Feed the Food Monsters! : Helping Co-diners Chew their Food Better with Augmented Reality

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Figure 1 With the help of "Feed the Food Monsters!" we are aiming to help people chew better.

Abstract

Chewing is crucial for digestion and as mindful eating suggests, it is important that we do it properly. Despite this, not many people chew their food properly. To help facilitate proper chewing, we developed "Feed the Food Monsters!", a two-player Augmented Reality game that aims to engage co-diners in proper chewing using their bodies as play. This game draws inspiration from Tetris and allows diners to view each other's chewing behavior through a playful interface that is overlaid on their torso. In this game, players wear HMDs and guide each other to chew properly in order to keep the food monsters quiet. Besides supporting chewing in a social dining setting, this game also makes a contribution to AR-based games where chewing actions are mapped to game actions. Ultimately, with this work, we hope to engage people in the practice of proper chewing in a fun and a pleasurable way.

CSS Concepts

• **Human-centered computing → Ubiquitous and mobile computing design and evaluation methods;** • *Human-centered computing → Interaction design;*

Author Keywords

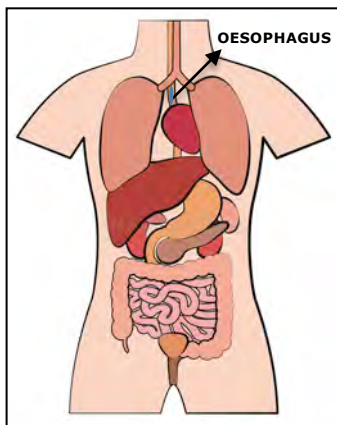Chewing; Augmented Reality; Social Dining; FoodCHI; Play;

Figure 2 The food passes through the oesophagus.

Introduction

Chewing food properly is good for our digestion and it is also one amongst the many important principles of mindful eating [5]. To chew properly means to bite and break food into smaller pieces using our teeth in order to make it easier to digest. Chewing helps in reducing stress on the oesophagus and it also aids the stomach in metabolising food. When chewing slowly, food gets coated with amylase, a digestive enzyme present in saliva that is important for carbohydrate digestion. Amylase then triggers the stomach to secrete and prepare its enzymes - pepsin and lipase, which help in breaking down proteins and fats respectively. To this end, chewing is useful for a healthy digestive system and for better absorption of nutrients [15]. Despite knowing the benefits of chewing, most people do not pay attention and neglect it in their everyday eating practices [7].

In order to engage people in chewing their food properly, we developed "Feed the Food Monsters!", a two-player Augmented Reality game that uses chewing as an interaction technique - by requiring the players to consume real food to feed the virtual food monsters that live in their stomach. We were inspired by prior works that illustrate the benefits of games to encourage people towards healthy eating [11]. However, instead of making a game that simply educates people about chewing, we aim to make chewing more engaging and pleasurable in a social dining setting. In particular, in order to explore a playful side of chewing, we build on the synergies between the digestive system and the popular game Tetris, where objects fall from the top to the bottom of the game similar to the way in which chewed food travels through the oesophagus (Figure 2). In our game, the diners wear head-mounted displays (HMDs), two HoloLens, while eating. Through these HMDs, they can see a virtual image (layer) overlaid on the co-diner's torso, with the food monsters positioned at the bottom of the image. As the co-diner begins to chew a food item, a virtual replica of it in the form of a food tile, appears in the game. Similar to the game Tetris, these food tiles fall from the top of the screen to the bottom. The player has to chew the food properly in order to feed the virtual hungry monsters. If he/she does not chew properly the monsters get agitated and make angry noises. Hence, in order to avoid these noises, the players have to chew the food properly.

Our game aims to help people engage in the practice of proper chewing. In addition to this, our game also demonstrates that chewing can be used as an engaging interaction technique to enrich Augmented Reality-based game experiences.

Related Works

The importance of chewing towards healthy digestion and nutrient absorption is widely known in the literature. For example, a study conducted by Smit et al. shows that higher chewing counts reduce food intake despite increasing chewing speed, and despite doubling meal duration for achieving a subjective reference point of feeling "comfortably full" [21]. Similarly, a study conducted by Zhu et al. illustrates that increasing the number of chews prolonged the meal duration and reduced the eating rate [29]. Kleef et al. stated that "enhancing chewing during an eating occasion may also enhance satiation and satiety and reduce food intake which otherwise leads to overeating" [24]. From the above-listed works, we learnt that increasing the number of chews and enhancing the chewing experience can help in supporting healthy eating practices.

Games to support healthy eating
Although to the best of our understanding, there is no existing work that directly aims to support chewing through play, various other playful systems exist in the literature to support healthy eating. Examples of such games are "Lunch Time" [19], "OrderUp!" [9], "MunchCrunch" [14], "Escape from the Diab" [23], and

Figure 3 The game's content is overlaid on the player's torso.

CHEW ZONE

GULP ZONE

MONSTERS ZONE

Figure 4 The game's content is divided into three zones, namely, the chew zone, the gulp zone and the monsters zone.

"Hungry Panda" [12]. Studies suggest that games are effective in changing health-related behaviors [4, 20] and can promote behavioral changes by enhancing motivation [4]. We note that the aforementioned games concentrate predominantly on the nutritional aspect of food, specifically on what we should eat, rather than how we should eat. However, by considering a holistic view of nutrition and health, we find that how we eat is also of importance and chewing is one of the key determinants of how we eat. This inspired us to go down this under-explored path to design our game to engage people in the practice of proper chewing.

Use of interactive technologies to enhance human-food interactions
Exploring the potential of technology to support playful engagement in human-food interaction is not new. For example, the combination of Augmented Reality and gustation has been previously explored by Takuji et al. [18]. The authors established a method to integrate gustatory information overlaid on food using Augmented Reality. Murer et al. integrated taste as a playful interaction technique by using a lollipop as a haptic input device that changes flavors [17]. Furthermore, Arnold et al. developed a Virtual Reality game called "You better eat to survive!" that utilized eating as a game mechanic to survive on a virtual island. The authors found that eating is a "viable, interesting and fun control method for gaming" [3]. Similarly, Mehta et al. developed "Arm-a-Dine", a social eating system that is controlled by the effective responses of the co-diner [25]. Finally, Koizumi et al. stated that chewing can be a form of interaction. Through their work, "Chewing Jockey" they were able to augment the texture of food and create a cross-modal illusion using sound filters [13]. These works teach us that interactive technologies can be used to enhance our eating experiences.

Design Rationale
Why social dining setting
Eating behavior is strongly influenced by social context [10]. The way we eat, what we eat and how much we eat is influenced by our co-diners. If we eat with someone who is eating a large amount then we are likely to model what they eat and consume more than what we would eat if we were dining alone [6]. On the other hand, we might eat less than usual if we think that eating a small amount will create a favorable social impression [25]. In essence, we eat differently when we are with other people compared to when we are alone [10]. Studies show that eating together makes us happier and healthier [27]. Besides, playing together also helps people bond [8]. Hence, we developed our game around a social dining scenario.

Why Augmented Reality
The primary value of Augmented Reality is that it brings virtual components of the digital world into a person's perception of the real world, and does so not as a simple representation of data, but through the integration of immersive sensations that are perceived as natural parts of an environment. We utilized AR to help diners visualize the process of ingestion and digestion by using virtual elements rather than showing them the actual anatomy of the human body (Figure 2). We used food tiles to represent chewed food that travels from the mouth to the stomach. We also used food monsters to represent the gut hormones present in our body that help in digestion [22].

"Feed the Food Monsters!"
In "Feed the Food Monsters!" both the players wear a HoloLens and can see the content overlaid on top of the co-player's torso (Figure 3) but not on their own torso because the virtual elements are mapped to the environment surrounding the player rather than on the player. The objective of the game is to let people engage in the practice of proper chewing in a playful way using their bodies as play [16].

Figure 5 A food tile is generated on the content overlaid on the co-players when the players put the food item in their mouth.

The Game
The game's content is divided into three zones (Figure 4).
1. Chew zone: The player has to chew the food item in this zone.
2. Gulp Zone: The player has to swallow the food item in this zone.
3. Monsters zone: The monsters present in this zone are comic representations of the hormones that help in digestion.

In the game, a real food item is represented as a virtual food tile. For example, a banana would be represented by a virtual banana tile. When a player puts a piece of real food in his/her mouth and starts chewing, a virtual food tile is generated on the display. This food tile moves through the three different zones mentioned above.

Starting the game
The game starts when one of the players puts a food item in their mouth. When the player starts chewing it, the motion is detected and a virtual food tile is generated on the top of the display, which then enters the chew zone (Figure 5).

Chew zone
When the tile reaches the chew zone, the food monsters squeal with joy as they see the tile approaching them. The co-player verbally guides the player to continue chewing until he/she reaches the gulp zone. As the player chews, the virtual food tile breaks into tiny pieces mimicking the way real food breaks when we chew (Figure 6).

The time for which a person can chew is dependent on the speed at which the tile breaks and moves in the chew zone. This speed varies with the food item being eaten, for example, a banana tile falls faster than a carrot tile because it takes more time to chew a real piece of a carrot than a banana.

Figure 6 The food tile breaks into pieces as the person continues to chew the food item.

Figure 7 When the food tile reaches the gulp zone, the co-player instructs the player to gulp the real food.
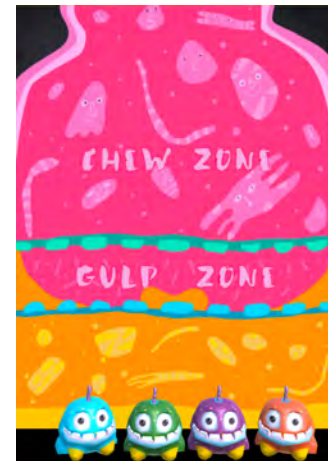

Figure 8 The monsters eat the food tiles and bulge in size.

Figure 9 An animation of the angry monsters when the player does not chew the food properly.

Gulp zone
Once the tiny pieces of the food tile reach the gulp zone (Figure 7), the co-player instructs the player to swallow the food to reach the monsters zone.

Monsters zone
When the food tiles reach the monsters, they eat the tiles and bulge in size (Figure 8), similar to the way in which our stomach bulges when we eat food.

As the game progresses and the players continue to eat food, their respective monsters grow larger in size. When they reach their maximum limit the game ends for that particular player, as his/her monsters can eat no more. The other player can continue playing until his/her monsters reach their maximum limit.

If at any point the player gulps the real food when the food tile is still in the chew zone, the pieces of the virtual food tile are not small enough for the monsters to eat. This agitates them and thus they make angry noises and move angrily (Figure 9). Hence, in order to avoid the embarrassing environment created by the angry monsters, the player has to chew the food properly.

Implementation
There are various approaches to detect chewing, common methods are facial muscle movement recognition using cameras [26]; detection of chewing sounds using microphones [2]; glasses integrated with skull vibration sensors [28]; and ear-pad sensors measuring air-conducted vibrations [1]. A variety of constraints are associated with the implementation of the above techniques. For example, cameras and microphones require the users to face the camera when eating or eat in a noise-free environment respectively. While the skull vibration sensors and the ear-pad sensors offer more accurate detection of chewing actions, they need costly and sophisticated devices that may not easily integrate with the HoloLens. To address

this we came up with the approach of detecting the muscle movement associated with chewing and swallowing using EMG sensors. EMG sensors will detect the movements and send the data to the HoloLens using OSC via Wi-Fi. So far, we have designed and developed the gameplay and implemented our game using the "Wizard of Oz" technique, where we controlled the behavior of the monsters through the keyboard, based on the actions of the diners.

Future Work and Conclusion
In the future, we envision that our game, "Feed the Food Monsters!" will act as an inspiration for researchers to explore new ways of engaging people in the practice of proper chewing. It could be used to help people control their food intake. This can be realized in the game by fixing the portion sizes of the food. We also suggest that it can be used to increase people's food literacy. This can be achieved by making the monsters happy when eating healthy food and unhappy otherwise.

In a future study, we will recruit 20 participants to play the game. Parameters like the chewing time and the specified gulp time will be logged. The post-game interview will focus on their feelings about chewing slowly throughout the game. Results of the analysis will help us identify the key aspects of designing a chewing game. With this study, we also hope to understand other factors such as social awkwardness that might occur when playing the game.

Overall, we hope with our work we can engage people in the practice of proper chewing in a fun and a pleasurable way. We also hope we are able to contribute towards understanding eating game design and ultimately inspire designers to create a wider range of future play experiences.

Acknowledgements

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