the fore: knowledge and skill [22]. Knowledge about the exerting body is abstract and has an existence apart from the particular situation that it describes or explains. For example, participants in Jogging over a Distance expressed that knowledge about heart rate helps them understand their body better and therefore their effort investment, helping them to plan future runs. Skill allows people "to do things", and is gained predominantly through training and practice [22]. Skill can be facilitated by bodily exploration; for example, in Remote Impact participants explored the maximum intensity with which they could safely strike the surface with their fists, thus training their "hitting" skills.

Developing this bodily understanding has been described as acquiring kinaesthetic literacy [50, 51]. One design strategy to support such bodily understanding is through deliberate mapping between exertion actions and game actions that match players' abilities to the challenge ahead. This facilitates flow, putting the player "in the zone" in a manner thought to be conducive to learning [9]. We have identified four ways in which technology can support this matching, through the: 1) manual selection of difficulty level; 2) transformation of athletic abilities by "handicapping"; 3) pairing with similarly-skilled opponents in networked play; and 4) dynamic manipulation of game challenges in response to momentary and long-term changes in players' physical capabilities (e.g. detect when the player gets tired and adjust the difficulty accordingly).

Designers of exertion systems should also be aware of the dangers when mapping exertion actions: players who learn about their physical abilities through a non-uniform matching might overestimate the extent to which they can transfer their virtual skills to the physical world. As the involvement of the body can make these game experiences more emotional (when compared to button-press games)

[5], there is a danger of people over- or under-estimating their bodily powers, for example a player might believe that she/he is "superhero" strong after playing a superhero game.

Understanding of exertion & the Relating Body
In Jogging over a Distance, heart rate is mapped relative to the other person and is used as a game mechanic that contributes to social play. However, some study participants expressed that they would also like to access their individual heart rate in order to learn more about their bodies.

THE EXERTION FRAMEWORK IN ACTION

At its heart, the Exertion Framework is a **design vocabulary** – a tool for mediating discussions between designers. In the reverse of this process, the vocabulary can be used to set goals and aspirations for the design of new Exertion Games whose final forms are still unknown, using the body lenses and game concepts to systematically explore the space of possible exertion experiences. In this section, we describe how our framework was used to do just that.

Ideation using a Body Perspective

The central idea of "Hanging off a Bar" was inspired by considering how an Exertion Game could *not* have a **Moving Body**, unlike the majority of other Exertion Games.

Fig. 6. Hanging off a Bar

Hanging off a Bar is a game that plays with the idea of being a hero in an action movie who ends up hanging off a cliff, dangling over a wild river projected underneath the player (Fig. 6). The goal is for the player to hang on to the bar for as long as one can. From time to time, a raft slowly arrives, enticing the player to hang on just a little longer until the raft is close enough so that they can drop down onto it to rest and recover. They can't rest for too long, however, since they have to jump back up to the bar before the raft drifts into a waterfall behind the player. A projected timer shows the players how well they are doing. The longer the player hangs on to the bar, the less frequent and shorter the rafts become, resulting in decreasing opportunities for recovery which makes "hanging on" progressively harder.

Elaboration guided by the Exertion Framework

The core mechanic of Hanging off a Bar is based on the growing levels of pain and fatigue of the **Responding Body**. Conversely, the framework prompted a shift in focus from technological sensing based on the **Responding Body** (for example by measuring heart rate) to sensing based on the environment affected by the exertion. Since players naturally drop to the floor (both during opportunities to rest and when their grip fails) taking the view of the **Sensing Body** led to the decision to use a contact switch on the ground rather than strain sensors on the bar. A timer projected onto the floor provides **awareness** of the conflict between increasing pain and decreasing rest as the game progresses.

Although the game is only for solo-play at the moment, it has a strong element of the **Relating Body**. We noticed that observers quickly gather around a player, yelling motivational chants as the player faces **uncertainty** about the coming rafts (a typical game lasts only 30-50 seconds). Players also swing their legs to dissociate from the **awareness** of the increasing discomfort, which makes for a social experience by supporting a kind of **expression**. Players take away a new **understanding of exertion** about their physical response to hanging off a bar with only the slight **risk** of muscle strain.

Extensions suggested by the Exertion Framework

Possible extensions to the game inspired by the framework include a multi-player mode in which participants hang off the same bar over the same river, and share the same rafts. This would support a social **rhythm** of **moving bodies**, which could make for an interesting audience display. Furthermore, a multi-player system would allow for **Relating Bodies** to distract each other by, for example, slapping each other's hands or tickling the other person under the arm to steer the other player off the bar. This **Relating Body** notion could also occur in the virtual world: if one player does not need all the recovery time the raft offers and decides to get back on the bar early, the now lighter raft could drift off more quickly, thus affecting the other player.

A new game experience could also be created by shifting the scoring systems from the **Sensing Body** to the **Responding Body**: equipping players with heart rate monitors could create a challenging new play experience in which players have to hang on as long as they can while gaining bonus points for increasing their heart rate by swinging their legs, doing pull ups, etc. (increasing the **expression** of the **Moving Body**). Players will need to decide whether to "push their luck", as they try to find the right balance between energy conservation (to last longer) and expenditure (to get more points per unit time). This way, players could develop a greater **understanding of exertion** in terms of their **Responding Body –** what is the most effective way to raise heart rate without tiring the grip muscles: pulling up, swinging, or hanging loosely? Lastly, **risk** could be integrated into the reward system by having staggered bars of increasing height that the players can move between (the higher, the better), or by augmenting the bars or landing platform with light electrical shock capability.

Summary

We have presented a case study of how our Exertion Framework can be used to support the ideation, elaboration, and extension of novel Exertion Game concepts, but further work is needed to substantiate how the framework inspires creative design. Since the true value of such framework tools becomes evident within communities of design practice, our aim is to encourage interested designers and researchers to use the concepts and examples presented in this paper to perform their own analysis and design of Exertion Games, and to share the resulting ideas and experiences with the larger Exertion community.

DISCUSSION AND CONCLUSIONS

To understand what makes exertion experiences "tick" [4], and how and why they work, we have revisited and reflected on our experience designing, testing and evaluating Exertion Games. We propose a layered view of the human body, which provides designers with a "body perspective" for the design of exertion experiences. This perspective highlights that the body responds, moves, senses, and relates to other bodies in the context of exertion experiences. While such experiences can arise spontaneously, they typically benefit from determined goals in order to make the transition from action to activity. The special quality of games is that they offer goals that bring structure to such exertion experiences. Our body perspective and accompanying game schemas cut across all body lenses and provide a structure for exertion games.

Although our framework focused on games, our perspective on the human body helps us to see other interactive experiences that center on the body from an exertion perspective: for example, the nature of exertion in pervasive games, such as mobile phone games where players have to run across a city [33]. Furthermore, a view of exertion might also reveal insights into the design of interactive devices that support bodies exercising, such as computationally enhanced bikes and bodybuilding machines. We believe the Exertion Framework might also be useful in guiding studies of bodily labor, where it could contribute to design for a safer work environment. Additionally, the framework could be useful in learning environments where bodily skills are being taught and trained. As the use of exertion can affect trust and connectedness in mediated interactions [35], understanding exertion can also help us to create novel social experiences that expand our conventional view of CSCW applications: for example, networked exertion games could serve as trust-building activities for newly formed distributed teams. Our work also allows us to view embodied systems, such as tangible interfaces, from a body-centric, rather than device-centric, perspective.

In summary, our framework serves as a language for researchers to think and talk about exertion games, helps developers to identify opportunities for future interactive technologies and systems, and supports designers in creating new games that enable users to profit from the many benefits of exertion.

ACKNOWLEDGEMENTS

This work was partially supported by a Fulbright Scholarship and a Microsoft Research Asia Fellowship. Thanks to Nokia, Telstra, HCSNet and Scott Klemmer, Terry Winograd, Jeff Heer, Steven Dow, Ted Selker, Roz Picard and all the many helpers in the individual projects. Videos of the key experiences are at: http://exertioninterfaces.com

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